AluMag®

North America 2015 9th - 11th of Nov

AUTOMOTIVE LIGHTWEIGHT

PROCUREMENT SYMPOSIUM

Cobo Center, Detroit, USA

SYMPOSIUM FOCUS

- Aluminum
- Carbon Fibre
- Composites
- High Strength Steel
- Magnesium

The 3rd Automotive Lightweight Procurement Symposium to be focused on automotive lightweighting, supply / process chain and procurement management, will take place in Detroit from the 9th – 11th of Nov 2015. The symposium is held in the days leading up to the "ALUMINUM USA" exhibition taking place at the Cobo Center, Detroit, Michigan (Walking distance to symposium venue)

ATTENDING COMPANIES:

BOCAR GROUP, Ford, DAIMLER, NACFE, Gibbs Die Casting, UACJ, AluMag, NISSAN, CARBON WAR ROOM, GM, StrikoWestofen Group, NanoAl, SEISSENSCHMIDT, Remy, RioTintoAlcan, GRÄNGES, MARTINREA, ESD The Engineering Society of Detroit, NNi Training and Consulting Inc., MARTINREA HONSEL, Al Circle, HT Honda Trading, Automotive Insight, RUSAL, atieva, MERITOR, EXEDY Corporation, nemak, Sumitomo Corporation, ITOCHU, BHARAT FORGE GLOBAL HOLDING, MOTORINDIA, ALMAMET, ALMAG Aluminum SMARTER · BETTER · FASTER, Rane Expanding Horizons, Rassini, LINAMAR, VERSEVO NET SHAPE SOLUTIONS, TENNECO, NEUMAN ALUMINIUM RAUFOSS, JOGMEC, HONDA, FCA FIAT CHRYSLER AUTOMOBILES, alift, SUBARU

EXHIBITORS:

EJOT, kurtz ersa, BOCAR GROUP, ACTech, WHITEHALL INDUSTRIES, CPC, BHARAT FORGE ALUMINIUMTECHNIK, ALUMINUM BLANKING COMPANY, INC.

ORGANIZING PARTNERS & SPONSORS

Reed Exhibitions, ALUMINUM USA, ESD The Engineering Society of Detroit, BOCAR GROUP, kurtz ersa

AluMag®
Europe 2016 27th - 29th of Nov
AUTOMOTIVE LIGHTWEIGHT
PROCUREMENT SYMPOSIUM
Hilton Hotel in Duesseldorf, Germany

AluMag®
Asia 2016 6th - 8th of July
AUTOMOTIVE LIGHTWEIGHT
PROCUREMENT SYMPOSIUM
Jumeirah Himalayas Hotel in Shanghai, China

AluMag®

Europe ■ India ■ Americas ■ Asia

THE MARKET DEVELOPER

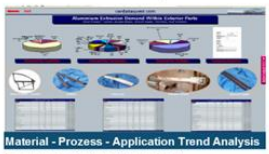
AluMag is "The Market Developer" that successfully penetrates new markets, creates business and localize leading supplier for your company. AluMag access any promising markets and open doors for your business – regardless of region, market, application, material, process or product. AluMag makes you successful – worldwide!

AluMag® offers the four following services - worldwide:

Market Research

- Aluminium Extrusion Customer Database
- Foundry & Tool Maker Database
- Automotive Application, Material & Process Analyses
- Various Industrial Application Research & Analyses

AluMag as your provider of automotive research and forecasting studies, offers you and your business, the market intelligence you need to realize the best strategic decisions



Material - Prozess - Application Trend Analysis

Large variety of market accesss, local & global:

- business database with 6,970+ companies and 18.700+ contacts
- 150+ satisfied customers worldwide
- Arranged 20+ roadshows/events since 2008

Extrusion Application

Your Benefits:

- Learn about your [potential] clients and competitors
- Obtain an inside view of the market
- Identify opportunities and threats
- Minimize risk and optimize profits
- Position your company successfully
- Based on data off the shelf, secondary re-search and interviews, AluMag generates validated researches

Market Development

- Analysis & Development of Market Opportunities
- Accelerate Market Penetration
- Manage New Product Launches
- Establish a Sales Force Sales on Demand

AluMag guides and supports your organization globally through the different market development phases until we have successfully launched, implemented or executed your project.

Map of activity - SAMPLES

Manage and integrate each aspect of your organization by initiating, planning, con-trolling, executing and closing out a new project. AluMag offers liaison mana-gement services as an addition to our customer's staff by bringing in the resources that define us.

JATCO Head Quarters Meeting in Japan

Your Benefits

- Analysis and development of Markets
- Realize opportunities
- Accelerate market penetration
- Establish a sales force
- Provide warehousing and distribution services
- Manage new product launches
- Sales on demand

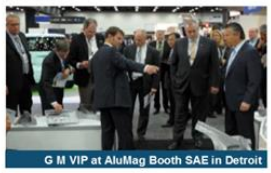
Roadshows / Events

- Organization of Technical & Commercial Roadshows
- Oversea Commercial & Technical Events
- Host In-House Events & Presentation
- Common Technology Booth at Leading Exhibitions

AluMag roadshows, tech-meetings and symposia are the first class events used by exhibitors and guest as a unique benchmark platform.

Daimler Sindelfingen as Roadshow Location

The AluMag think tank events are bringing in decision makers and executives in EUROPE, ASIA and NAFTA.



G M VIP at AluMag Booth SAE in Detroit

Upcoming Events:

- 2015 Nov: Automotive Lightweight Procurement Symposium in Detroit, USA
- 2016 April Common tech- booth at the SAE World Congress in Detroit, USA
- 2016 Jul: Automotive Lightweight Procurement Symposium in Shanghai, China
- 2016 Nov: Automotive Lightweight Procurement Symposium in Duesseldorf, Germany.

Strategic Localization

- Warehousing & Distribution Service
- Supplier & Tie-up Localization
- Identification & Trade-off of new Technology
- Foreign Market Business Cases and whose Realization

AluMag has the global expertise to search, identify, evaluate and validate potential strategic business opportunities for expansions and partnerships that will assist your business growth plans regionally and globally

On-Site Greenfield Planning Meeting

Services for:

- Search, develop and present potential acquisition candidates for regional and global business expansions
- Localization of new manufacturing / service sites for business expansions
- Identification of new technology supplier development related to products, processes and materials
- Search, develop and present potential business partners / suppliers to support regional and/or global supply programs
- Evaluate potential competitor profiles for new or existing business in non-presence geographies
- Evaluate new emerging technologies and processes for business expansions

Are you:

- **looking for specific data, information and outlook about product, material, customer, supplier, technologies, ...**
- **want to discuss your project, increase sales, access new markets, ...**
- **interested to participate in one of our roadshows / events or organize your customized showcase ...**
- **looking to localize, expand into new markets, countries, tie-up targets, ...**

please contact your AluMag Team to receive a quote or proposal

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N. America Automotive Lightweight Procurement Symposium

2015 9th – 11th Nov

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AluMag®

Europe ■ India ■ Americas ■ Asia

THE MARKET DEVELOPER

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Company Speechs by:

Agenda

Agenda: (Is Continuously Being Updated)

Monday The 9th Of November – Cobo Center, Detroit

05:30pm - 07:30pm

Pre-registration and Welcome

Reception

Tuesday The 10th Of November – Cobo Center, Detroit

08:30am – 09:15am

Registration

Morning Coffee / Tea

09:15am – 09:30am

Welcome:

Mr. Jost GAERTNER - Managing Partner At AluMag Automotive GmbH

09:30am – 10:25am

Opening Keynote: Mr. Craig RENNEKER - Chief Engineer, New A/T Programs & Component – Transmission & Driveline Engineering At Ford Research & Innovation Center

Lightweight Transmission & Driveline Components: Practical Challenges

10:25am – 11:00am

Break for Refreshments/Coffee/Tea, Snacks, Networking, Tech Exhibition

11:00am – 11:45am

Paper 1: Mr Mike ROETH – Executive Director At North American Council for Freight Efficiency (NACFE) & Operations Leader – Carbon War Room

Paper 1: Mr. Karl MAYER – Director Product Line Management At Meritor

Lightweighting Heavy Duty Class 8 Tractors and Trailers

11:45am – 01:45pm

Break for Lunch, Refreshments, Networking, Tech Exhibition

01:45pm – 02:25pm

Paper 2: Mr Ryan BROWN – Director Of Sales At StrikoWestofen America

Analysis Of Cost Drivers When Buying Lightweight Solutions / Materials & The Elimination Of These

02:30pm – 03:10pm

Paper 3: Mr. Lothar HARTMANN – Managing Director Foundry Machines & Trimming Presses At Kurtz GmbH

Chassis & Suspension Weight Reduction By LPDC Aluminum With Hollow Cross Sections

Mr. Kevin CROY - NAFTA Sales Manager Foundry Machines & Trimming Presses At Kurtz GmbH

03:15pm – 03:45pm

Paper 4: Mr. Jörg MANTWILL – Director Sales At Bharat Forge Aluminiumtechnik GmbH & Co. KG

HCM And Aluminum Forging – Partnership To Birth Chassis Parts' Safety

03:45pm – 04:15pm

Break for Refreshments/Coffee/Tea, Snacks, Networking, Tech Exhibition

04:15pm – 04:55pm

Paper 5: Mr. Gary F. RUFF - President and Chief Executive Officer, Ruff and Associates, LLC 8/12 - Present

Advanced Counter Pressure Casting Process for Light-Weighting of Auto and Truck Chassis and Suspension Components

05:00pm – 05:55pm

Closing Keynote: Mr. Gilberto SALDIVAR – New Projects Group Manager At Bocar Group

Key Factors To Achieve Mechanical Properties In Lightweight Structural Parts

05:55pm – 06:00pm

Summary:

Mr. Roberto BOEKER – Managing Partner At AluMag Automotive LLC

Agenda

06:00pm - 08:00pm

Dinner Speech:

Mr. Richard KLEIN -
Responsibility Strategic Planning - Business Development & German Business At BOCAR

Wednesday The 11th Of Nov – Cobo Center, Detroit

08:15am – 08:55am

Mr. Ali JAMMOUL – Global Director Body Exterior And Safety Engineering At Ford

Body Lightweighting

09:00am – 09:40am

Paper 1: Dr. Gerald COLE – President At Light Weight Strategies LLC

Light Weighting the Automotive Industry - The Road to 2025 CAFÉ

09:45am – 10:25am

Paper 2: Mr. Laurence CLAUS - President At NMI Training & Consulting Inc. & Technical Consultant To EJOT Fastening Systems LP USA

EJOT Fastening Solutions Enable Lightweight Body-in-white Assembly

10:25am – 11:00am

Break for Refreshments/Coffee/ Tea, Snacks, Networking, Tech Exhibition

11:00am – 11:40am

Paper 3: Dr. Akio NIIKURA - General Manager R&D Division At UACJ Corp.

UACJ's Global Strategy And Approach To The Automotive Aluminum Market

11:45am – 12:05pm

Paper 4:
Mr. Lawrence E. BROWN – Executive Director At Lightweight Innovations For Tomorrow

Lightweight Innovations For Tomorrow!!!!

12:10pm – 12:40pm

Closing Keynote:
Ms. Laura ANDERSON – CEO At Aluminum Blanking Company

The Story Behind Aluminum's Sourcing Evolution: A North America Perspective

12:40pm – 12:45pm

Summary:

Mr. Jost GAERTNER, Managing Partner At AluMag Automotive GmbH

12:45 pm – 01:30pm

Reception Speech With Snacks & Finger Food

Mr. Michael KOEHLER - Industry Vice President At Reed Exhibitions USA

01:30pm – 05:30pm

Individual Or Guided Visit At The 2015 "Aluminum USA" Exhibition

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TITLE

Lightweight Transmission & Driveline Components: Practical Challenges

ABSTRACT

- OEM conflict: fuel/weight vs. cost
- Audience participation: Poll
- Challenges for Transmission & Driveline
- Ford strategies for weight optimization
- Conclusions

Short Biography

Craig Renneker

Title: Chief Engineer, Front-Drive Systems, Transmission & Driveline Engineering, Ford Motor Company

Education: Bachelor's degree in Mechanical Engineering from General Motors Institute (now Kettering University), 1986

Master's degree in Mechanical Engineering from Stanford University, 1987

Experience: Mr. Renneker joined Ford Motor Company in May, 2000. Since then he has overseen the development and launch of several automatic transmission programs, including the TorqShift 5-speed, CVT, 6R60, 6F50, 6F35, 6R140, HF35 and DPS6 used in a variety of Ford products. He now has responsibility for the new 9&10-speeds jointly developed with GM.

Responsibilities: Mr. Renneker has responsibility for the development of all new automatic and hybrid transmission programs within Ford, as well as all component engineering activities. Professional activities: Ford Technical Advisory Board, Society of Automotive Engineers (member, session organizer), Car Training Institute Transmission symposium (advisory board member and speaker).

ONE FORD
ONE TEAM • ONE PLAN • ONE GOAL

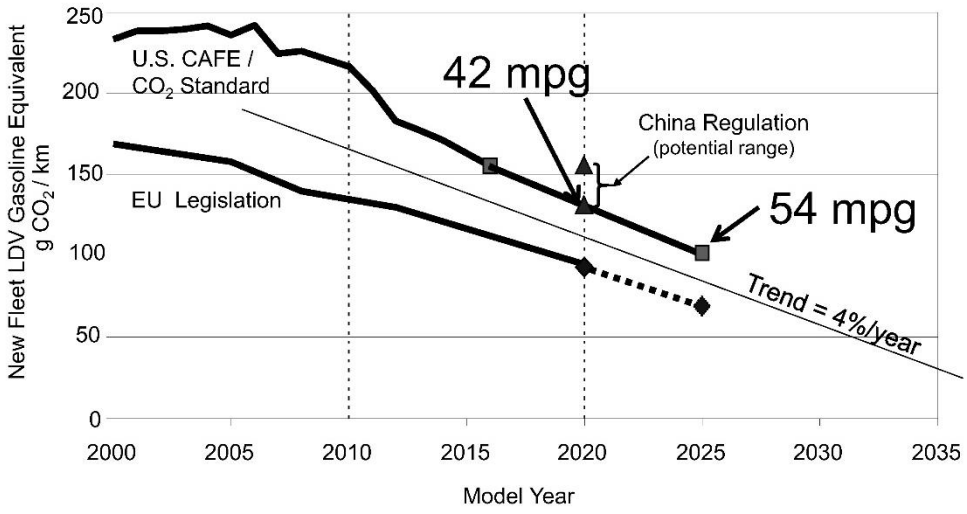
Lightweight Transmission & Driveline Components: Practical Challenges

Craig Renneker
Chief Engineer – New A/T Programs & Component Engineering
Transmission & Driveline Engineering

Agenda

- OEM conflict: fuel/weight vs. cost
- Audience participation: Poll
- Challenges for Transmission & Driveline
- Ford strategies for weight optimization
- Conclusions

The Driver: Global CO_2 Reduction



Weight reduction will be needed to meet these goals.

3

- BUT – will customers pay for the required technology?

Manufacturer	June 2013 Transaction Price	May 2013 Transaction Price	June 2012 Transaction Price	Percent Change June 2012 to June 2013	Percent Change May 2013 to June 2013
Chrysler (Chrysler, Dodge, Jeep, Ram, Fiat)	$29,876	$29,964	$ 29,590	1.0%	-0.3%
Ford (Ford, Lincoln)	$33,272	$33,089	$ 31,947	4.1%	0.6%
GM (Buick, Cadillac, Chevrolet, GMC)	$33,218	$33,147	$ 32,824	1.2%	0.2%
Honda (Acura, Honda)	$27,165	$27,082	$ 27,055	0.4%	0.3%
Hyundai/Kia	$22,529	$22,608	$ 22,121	1.8%	-0.3%
Nissan (Nissan, Infiniti)	$28,311	$27,816	$ 28,283	0.1%	1.8%
Toyota (Lexus, Scion, Toyota)	$29,177	$29,004	$ 27,910	4.5%	0.6%
Volkswagen (Audi, Porsche, Volkswagen)	$33,802	$33,698	$ 33,368	1.3%	0.3%
Industry	**$31,125**	**$30,978**	**$ 30,508**	**2.0%**	**0.5%**

Source: TrueCar, Inc.

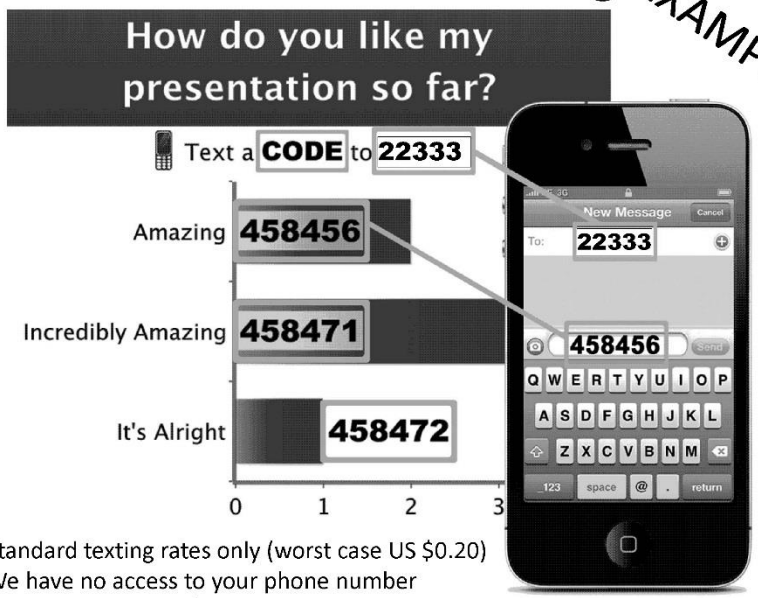
- Customers may tolerate 2% annual price increase = ~$617
- We need 4% fuel economy increase annually
- $617/4% = $154 per % fuel economy increase
- BUT: customers are also demanding additional vehicle content (safety, performance, infotainment, etc.) competing with those $

4

Audience Participation: Text Message Polling

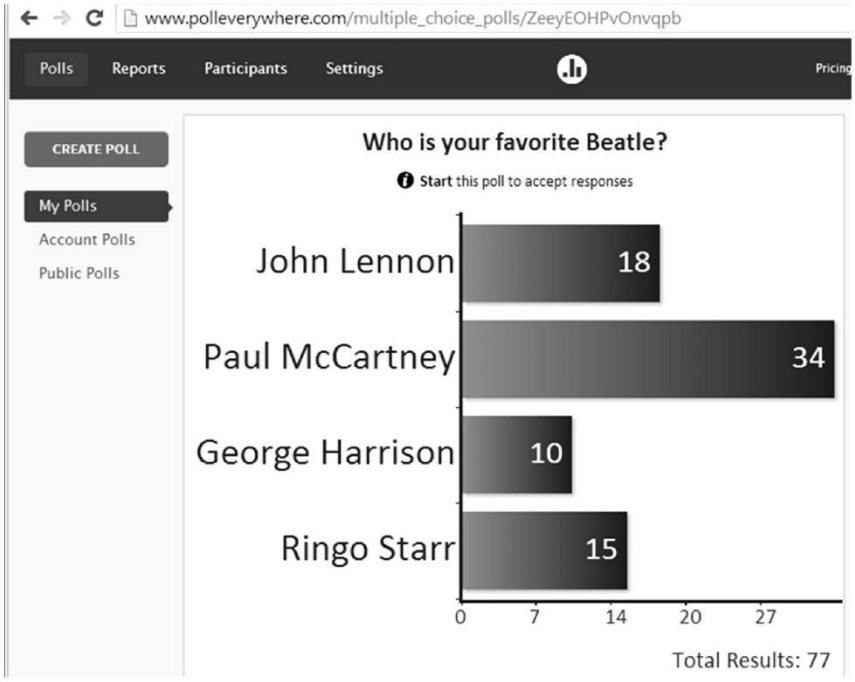
- Sample question
- How much are OEMs willing to pay for a 1% reduction in fuel consumption?
- How much are OEMS willing to pay for a 1 kilogram mass reduction?

How To Vote via Texting EXAMPLE

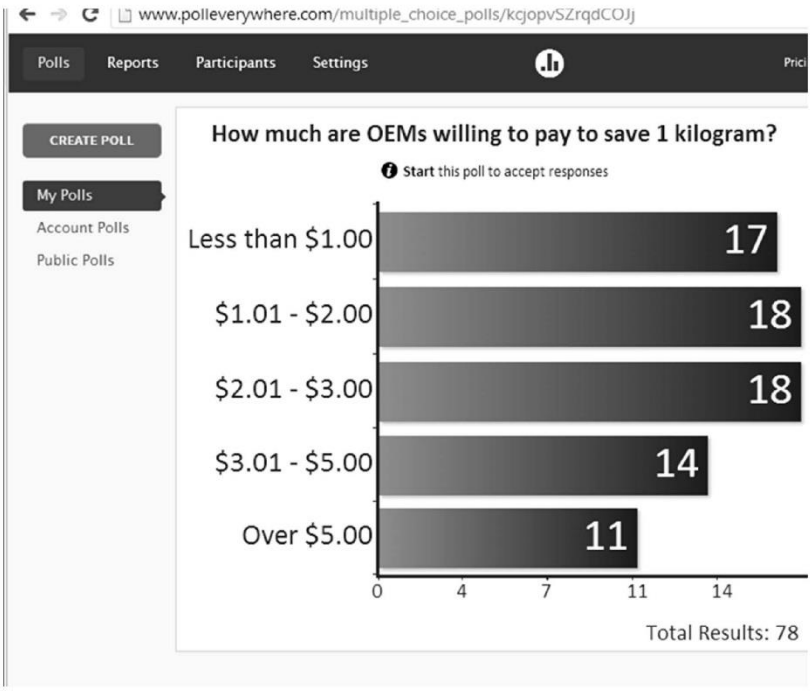


TIPS

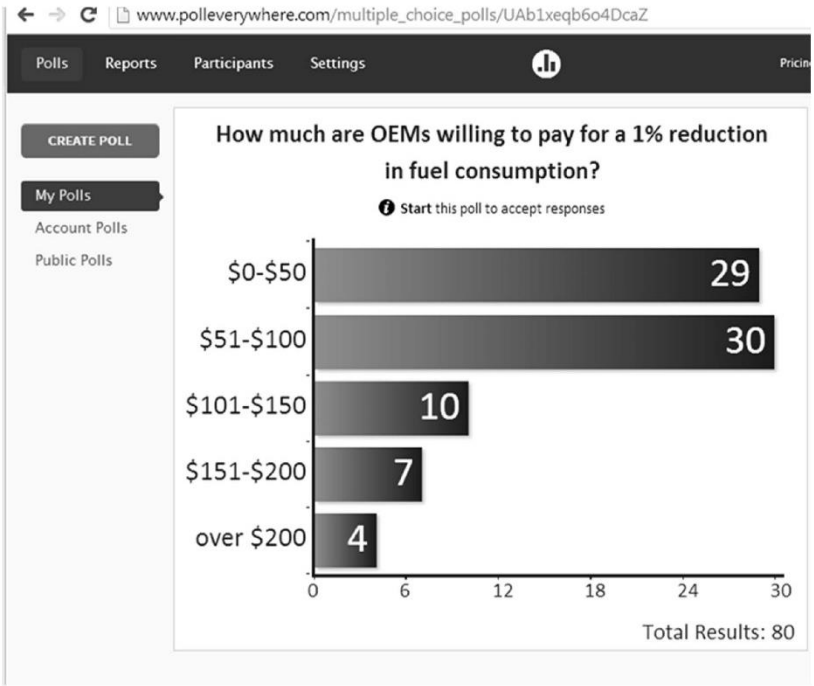
1. Standard texting rates only (worst case US $0.20)
2. We have no access to your phone number
3. Capitalization doesn't matter, but spaces and spelling do


www.polleverywhere.com/multiple_choice_polls/ZeeyEOHPvOnvqpb
Polls
Reports
Participants
Settings
Pricing
CREATE POLL
My Polls
Account Polls
Public Polls
Who is your favorite Beatle?
Start this poll to accept responses
John Lennon
18
Paul McCartney
34
George Harrison
10
Ringo Starr
15
0
7
14
20
27
Total Results: 77

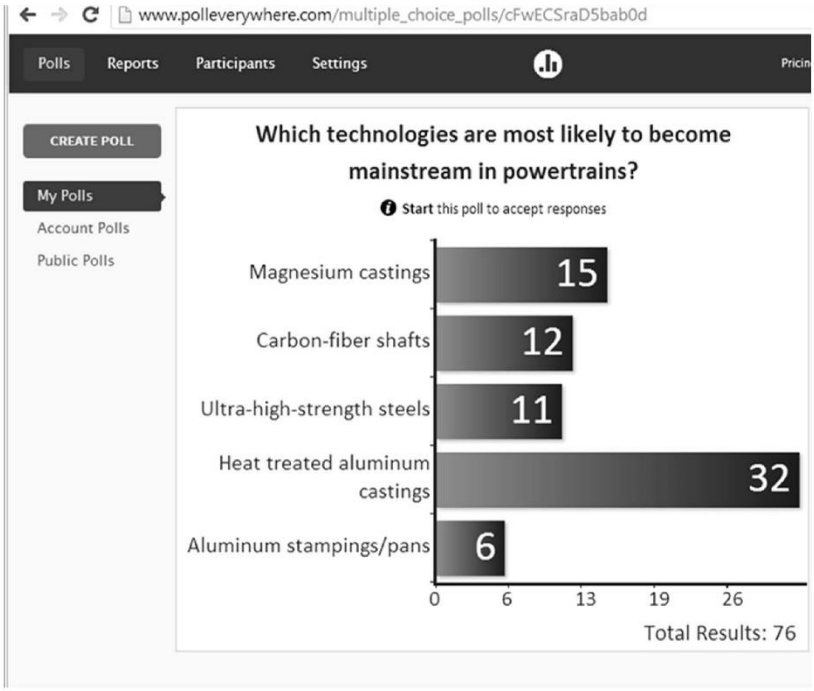
7


www.polleverywhere.com/multiple_choice_polls/kcjopvSZrqdCOJj
Polls
Reports
Participants
Settings
CREATE POLL
My Polls
Account Polls
Public Polls
How much are OEMs willing to pay to save 1 kilogram?
Start this poll to accept responses
Less than $1.00
17
$1.01 - $2.00
18
$2.01 - $3.00
18
$3.01 - $5.00
14
Over $5.00
11
0
4
7
11
14
Total Results: 78

8

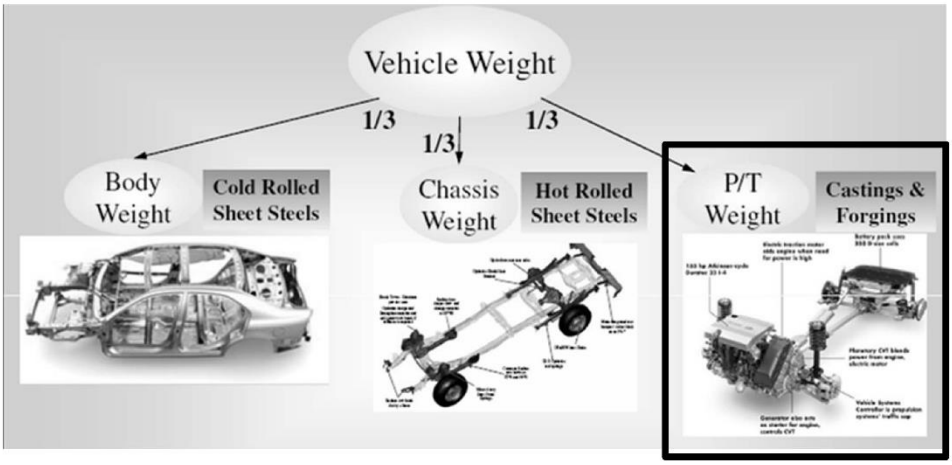

www.polleverywhere.com/multiple_choice_polls/UAb1xeqb6o4DcaZ
Polls
Reports
Participants
Settings
CREATE POLL
My Polls
Account Polls
Public Polls
How much are OEMs willing to pay for a 1% reduction in fuel consumption?
Start this poll to accept responses
$0-$50
29
$51-$100
30
$101-$150
10
$151-$200
7
over $200
4
0
6
12
18
24
30
Total Results: 80

9


www.polleverywhere.com/multiple_choice_polls/cFwECSraD5bab0d
Polls
Reports
Participants
Settings
CREATE POLL
My Polls
Account Polls
Public Polls
Which technologies are most likely to become mainstream in powertrains?
Start this poll to accept responses
Magnesium castings
15
Carbon-fiber shafts
12
Ultra-high-strength steels
11
Heat treated aluminum castings
32
Aluminum stampings/pans
6
0
6
13
19
26
Total Results: 76

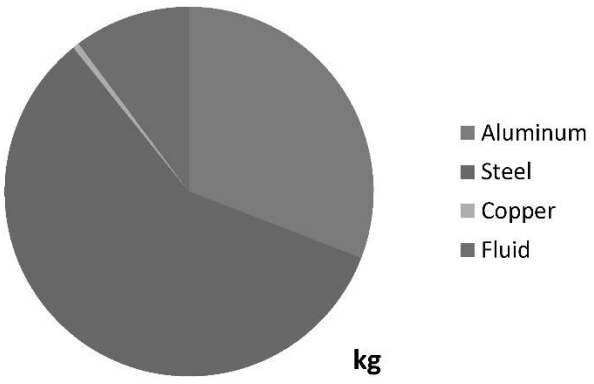
10

Role of Powertrain in Vehicle Mass



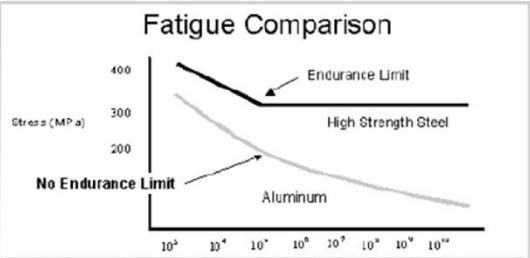
The Powertrain makes up ~1/3 of total vehicle weight

Typical Automatic Transmission Weight Split



Steel is still the primary material in a typical automatic transmission

Duty cycle requirements



Aluminum 5052-O	= 124 MPa at 50(10^7) Cycles
Dual Phase 600	= 307 MPa (Endurance Limit)
TRIP 600	= 336 MPa (Endurance Limit)

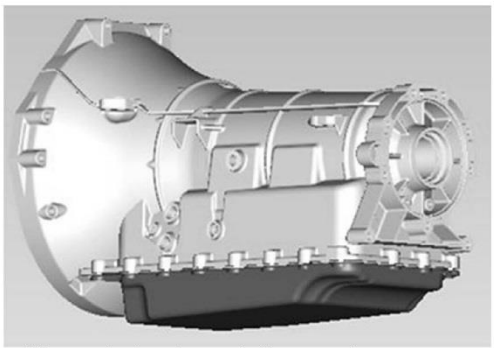
Practically speaking, steel is the only practical choice for many transmission & driveline parts

- Shafts
- Gears
- Springs
- Bearings
- Torque converters

Modulus!!!

Steel is the primary choice for many transmission components

Transmission Case: Aluminum or Magnesium?



AS 31 HP transmission case

Mercedes magnesium case

- Die cast aluminum is the most common material for transmission cases
  - Mercedes & VW are notable users of magnesium for auto trans cases
- Why don't more OEM's use magnesium?
  - Density/stiffness ratio is only marginally better than aluminum
  - Inherent creep issues limit application to low-stress designs (e.g. RWD)
  - The supply base for large, magnesium castings is very limited
  - Classic magnesium machining concerns

Magnesium is still relatively rare in high-volume applications

Ford Magnesium Success: Transfer Case

- Ford's supplier/partner Borg Warner produces a high-volume transfer case with a magnesium housing
- Millions have been produced for F150 pickup trucks and other applications
- Cost/weight trade-off is close – but favors magnesium
  - Enabled by relatively low stress and temperature requirements

Ford uses magnesium in the driveline: via Borg Warner

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Planetary Carrier Construction Options

Carrier construction	Cost	Integral features	Weight	Strength
Welded steel stampings	Low	Simple	Base	Base
Powder metal	Med	Complex	Base	Hi
Aluminum casting	Hi	Simple	Low	Lo

Stamped steel

Powder metal

Cast Aluminum

Aluminum carriers are likely to used more frequently

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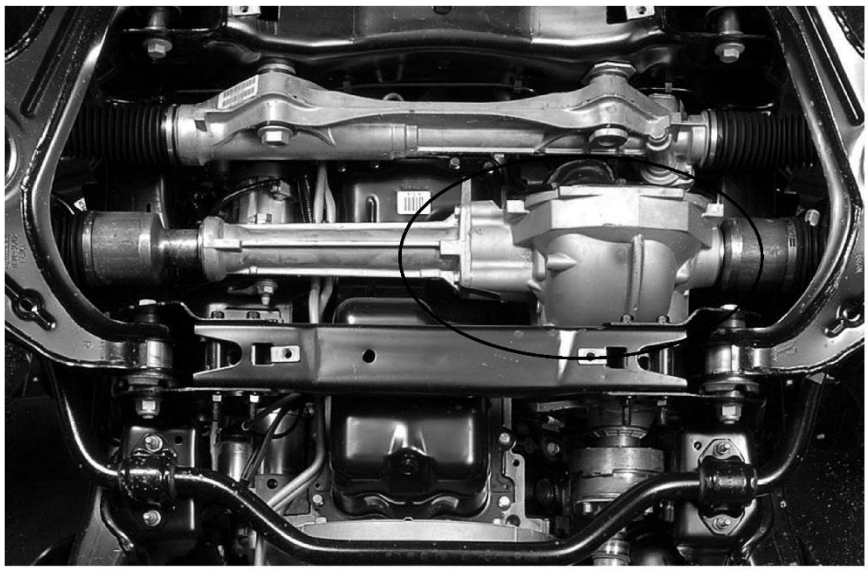
Torque Converters: oil & steel

- Torque converters present special challenges for the use of lightweight materials.
- The housings are generally stiffness-limited – requiring steel modulus
  - High-speed centrifugal load
  - Pressure
- Stators are typically aluminum, (Chrysler has magnesium)
- All available space is filled with oil
- Damper content is INCREASING converter weight (e.g. pendulums)
  - Turbo direct-injection creates torsional spikes similar to diesels

Torque converters will remain a popular launch device: getting heavier!

F150/Expedition Front Axle Carrier



Ford is a leader in the use of high-strength aluminum in truck axles

Axle housing alternatives

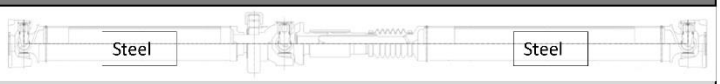
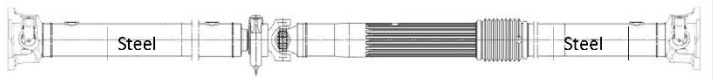
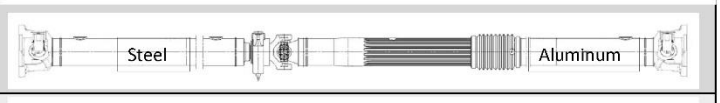
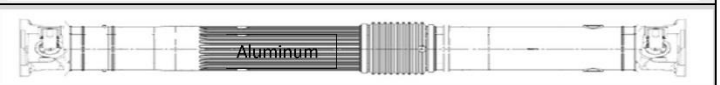
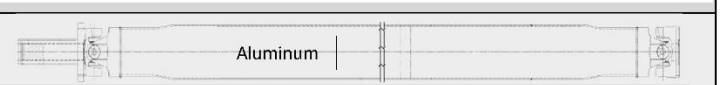
	Magnesium	Aluminum				Iron	
	Die Cast	Die Cast	Low-Pressure Vertical	Squeeze Casting	Semi Permanent Mold	Ductile Iron	Compacted Graphite Iron
Density – gr/cm^3	1800	2700	2700	2700	2700	7000	7000
Material YTS - MPa	130	160	290	290	179	310	350
Modulus - GPa	45	69	69	69	69	170	150
Density-stiffness ratio	40	39	39	39	39	41	46
Density-YTS ratio	13.8	16.9	9.3	9.3	15	22.6	20.0
Supplier Availability	R	Y	R	R	Y	Y	R

Heat-treated aluminum castings are good choices: need more suppliers!

9/11/2015

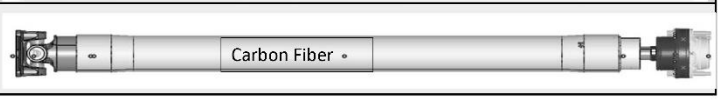
19

Driveshafts: Aluminum vs Steel

Weight savings (kg)	Cost Increase	Driveshaft Design
base	base	
1	-	
3	+ +	
5	- -	
6	+ +	
8	-	

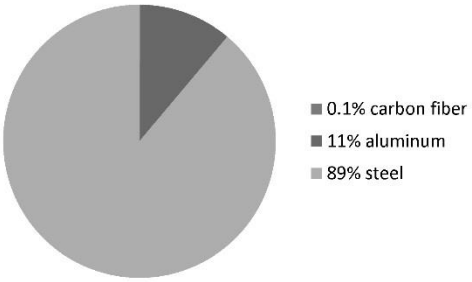
Aluminum technology is ready – but expensive

Driveshafts: Carbon Fiber vs Steel

Weight savings (kg)	Cost Increase	Driveshaft Design
base	base	
4	+ + + +	

Carbon fiber is very expensive – not yet ready for high-volume

Ford Driveshaft Material Usage



Aluminum use decreased from 18% in 2010 to 11% in 2013

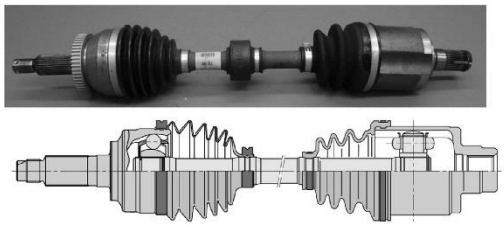
Why don't we use more aluminum driveshafts?

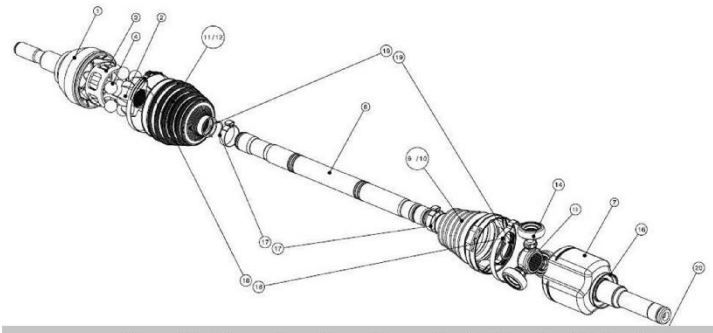
- The weight "buy" is marginal – vehicle teams spend their money elsewhere
- This should change and favor aluminum as "lower-hanging fruit" is exhausted

Steel will dominate driveshafts until aluminum cost/weight improves

Halfshafts: Can they be lighter?

- Halfshafts are very highly stressed
  - High-cycle loads
  - Hard, tough surfaces for sliding elements
- Stiffness is as important as strength
- Package environment is cramped
- Steel is the practical material choice

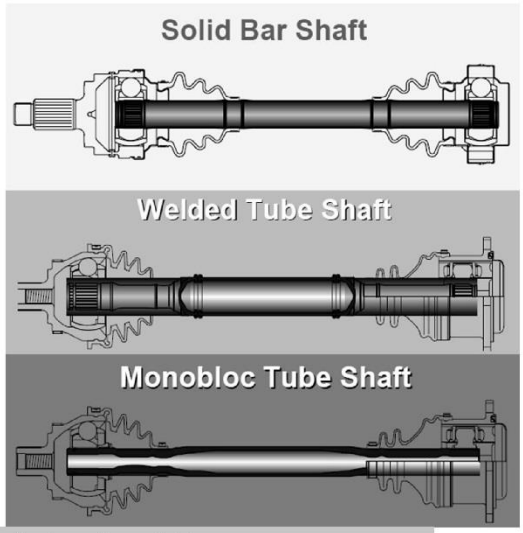




Steel is the dominant material in halfshafts

Light-weight Halfshafts

- Hollow shafts provide some opportunity
- Two alternatives:
  - Welded tubing
  - Monobloc
- Neither provide a compelling cost/weight "buy"
- Ford volume continues to be dominated by traditional solid-bar halfshafts



Hollow shafts help – but $$$

Ford Strategies to Reduce Weight

- Weight efficiency analysis for every part
- Vehicle duty cycle data acquisition to define customer requirements
- CAE automated weight optimization
- Increased model complexity
- Continued development for lightweight materials

A structured weight analysis process is needed.

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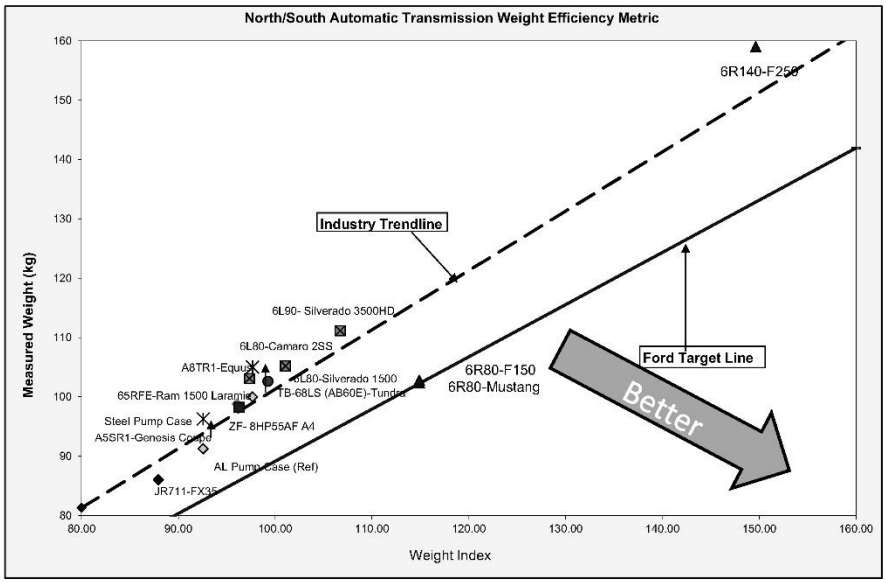
Weight Efficiency Metrics



Ford uses Weight Efficiency Metrics for every part in the vehicle

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Duty Cycle Optimization

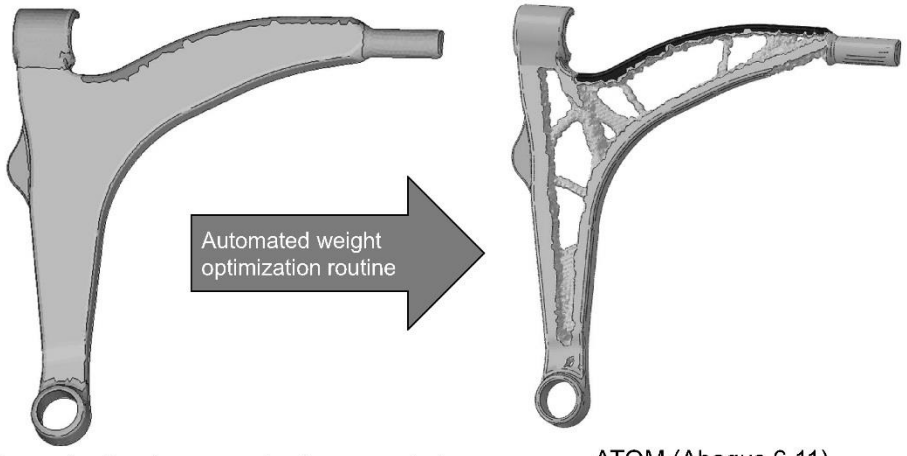
- Ford invests heavily in gathering real-world load data for all vehicle systems
- North American and European road systems and drive cycles are well documented. Adding new global regions regularly
- Fully-instrumented vehicles with acquisition systems generate terabytes of data
- Time-history format data; can retrieve damaging events and project to 150K/ 250K miles

US-Specific Example

5 Cities	Boston Denver Phoenix Pittsburgh Yellowknife
3 Types of Routes	City Rural Expressway
3 Driving Aggressiveness Levels	Mild Moderate High
3 Road Severity Levels	Smooth Moderate Rough

We must know how our customers drive – in every global market

Weight Optimization with CAE



Example: Front suspension lower control arm

ATOM (Abaqus 6.11)

Ford makes extensive use of automated CAE weight optimization

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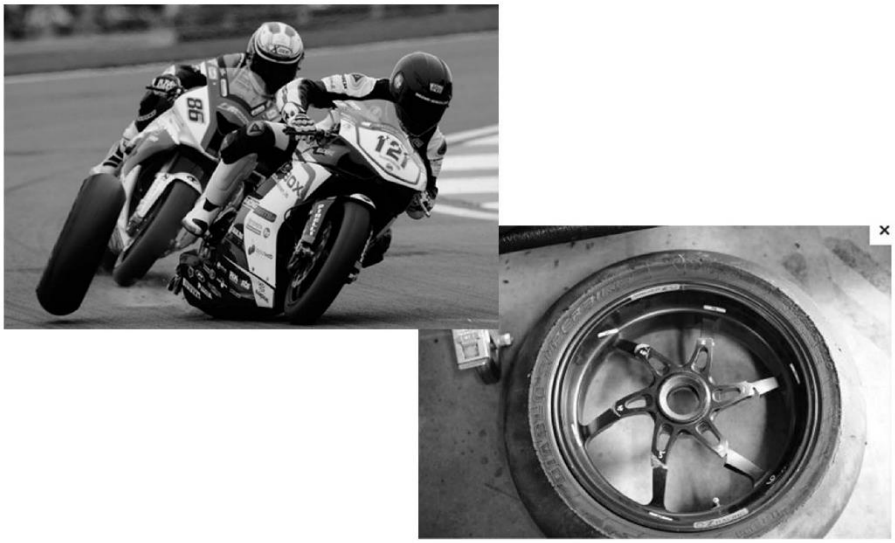
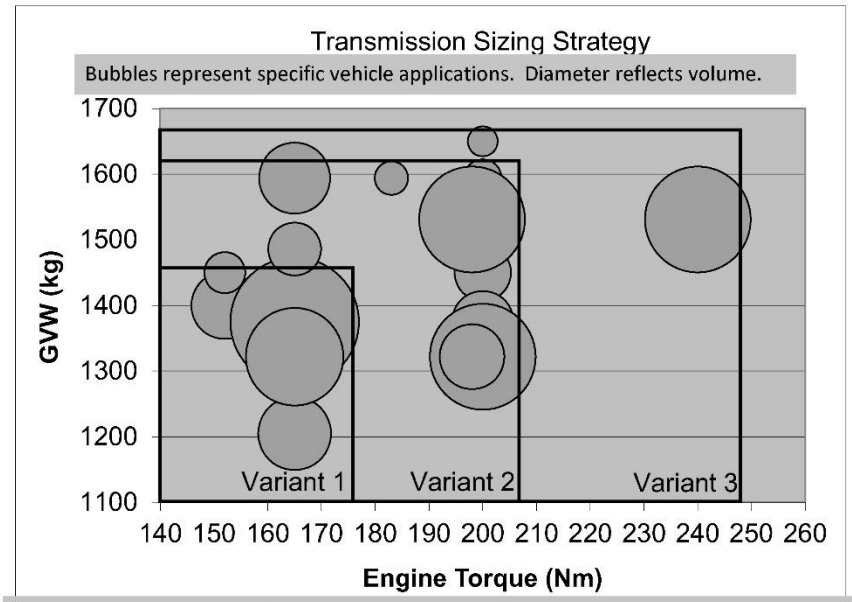
What if we push too far?



Push to the limit, then add a little back in!

29

Increased complexity for weight optimization



Pressure for weight optimization will increase model complexity

30

Conclusions

- The pressure to reduce weight will only intensify
- The pressure to reduce cost will not abate, keeping trade-offs challenging
- We need to expand our supply base for high-strength, low-weight components
- We will continue a structured weight optimization process
- Our product complexity will expand as we optimize size to match customer needs
- There are no easy answers, only opportunities for engineering work
- Ford intends to aggressively push for weight reduction to maintain fuel economy leadership

Thank you for your attention!

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Mr. Mike ROETH
Executive Director
North American Council for Freight Efficiency (NACFE) & Operations Leader

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TITLE

Lightweighting Heavy Duty Class 8 Tractors and Trailers

ABSTRACT

The North American Council for Freight Efficiency is a non-profit dedicated to doubling the efficiency of NA goods movement. It works with the Carbon War Room a Sir Richard Branson startup, which intervenes in markets to accelerate the adoption of business solutions that reduce carbon emissions at gigaton scale and advance the low-carbon economy. In August 2015, the group issued a Confidence Report on lightweighting Class 8 Tractor Trailers for Freight Efficiency. For heavy duty trucks, weight reduction helps fuel efficiency by lowering the rolling resistance of the vehicle, but also increases freight efficiency. Increased payloads, for those loads that max out in allowable weight, which in the USA is 80,000 pounds. Key trends in this area include the fact that the equipment is heavier due to emissions equipment and other fuel saving devices being added to the tractors and trailers as well as more features added as driver amenities. At the same time, freight is becoming denser and more pallets are being added to each trailer. Many products are available to lower weights, but have cost challenges as well as other barriers to adoption. The report findings can be found on www.truckingefficiency.org in technologies and operational practices and will be shared by the speakers.

Meritor Headquarters

Karl MAYER
Director Product Line Management

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www.meritor.com

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Carbon War Room – Meritor Headquarters

Today

Mike Roeth, Executive Director, NACFE & CWR

Karl Mayer, Director, Meritor

- Trucking Efficiency
- Fleet Fuel Study
- LWing Confidence
- Manufacturer Perspective
- Questions and Answers

MERITOR

NACFE

Trucking Efficiency

Dedicated to doubling the efficiency of North American goods movement

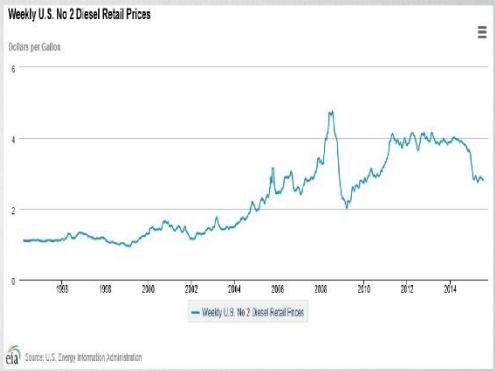
We pursue this goal in two ways:

1. By improving the quality of information flow and
2. By highlighting successful adoption of technologies

www.nacfe.org

www.truckingefficiency.org

Fuel Costs



$75,000/year 1% savings = $750 year/truck

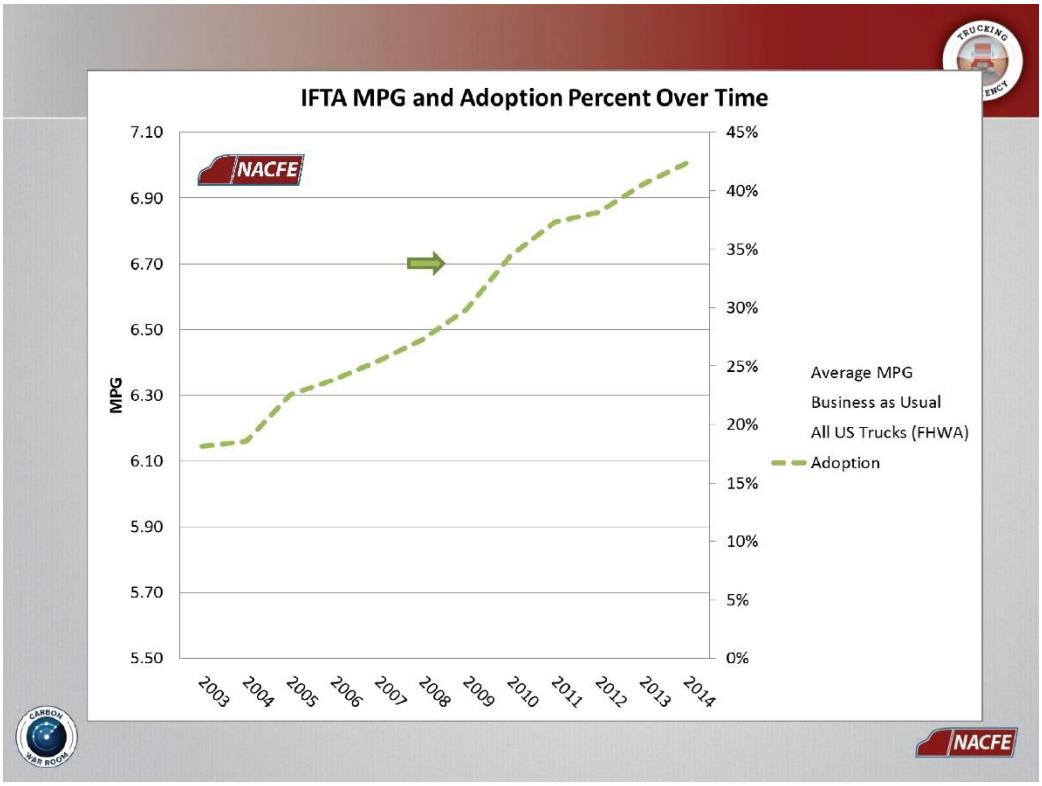
Annual Fleet Fuel Study

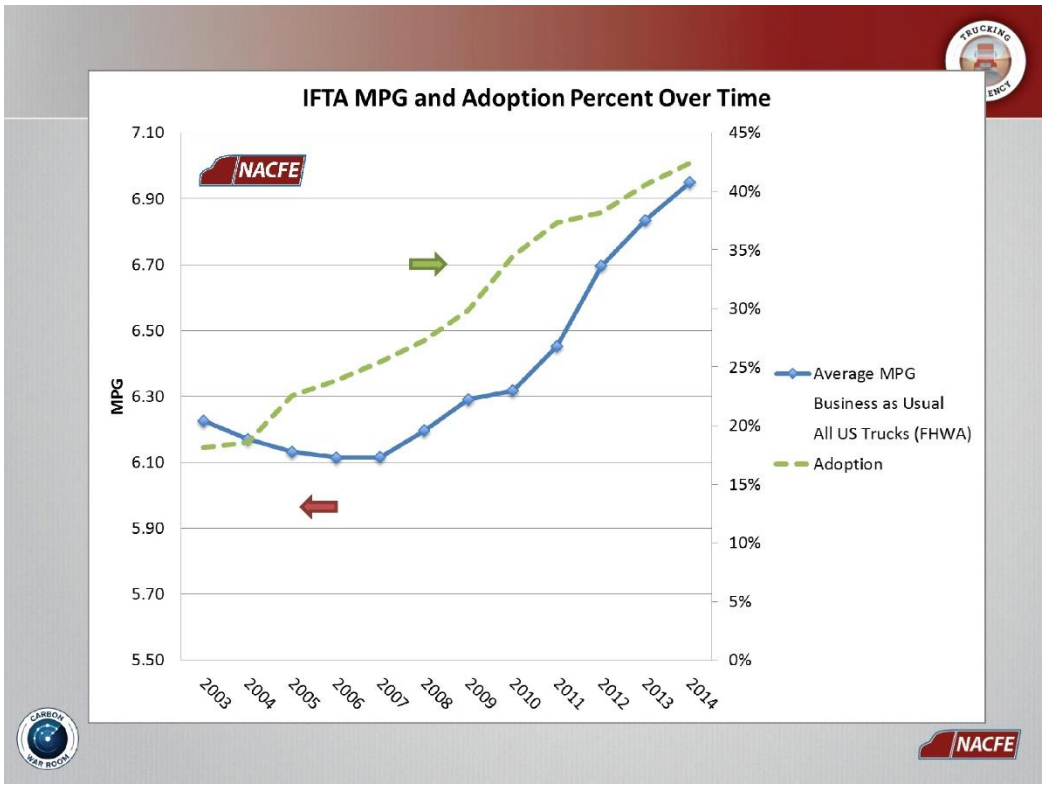
Real Fleets. Real Experience.

Fuel Economy Technologies

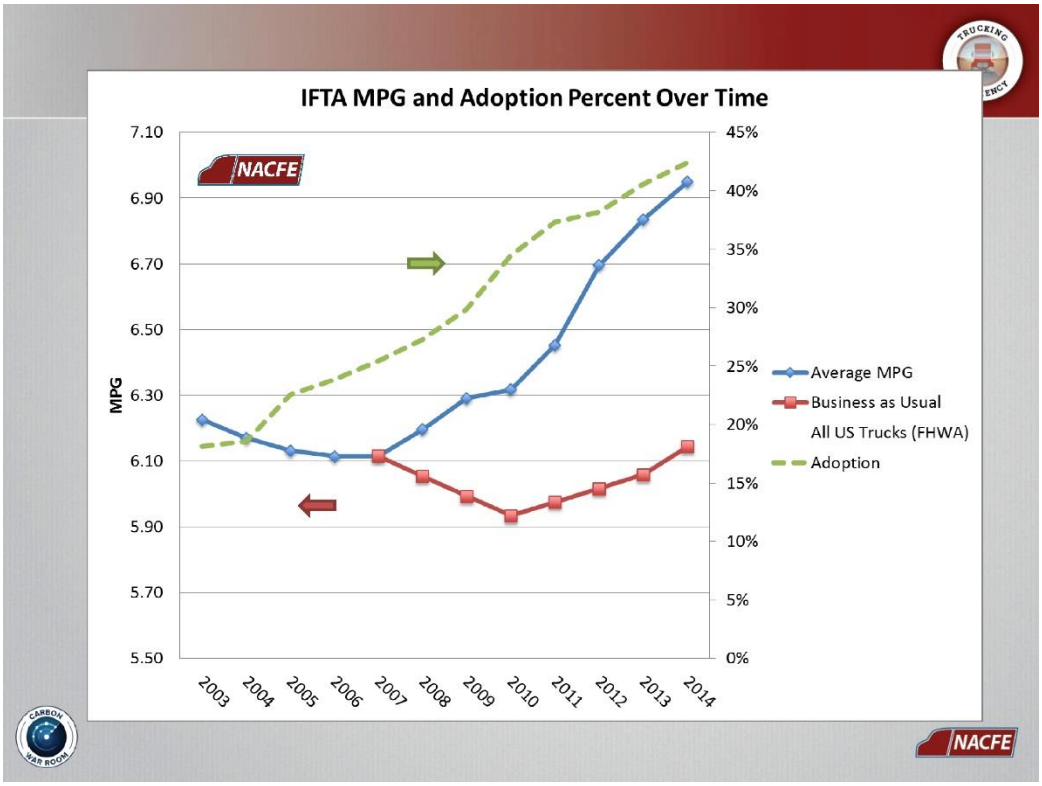
- Which ones are most popular on new trucks?
- Did they keep buying them?
- Are they delivering fuel savings?

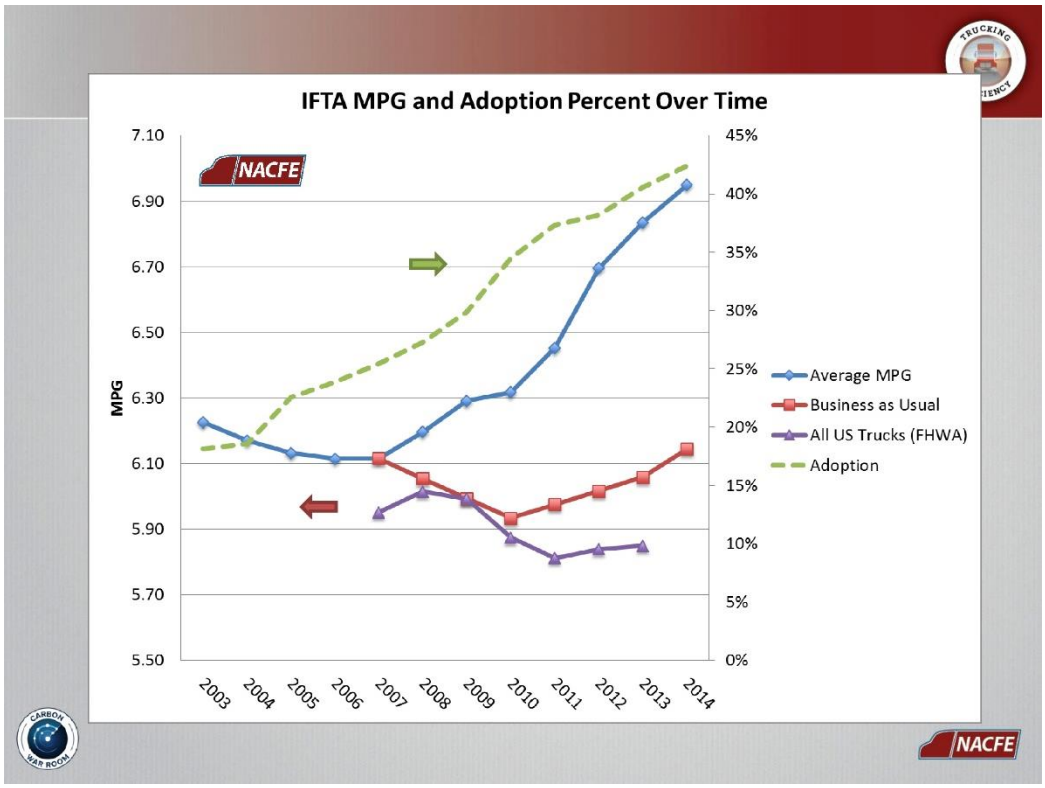
Carbon War Room - Meritor Headquarters

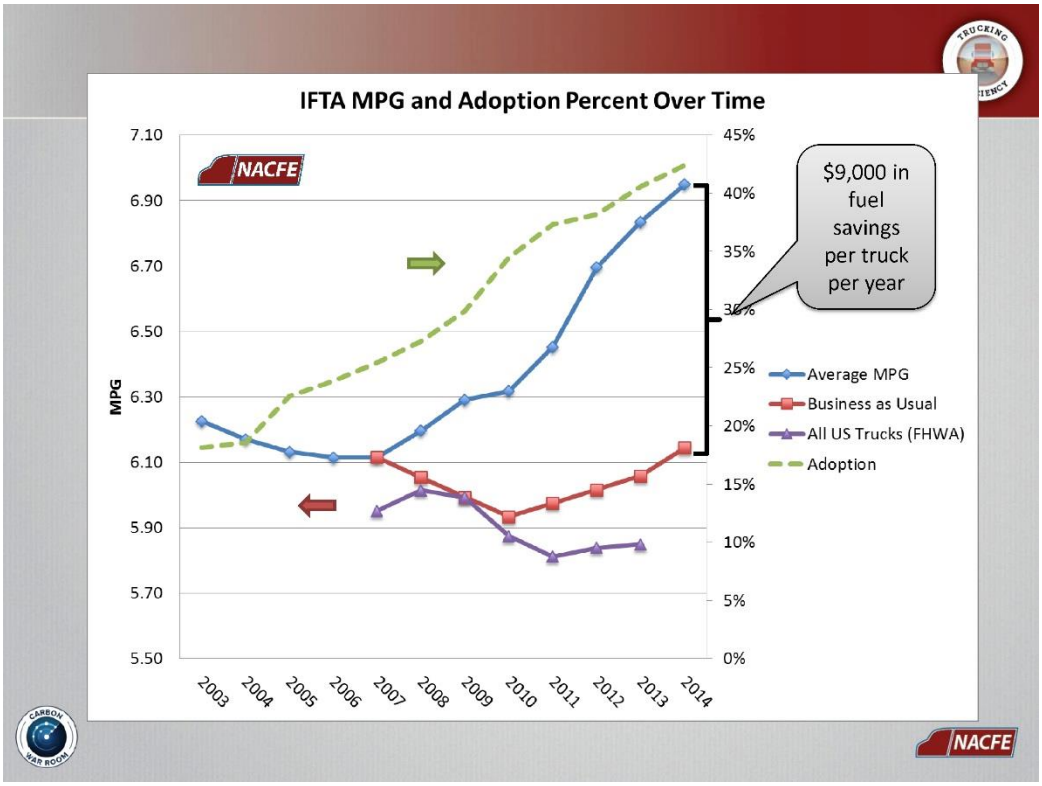




Carbon War Room - Meritor Headquarters







Gov't Interest in Fuel Efficiency

- US EPA's SmartWay "voluntary" in 2004
- CARB legislation implemented in early 2010
- EPA / NHTSA Heavy Duty Greenhouse Gas Rule: Phase 1
- EPA / NHTSA Heavy Duty Greenhouse Gas Rule: Phase 2

US EPA Certified SmartWay

California Environmental Protection Agency AIR RESOURCES BOARD

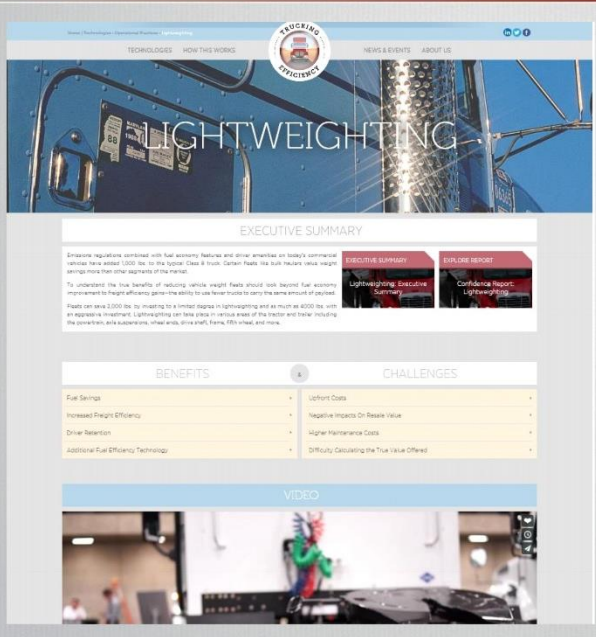
United States Environmental Protection Agency

NHTSA www.nhtsa.gov

Helping YOU Make Decisions

- Confidence Reports
- Decision-Making Tools
- Workshops
- Tech Guide at www.truckingefficiency.org
- Thought Leadership
- Industry Events
- Collaboration

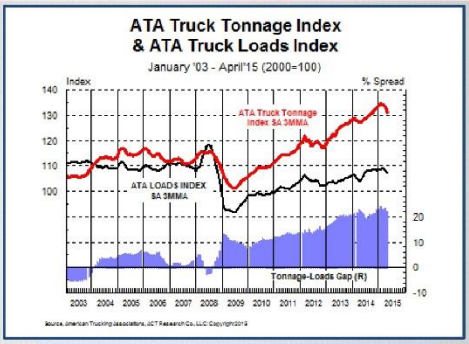
Study Released August '15



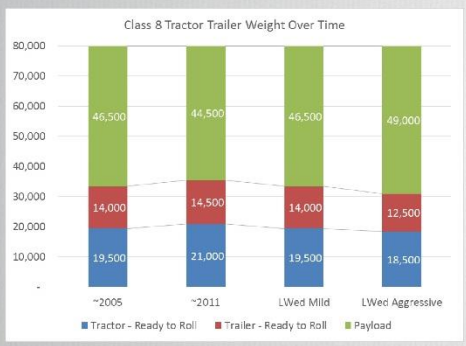
Details here including free downloadable report

Why Lightweighting?

- Industry Trends
  - Tractors and Trailers have gotten heavier
  - Denser Freight
  - More Pallets/Trailer
- Shippers asking for more Payload
- Three "Categories"



Weight over Time



- Tractors, and to some extent Trailers, have gotten heavier
  - Emissions
  - Driver Amenities
  - Fuel Economy Features
- Actions
  - Mild Lightweighting
  - Aggressive Lightweighting

Benefits and Challenges

Benefits & Enablers

- Regulations
- Increased Freight Efficiency
- Improved Fuel Economy
- Sustainability Goals
- Additional FE Technologies

Challenges & Consequences

- Upfront Cost
- Residual Value
- Maintenance Costs
- Redundant Product Testing
- Driver Retention
- Ability to take Advantage
- Over-spec

Fuel Efficiency Technology

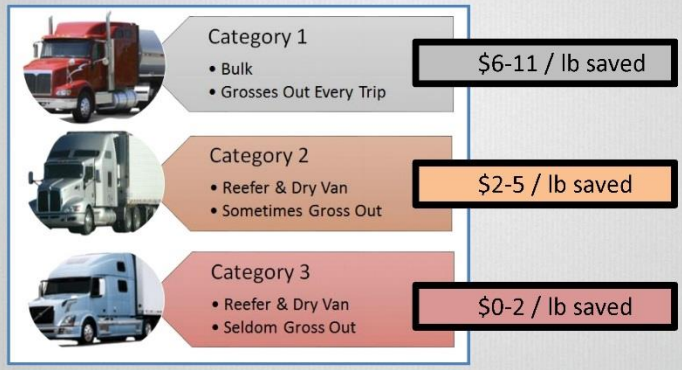
Feature	Estimated Weight (lbs.)
Full chassis fairings	360
Trailer skirts	180-250
Tail skirts	120-175
APU (Federal law allows 400 lb. exemption for this weight)	400-500
AMT	150-500
TOTAL WEIGHT ADDED FOR FUEL ECONOMY	1,210 lbs.

+ Compressed natural gas (CNG)	1500-2000 lbs

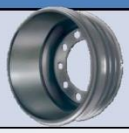
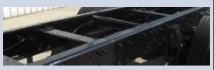
Measurable fuel savings, at the expense of weight.

Lightweighting

Value in Dollars per Pound

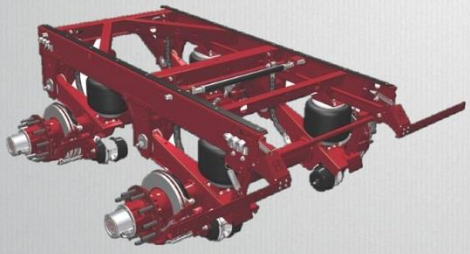


Material Conversion

Product	Baseline	Conversion	Weight Savings per Tractor
BRAKE DRUM 	Iron	Steel shell with iron liner	168 lbs
WHEEL 	Steel	Aluminum	307 lbs
FRAME RAILS 	Steel	High Strength Steel	200 – 300 lbs
LEAF SPRINGS 	Steel	Composite	125 lbs per Trailer

Design Integration

Wide Base Wheels
Weight Savings 400 lbs / tractor
308 lbs / trailer



Trailer Slider Box

Optimized steel design
Weight savings 100 lbs
Lower cost

Right-Sizing

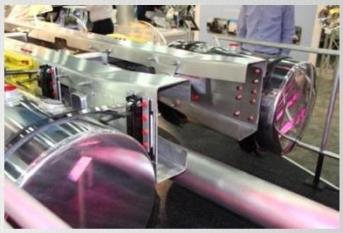
Fuel Tanks

Hours of Service (HOS) = 11 Average fuel economy = 6 mpg Average speed = 55 mph
11 hours * 55 mph / 6 mpg = 101 gallons

@ 7 lbs / gal diesel, an extra 50 gal = 350 lbs → Equivalent to weight of trailer skirts or AMT

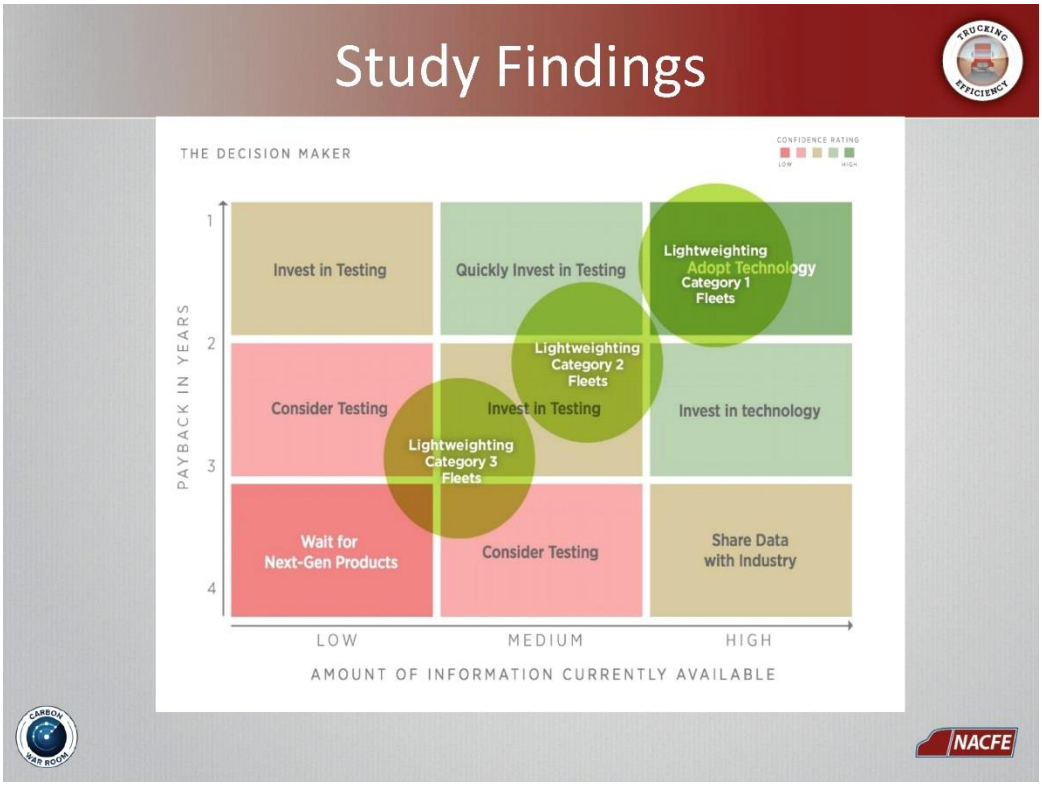
Future Innovations

- Materials
- Design
- Improve quality of current offering to increase take rate



Study Findings

- Findings
  - Heavier equipment
  - Denser freight
  - Fleets hesitant to LW
  - Industry trends indicate need for LW8ing will increase
  - Fuel economy and freight efficiency
  - Opportunities exist, and more coming
- Recommendations
  - Category 2 and 3 fleets should begin to explore LW8ing (lightweighting).
  - Supply chain collaboration can bring down costs and shorten lead time.
  - Fuel efficiency depends on lightweighting due to other technologies


Study Findings
THE DECISION MAKER
CONFIDENCE RATING
LOW
HIGH
PAYBACK IN YEARS
1
2
3
4
Invest in Testing
Quickly Invest in Testing
Lightweighting
Adopt Technology
Category 1
Fleets
Lightweighting
Category 2
Fleets
Consider Testing
Invest in Testing
Invest in technology
Lightweighting
Category 3
Fleets
Wait for
Next-Gen Products
Consider Testing
Share Data
with Industry
LOW
MEDIUM
HIGH
AMOUNT OF INFORMATION CURRENTLY AVAILABLE
NACFE


MERITOR
Meritor Business Overview
&
Lightweight Solutions

Carbon War Room - Meritor Headquarters

Business Segments

Commercial Truck & Industrial

- Drivetrain systems and components, including axles, drivelines, braking and suspension systems
- Medium- and heavy-duty truck markets in North America, South America, Europe and Asia Pacific
- Truck, defense and specialty

Aftermarket & Trailer

- New and remanufactured axles, brakes, suspensions, transmissions and components for all-makes aftermarket customers
- Wide variety of undercarriage products and systems for trailer applications

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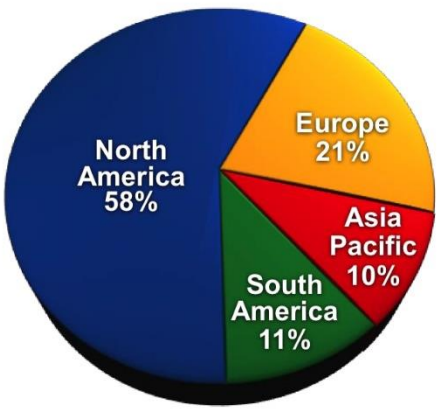
Globally Diverse Business Portfolio

FY14 Sales by Segment

FY14 Sales by Region



FY14 Sales $3.8B

28

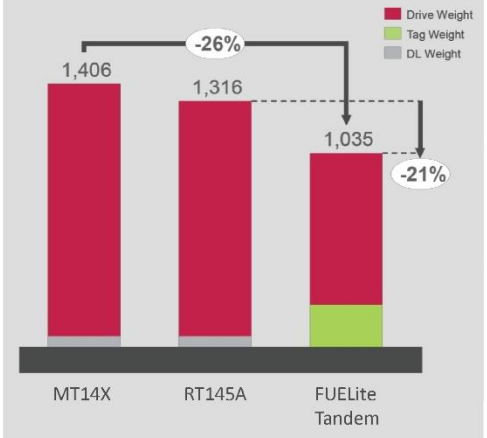
Lightweight Solutions – Available Today

Meritor has multiple solutions that can save 400 lbs or more

29

FUELite 6x2 Tandem Drive Axle- Benefits

LIGHTER WEIGHT FUELite Tandem



[1] Weights will very based on configuration and ratio (this weight based on std. track, 9.5mm wall housing, std diff carrier, 17T yokes and std angle interaxle prooshaft)

[2] Weights will very based on configuration and ratio (this weight based on dualtrac, 12.7mm wall housing, DCDL carrier, 17T yoke & torque rod bracket on tag axle)

- Weight savings:
  - Nearly 400lbs lighter than typical linehaul tandem

400 lb. WEIGHT REDUCTION

- Fuel Efficiency
  - Estimated 2% fuel savings

* Actual fuel savings may vary and will depend on a variety of factors beyond Meritor, Inc.'s, control, including load, vehicle type, driver performance, distances traveled, vehicle speed, road conditions, etc.

2% INCREASE IN FUEL EFFICIENCY

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Future Opportunities for Lightweighting

Meritor will continue to research and develop components with the following in mind:

- Alternative steel types
- Aluminum
- Composites
- Design optimization and component integration

Use of aluminum structures for trailer suspensions

Suspension and Axle Interface

Integration of brake structure and knuckle

- The challenge of alternative materials is the cost benefit equation.
- OEM customers want products at same/similar price.
- Limited market (bulk haulers) in the industry will pay a premium for lightweighting

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Questions?

Mike Roeth, Executive Director, NACFE & CWR

Karl Mayer, Director, Meritor

- Trucking Efficiency
- Fleet Fuel Study
- LWing Confidence
- Manufacturer Perspective
- Questions and Answers

StrikoWestofen Group

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Director Of Sales

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www.strikodynarad.com/

TITLE

Analysis Of Cost Drivers When Buying Lightweight Solutions / Materials &

The Elimination Of These

ABSTRACT

77% of the total energy required to cast an aluminum part in HPDC is spent in the melting and holding process, before the metal reaches the shot sleeve on any HPDC Machine.

Millions of Dollars are unnecessarily wasted every year in gas consumption and in metal loss during the melting process.

Efficient melting processes will not only improve the quality of the metal that is discharged from the melting furnace, but it also reduces the cost drivers associated with melting aluminum – as previously mentioned, in gas consumption and metal losses.

Thus, the metal quality and profitability of every die caster or foundry starts in the melt shop.

Striko Westofen America

North American Lightweight Procurement Symposium

Nov. 9-11, 2015

„The **efficiency** of a **casting process** starts in the **melt shop**.“

Quote from a leading die-caster and long-time StrikoWestofen customer

StrikoWestofen

StrikoWestofen

STRIKOWESTOFEN SUPPLYING FOUNDRIES FOR OVER 60 YEARS

- „As a globally acting company with over **60 years of history** in thermal process technology we have a very good sense for the needs of our customers.“
- „More than **8,000 units sold worldwide** are proof and basis for our continuous innovations.“

Rudolf Riedel - CEO StrikoWestofen Group

Striko Westofen America

STRIKOWESTOFEN
HEADQUARTERED IN GERMANY

StrikoWestofen

STRIKOWESTOFEN
NORTH AMERICAN HQ IN ZEELAND, MI

StrikoWestofen

Striko Westofen America

StrikoWestofen

StrikoWestofen
We are where our customers are

- Subsidiaries, sales and service partners
  - In 25 countries
  - Throughout Europe, Asia and America

StrikoWestofen

Topics Covered

Industry Bell Curve

Operational Costs of the Melt Shop

Reduction of Energy Consumption

Increasing Metal Yield & Melting Capacity

Return on Investment – Shaft Melting

Dosing Process Control

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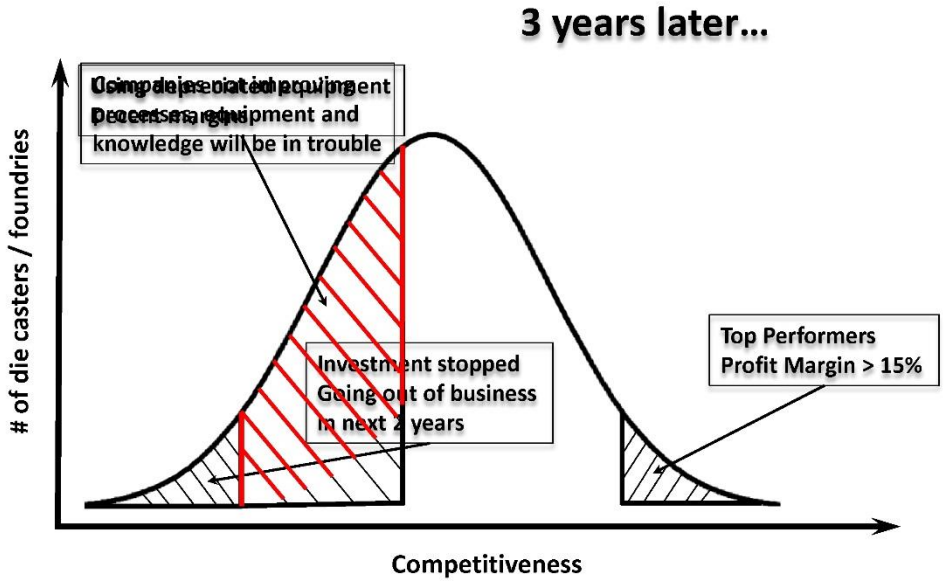
INDUSTRY BELL CURVE



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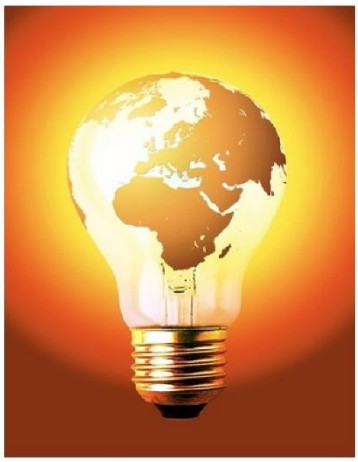
OPERATIONAL COSTS OF THE MELT SHOP:

Energy Costs and Metal Loss Drive Operational Costs

- **Over 95%** of the total cost of furnace ownership is generated by
  - **Energy consumption**
  - **Loss of metal**
- **77% of the energy** used for an aluminum die-casting operation goes into
  - **Melting process**
  - **Holding process**
  - **Dosing process**

**Source: NADCA Survey*



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Keep melt shop costs down

STRIKOMELTER®: Shaft Melter

REVERB FURNACE

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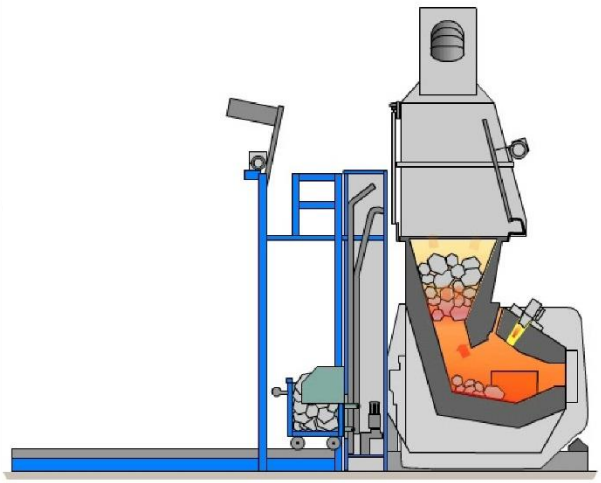
REDUCTION OF ENERGY CONSUMPTION:

Advantages of Shaft Melting Furnaces

- **ETAMAX® shaft geometry** uses hot exhaust gases from holding and melting to preheat the charging material

Results:

- **Rapid melting process**
- **High melt quality**
  - Minimal oxide inclusions
  - Density index 6% or better
- **Low energy consumption**
- **Reduced CO_2-emissions**



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REDUCTION OF ENERGY CONSUMPTION:
Benefits of Lower Gas Consumption

- **Molten aluminum above 1220°F can absorb high amounts of hydrogen**
- Gas-fired melting process can increase hydrogen content in aluminum
- Hydrogen must be minimized via degassing before casting process

- **Especially important for thin-walled structural castings**
- **Melting technology key factor to success at HPDC**

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REDUCTION OF ENERGY CONSUMPTION:
Benefits of Lower Gas Consumption

- **Energy consumption of less than 850 BTU/lb**
(validated under operating conditions)

- **Savings of 10 to 60 percent** compared to competitive technologies

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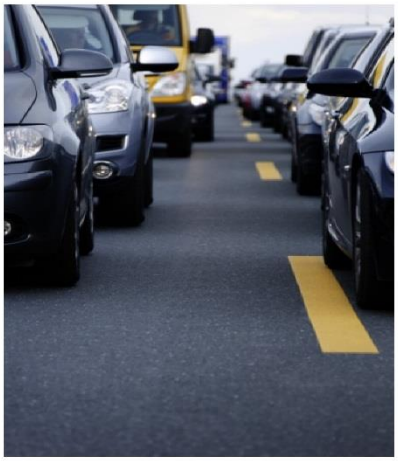
REDUCTION OF ENERGY CONSUMPTION:
Benefits of Lower Gas Consumption

- CO_2 emissions of 129 kg/t
  - Compared to 180 kg/ton with other tower melter
- CO_2 savings / year
  - Emissions of **400 – 900 cars**



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INCREASING METAL YIELD AND MELTING CAPACITY:
Shaft Melting Process Advantages

- **Metal yield up to 99.7 %**
  - Ex. Melting 10 mil. lbs./yr, 1% metal loss savings =$100,000 / year at $1.00/lb.

- **High productivity**
  - Charging ingots and production returns

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INCREASING METAL YIELD AND MELTING CAPACITY:
Shaft Melting Process Advantages

- **Sludge**
  - Forms when holding temperatures are too low, below 1225°F
- **Corundum**
  - Forms when holding temperatures are too high and in difficult-to-clean areas

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Theoretical/Best Practice
Energy Use In Metalcasting Operations

J. F. Schifo
J.T. Radia

KERAMIDA Environmental, Inc.
Indianapolis, IN

May 2004

Prepared under Contract to
Advanced Technology Institute
North Charleston, SC

for the
U.S. Department of Energy
Industrial Technologies Program
Washington, DC

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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SUMMARY ENERGY CONSUMPTION AND MELT LOSS:

3rd Party Verification

Table 21 - Aluminum Melt Furnace Comparisons

	Melt		Tapped				Ship**
	Gross Btu/pound	Melt Loss	Btu/pound	Btu(10^6)/Ton	Tacit Btu/pound	Tacit Btu(10^6)/Ton	Tacit Btu(10^6)/Ton
Reverberatory Gas Furnace AFS Article (25)	1,975	5.5%	2,090	4.18	2,142	4.28	6.59
Reverberatory Gas Furnace Actual*	**2,418**	**5.5%**	**2,559**	**5.12**	**2,623**	**5.25**	**8.07**
Stack Melter, Die Cast Facility(26)	703	1.25%	712	1.42	730	1.46	2.25
Stack Melter Actual	**861**	**1.25%**	**872**	**1.74**	**893**	**1.79**	**2.75**

* "Actual" is the total energy usage including downshifts and weekends based on running at 50% of rated capacities. (Actual data on die casting operation stack melter.) Reverberatory "Actual" using the same ratio of energy differences as stack melter.

**Tons shipped considered 65% of melt. (Yield)

http://energy.gov/eere/amo/downloads/itp-metal-casting-theoreticalbest-practice-energy-use-metalcasting-operations

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ROI CALCULATION:

Shaft vs. Reverb Melting Furnace Comparison

"Die Casting Direct"

Aluminum/day = 100,000 lbs.
Prod days/yr = 240

$/lb. Al = $0.90
$/Therm = $0.42

Current Furnace = 50,000 lb. Reverb
Melt loss = 4.2 %
BTU/lb = 2418

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ROI CALCULATION:

Shaft vs. Reverb Melting Furnace Comparison

Annual gas savings:

240 days x 100,000 lbs./day = 24 mil. lbs/yr.

BTU savings potential = 2418 − 861 = 1,557 BTU/lb.

1,557 BTU ÷ 100,000 BTU/Therm = 0.01557

24 mil lbs x 0.01557 Therms x $ 0.42/Therm =

$ 156,945/yr.

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ROI CALCULATION:

Shaft vs. Reverb Melting Furnace Comparison

Annual Melt Loss Savings:

4.2 % Reverb − 1.25 % Shaft = 2.95 %/lb.

24 mil lb. x Δ2.95 % x $0.90/lb Al =

$ 637,200/yr.

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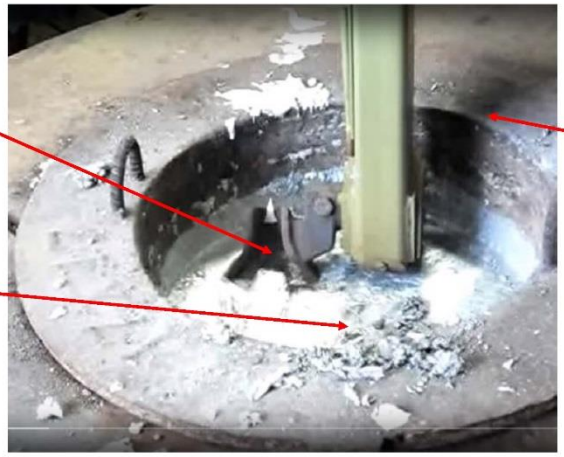
DOSING PROCESS CONTROL:

Status quo in 80% of North American Die Cast Facilities



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WESTOMAT® - World Class Dosing Units.

The WESTOMAT® has virtually become a synonym for dosing furnaces. After all, it guarantees the highest precision and is more economical than automatic ladling systems with dipping furnaces by two thirds of energy consumption. Suitable for dosing from high pressure to sand casting.

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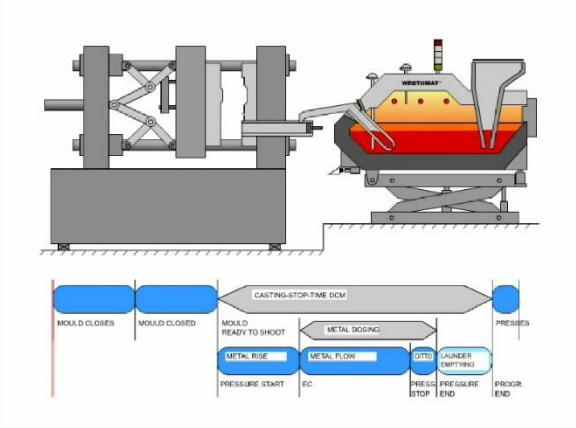
DOSING PROCESS CONTROL:

Westomat® for HPDC, Gravity and Sand Casting



- Lowest energy consumption: 1/3 electricity of conventional ladle system
- High dosing accuracy, up to +/-1%
- Best metal quality; least disruption of metal in dosing process; porous plugs available
- High productivity; uptimes to 98%
- Long life time

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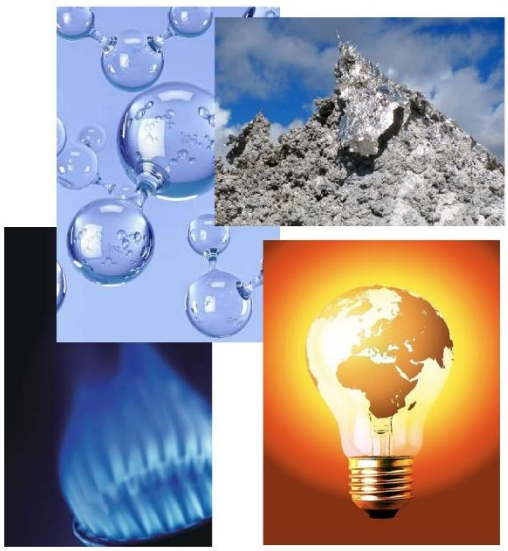
DOSING PROCESS CONTROL:

Energy, Melt Loss, Melt Quality, Repeatibility

- Energy consumption
- Metal yield
- System availability



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STRIKOWESTOFEN:
Forming Long-Term Partnerships

- Customer base
  - leading manufacturers
  - leading foundries
  - around the globe

- General Motors
- Tesla
- Magna
- Pace Industries
- Gibbs Die Casting

- Partnerships over decades
  - 14% > 20 years
  - 58% 5 – 19 years
  - 18% 1 - 4 years

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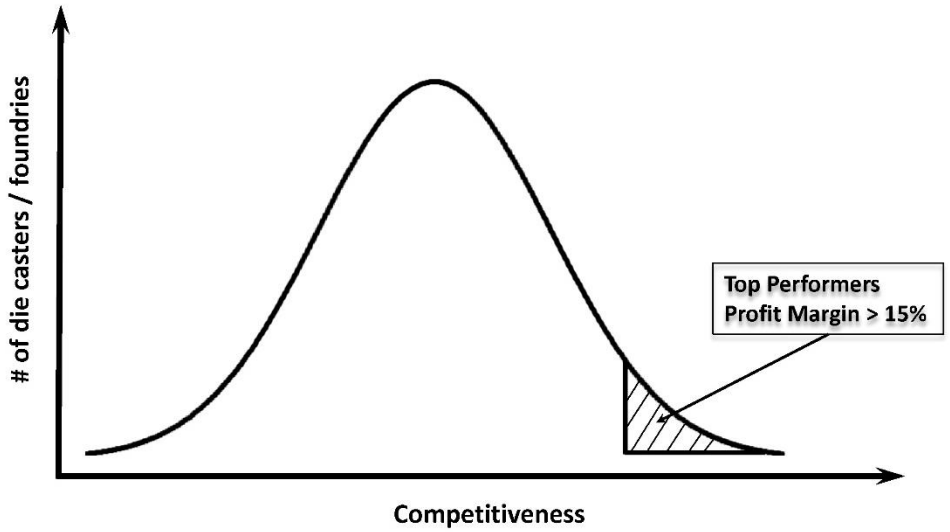
INDUSTRY BELL CURVE



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2015 Die Casting Competition Winners

- 5 awards presented for HPDC aluminum castings
  - 1 x < 1 lb Castings
  - 2 x 1 -10 lbs. Castings
  - 1 x > 10 lb. Castings
  - 1 x Structural Die Casting

✓ All 5 using StrikoWestofen melting and/or dosing equipment!

StrikoWestofen America

References

MAGNA, GM, SHILOH, nemak, PACE INDUSTRIES, Gibbs DIE CASTING, SUZUKI, TESLA, SUPERIOR, brembo, +GF+, BOCAR GROUP

Striko Westofen America

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TITLE

Chassis & Suspension Weight Reduction By LPDC Aluminum With Hollow Cross Sections

ABSTRACT

Lightweight construction is a dominant theme in the automotive industry. The latest emission standards and CO2 fleet requirements of governments are forcing our customers to find new ways to reduce the weight of the vehicle. This ranges from lighter, yet more stable crankcases via weight-optimized chassis parts.

Mr. Kevin CROY
NAFTA Sales Manager Foundry Machines & Trimming Presses

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TITLE

Chassis & Suspension Weight Reduction By LPDC Aluminum With Hollow Cross Sections

ABSTRACT

Lightweight construction is a dominant theme in the automotive industry. The latest emission standards and CO2 fleet requirements of governments are forcing our customers to find new ways to reduce the weight of the vehicle. This ranges from lighter, yet more stable crankcases via weight-optimized chassis parts.

Today new developments in the field of sand core production, casting machines and process technology allow structual parts and crankcases to be produced with the low-pressure casting.

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Chassis & Suspension Weight Reduction By LPDC Aluminum With Hollow Cross Sections

Agenda

1. **Short introduction – Who is Kurtz?**
2. **General Topics and motivation to use LPDC**
   - Motivation
   - Casting process – Low Pressure Casting
   - Cost pressure
   - Process as a whole
3. **Layouts Casting Lines from experience**
4. **Application regarding light weight construction**
   - Properties cast parts
   - Productivity
   - Sand core technology
     - Type of sand cores
     - Core handling
5. **Summary and prospects**

1. Who is KurtzErsa?

Business Segments

Electronics Production Equipment

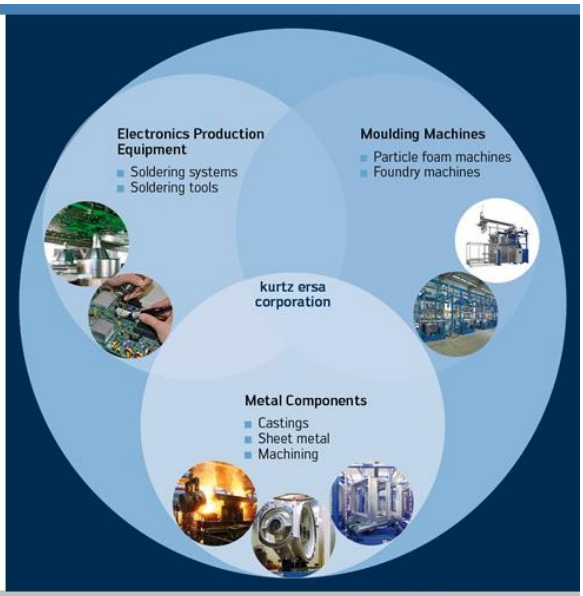
- Soldering systems
- Soldering tools

Metal Components

- Castings
- Sheet metal
- Machining

Molding Machines

- Particle foam machines
- Foundry machines



Corporate history

1779	Forge hammer mill
1852	Iron foundry
1860	Machine factory
1971	Particle foam machines
1982	Aluminum foundry
1983	Casting machines
1984	Internationalization: USA
1987	Internationalization: China
1993	Soldering technology
1996	Sheet metal technology
1998	Kurtz Holding
2004	225th anniversary of kurtz ersa Machinery factory Kurtz Zhuhai, China
2006	Internationalization: Russia
2007	Stencil printers
2009	Trimming presses
2011	New corporate identity
2012	New powder coating plant
2013	New assembly shop
2014	Anniversary 235 years Kurtz Ersa|Hammer Museum
2015	Opening SMART FOUNDRY

Where it all began: Forge hammer mill in Hasloch

kurtz ersa headquarters in Kreuzwertheim today

KURTZ Trimming Presses

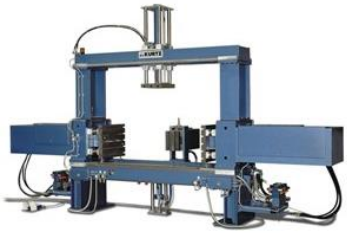
KPS 3000 SKT

KPS 1000

KPS 500

KPC 520

KURTZ Tilting and Gravity Casting Machines



AK10

AK01

Gravity Casting Cell

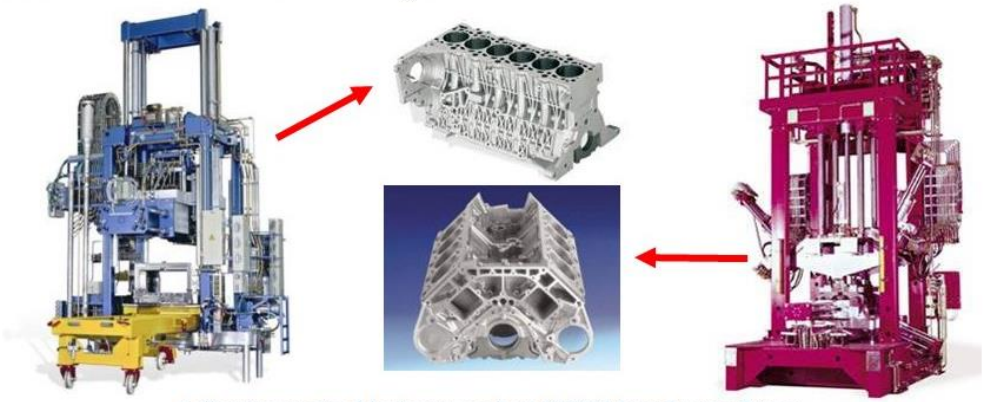
KURTZ Low Pressure Casting Machines

AL 10-7 SC

AL 14-10 SR

AL 13-13 FSC with furnace shuttle

KURTZ Customized LP-Casting Machines



Following engine blocks are cast on KURTZ foundry machines:
BMW F1 – Racing, BMW V8, V10 and V12, Porsche V8 - Sports utility vehicle; Audi V6 and V8, BMW R6 Diesel, VW R5 and V10 Diesel, Jaguar V8, Land Rover V8

2. General Topics and motivation to use LPDC for Chassis and Suspension part casting

- Motivation
- Casting Process – Low Pressure
- Cost pressure
- Process as a whole

Motivation of our customers

Why **Lightweight**

- CO2 reduction
- Reduced fuel consumption
- Material substitution
- Component substitution
- Material Handling

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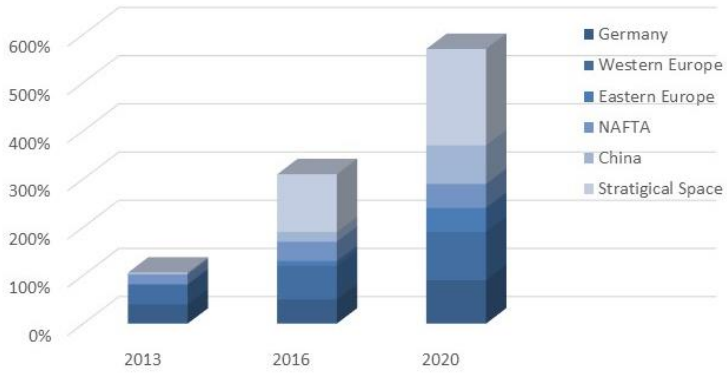
Motivation of our customers

Development Purchasing Volume Chassis and Suspension LM-Castings



- Growth of market volume in Europe through use of more LM castings in chassis and suspension parts
- NAFTA grows with new automobile architectures
- China grows over proportional due to additional quantities

Graphs are courtesy of BMW

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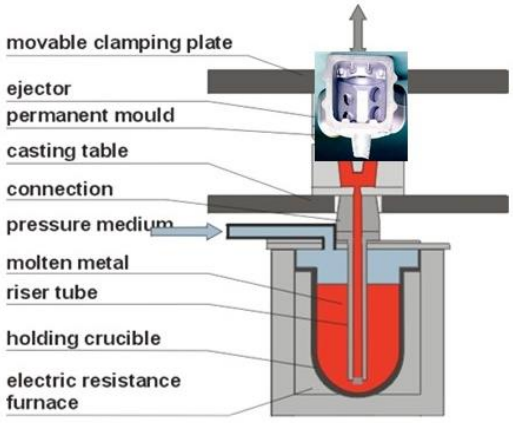
Requirements of machine- and process development

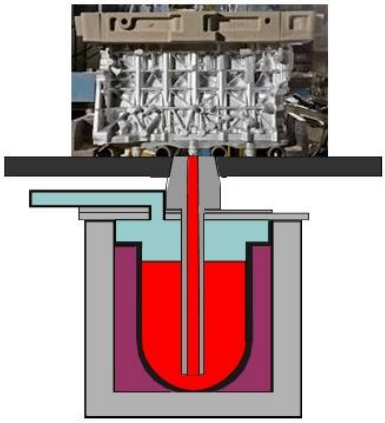
- Developing of inorganic core binder systems
- Developing of a special casting process with the use of low pressure machines
- Developing highly efficient LPDC machines and casting lines
- Special casting line concepts for highest Al material cleanliness

Basic Concept of Low Pressure Die Casting

Low pressure for metal dies



Low pressure for sand packages



Advantages and Benefits of Low Pressure

- **Controllable filling of the mold**
  filling against gravity force → no turbulence
  → less oxide films
  → better mechanical properties
- **Feeding Pressure** → better mechanical properties
  → 1bar feeding ≙ 6m height (Mg)
  → 1bar feeding ≙ 4m height (Al)
- **Metal is kept within a closed vessel**
  metal bath surface not disturbed or ruptured → cleaner material
- **Operation under a protected atmosphere** → no respectively low hydrogen content
- **Controlled solidification with pressurized furnace**
  higher yield than with conventional risers → higher yield
- **Highly automated process** → less human faults

Comparison Gravity Die Casting – Low Pressure Die Casting

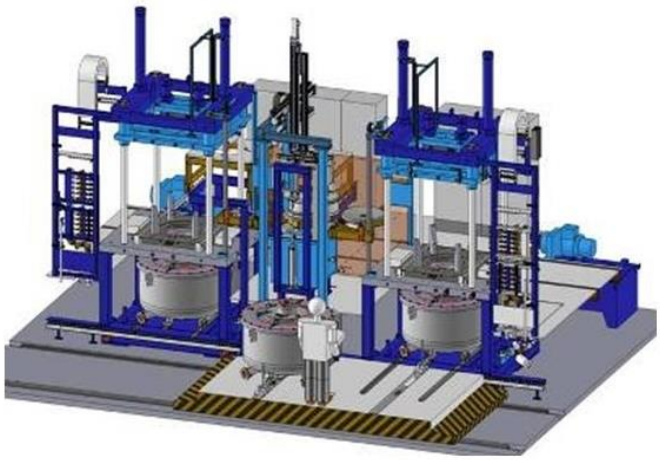
Example of yield:
Comparison of gravity die casting and low pressure die casting

21,3 kg	Casting weight	12,2 kg
54%	Output	92%
7 pcs/h	Productivity	8 pcs/h

Example

- 50,000 parts / year
- 9 kg / part saving cycle
  = 450,000 kg aluminum
- 7% melting loss = 31,500 kg
- Total weight 481,500 kg
- Melting costs per
  kg Ø 0.50 € x 481,500 kg
  = 240,750.00 €

New Machine concepts



Furnace exchange shuttles – 2800 kg Al

Furnace Concept - Metallurgy

Furnace exchange with following advantages:

- Preparation of melt outside of casting unit
- Furnace under sealed conditions
  settlement of melt
- No metal transfer after degassing
- Exchange of furnace within short time intervals
  1 – 2 cycle down; "start" furnace exchange within
  non-productive time positive for thermal economy of tooling
  therefore no or only few starting scrap due to furnace exchange
- Flexibility and different alloys

Furnace insulation / Energy costs

Cost reduction thanks to furnace insulation

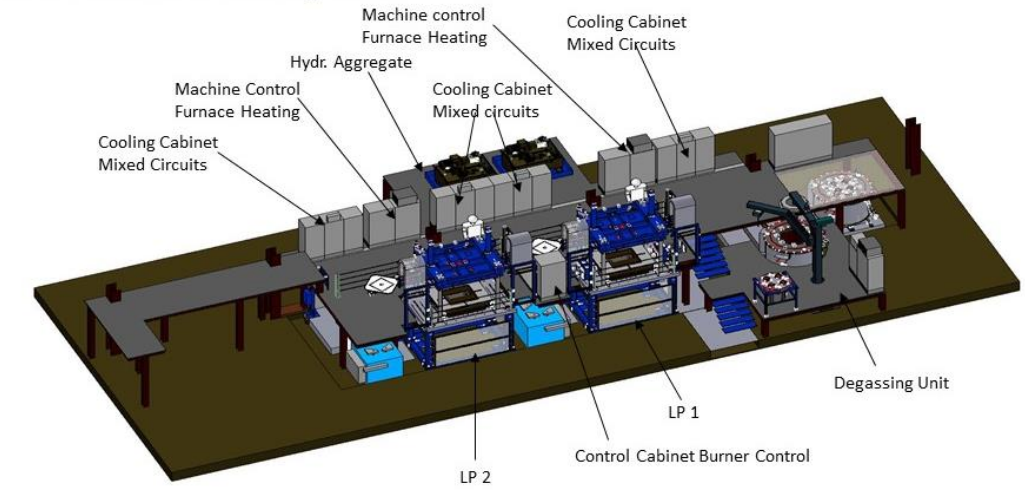
- reduction of energy costs by 40 - 50 %
- Savings per year: approx. 50.000,- €
  - 300 kg furnace
  - 6 x 2 furnaces in line

Special mold cooling system – for optimized process control

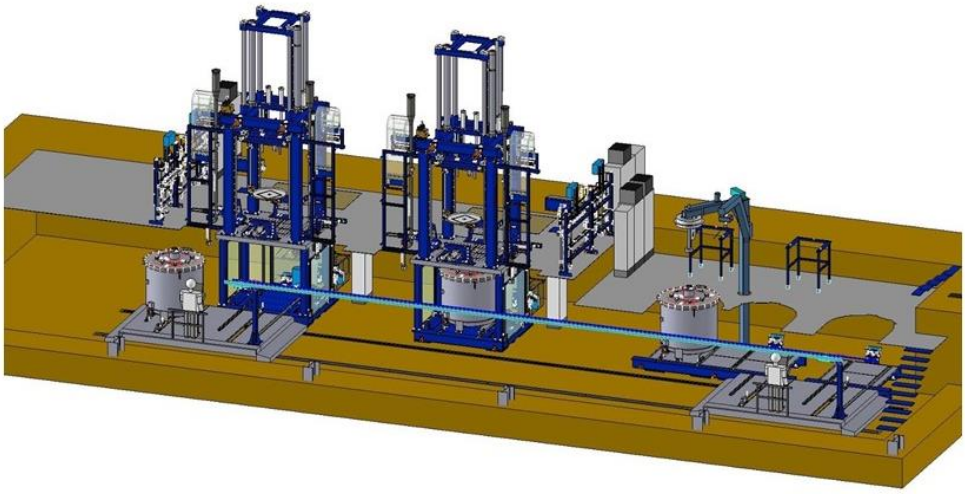
Tool change system – for very quick mold change overs

3. Layouts Casting Lines from experience

Low Pressure Casting Line



Low Pressure Casting Line



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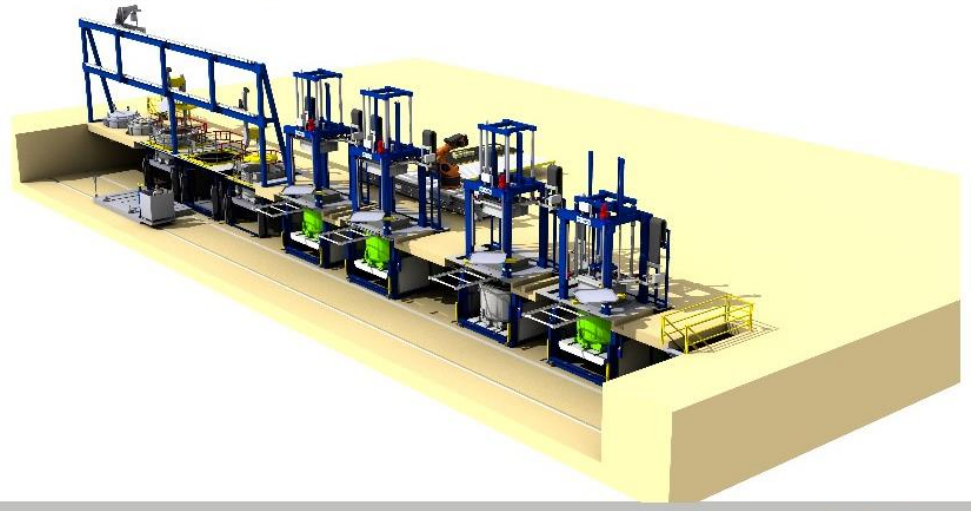
Low Pressure Casting Line



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Low Pressure Casting Line

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Automation

Automation Tasks

- Core handling
- Insert sieves
- Casting removal
- Cleaning mould
- Cooling
- Marking with plausibility check
- Peripherals
- Unloading

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4. Application regarding light weight construction

- Properties cast parts
- Productivity
- Core technology
  - Type of cores
  - Core handling

Structure Part Side Beam for Al-Car Body

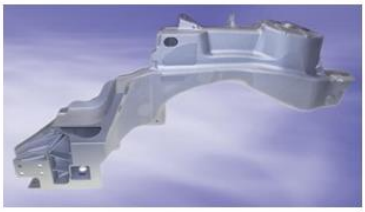
Product:
Side beam,
complex cast with cores
LP-Die-Casting
AlSi7Mg0,2 T6
Wall thickness ≥ 3,5 mm

Mechanical Properties
(critical areas):

$R_{p0,2}$	≥ 160 N/mm²
R_m	≥ 240 N/mm²
A_5	≥ 12 %

Main Characteristics:
- Large dimensions
  - 1200 mm
- Thin walls
  - Actual 4 mm
  - Aim ≥ 2,5 mm
- High ductility
- High yield strength

1200 x 800 / 20kg



***Source**: Martinrea Honsel Germany GmbH*

Low Pressure WITHOUT Sand Core

Product: B8 knuckle front le/ri
Model: Audi A4, A5

Process: Low pressure die casting, 4 cavities
Scope: Casting, boring, blasting, heat treatment
Alloy: AlSi7Mg; 3,65 kg

Source: **Georg Fischer Kokillenguss GmbH, Herzogenburg, Austria**

+GF+

Low Pressure WITH Sand Core / Suspension Part

Product: knuckle le/ri
Model: Porsche Panamera

Process: Low pressure die casting, 4 cavities
Scope: Core making, casting, de-coring, trimming, sawing, heat treatment, processing
Alloy: AlSi7Mg; 4,35 kg

Source: **Georg Fischer Kokillenguss GmbH, Herzogenburg, Austria**

+GF+

Mechanical Properties Knuckle

Knuckle Porsche Panamera - Sandcore		Knuckle Audi B8 – no cores	
Yield Strength			
Target: 220 MPa	Actual: 222-260 MPa	Target: 220 Mpa	Actual: 239-286 MPa
Tensile Strength			
Target: 260 Mpa	Actual: 288-336 MPa	Target: 280 MPa	Actual: 305-343 MPa
Elongation			
Target: 6 %	Actual: 6-12 %	Target: 5 %	Actual: 5-14 %

Source: **Georg Fischer Kokillenguss GmbH, Herzogenburg, Austria**

+GF+

Low Pressure WITH Sand Core / Suspension Part

Product: Transverse control arm le/ri
Model: Porsche Panamera

Process: Low pressure die casting, 2 cavities
Scope: Core production, casting, de-coring, trimming, sawing, heat treatment, processing, assembly rubber bearings
Alloy: AlSi7Mg; 3,70 kg

Source: **Georg Fischer Kokillenguss GmbH, Herzogenburg, Austria**

+GF+

Low Pressure WITH Sand Core / Suspension Part

Product:	Swivel bearing le / ri
Model:	Porsche Panamera
Process:	Low pressure die casting, 4 cavities
Scope:	Core production, casting, de-coring, trimming, sawing, heat treatment, processing, assembly cone bushings
Alloy:	AlSi7Mg; 4,20 kg

Source: **Georg Fischer Kokillenguss GmbH, Herzogenburg, Austria**

+GF+

Mechanical Properties Swivel Bearing

Swivel bearing Porsche Panamera		Swivel bearing Porsche Panamera	
Yield Strength			
Target: 220 MPa	Actual: 221-268 MPa	Target: 220 MPa	Actual: 228-265 MPa
Tensile Strength			
Target: 260 MPa	Actual: 292-346 MPa	Target: 260 MPa	Actual: 293-344 MPa
Elongation			
Target: 6 %	Actual: 6-12 %	Target: 6 %	Actual: 6-12 %

Source: **Georg Fischer Kokillenguss GmbH, Herzogenburg, Austria**

+GF+

Low Pressure / Suspension Part

Product:	Cross beam
Model:	Porsche Panamera
Process:	Low pressure die casting, 2 cavities
Scope:	Casting, trimming, sawing, heat treatment, processing
Alloy:	AlSi7Mg; 6,1 kg

***Source*: Georg Fischer Kokillenguss GmbH, Herzogenburg, Austria**

+GF+

5. Summary and Prospects

Summary

- **Light weight construction / Core casting**
  - One cast part replaces several sheet metal parts which have to be joined together
  - Weight reduction
  - Profitably
- **Part geometry**
  - Dimensions of known suspension parts up to structural parts
  - Larger and more complex
  - Core technology– anorganic cores
- **Plant designs**
  - Casting machines and furnaces become larger
  - Multiple cavity 4- up to 8-cavities
  - Riser tube/ gating concepts more complex
  - More cooling and controlled
  - Melting/ furnace logistics

Reasons for low pressure casting

- **Casting requirements**
  - Mechanical properties
  - Elongation
- **Economical**
  - Cycle material
    - ➢ Profit by reduced energy costs – melting down
    - ➢ Profit by „Return cycle material – Recycling"
  - Cycle time – multiple cavities
- **All round part concept**
  - Easier way from cast part up to finished part
  - Less post-processing
- **Plant concepts / Investments**
  - The bottom line is economical!
  - Will stand every competition!

Prospects

- Light weight construction / core casting as promising casting
- Tailored universal machines in large format
  - Is our standard
  - Cycle time – multiple cavity
- Low pressure as intelligent concept
  - Classic low pressure casting
  - Low pressure casting combined with gravity casting
  - Cycle time by multiple cavity unbeatable
  - MORE than competitive, low pressure compared to high pressure die casting

Thank you very much for your attention!

Bharat Forge Aluminiumtechnik

Mr. Jörg MANTWILL
Director Sales

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TITLE

HCM And Aluminum Forging – Partnership To Birth Chassis Parts' Safety

ABSTRACT

Car manufacturers are looking for ways to constantly improve their environmental impact and trying to reduce their carbon footprint. Aluminum is more and more becoming their favorite material due to its significant lighter weight and following advantages for fuel efficiency.

Beside the car body parts, the development activities are focused on powertrain and chassis parts. Bharat Forge Aluminiumtechnik (BFAT), manufacturer of control arms and knuckles, is able to realize significant weight reductions by combining aluminum with function optimized design layout and forging technology. Furthermore, the company has closed its loop of material recycling and the product's global footprint is reduced by 40% - an ideal constellation to master the current challenges.

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HCM and Aluminum forging partnership to birth chassis parts' safety

Automotive Lightweight Procurement
Symposium 2015
9th - 11th of Nov 2015 in Detroit

Paper 4
Mr. Joerg Mantwill - Director Sales
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BHARAT FORGE ALUMINIUMTECHNIK | KALYANI

CONTENT | COMPANY | TECHNOLOGY | PROSPECTS

COMPANY

- Key facts Bharat Forge
- Business unit Bharat Forge Aluminiumtechnik GmbH

TECHNOLOGY

- Product focus
- Al Casting vs. Alumimium Forging
- HCM – Base for chassis parts` safety

PROSPECTS

- BFAT – Al chassis specialist worldwide
- BFAT – Full service partner for OEM
- BFAT – Synonym for material and design improvement

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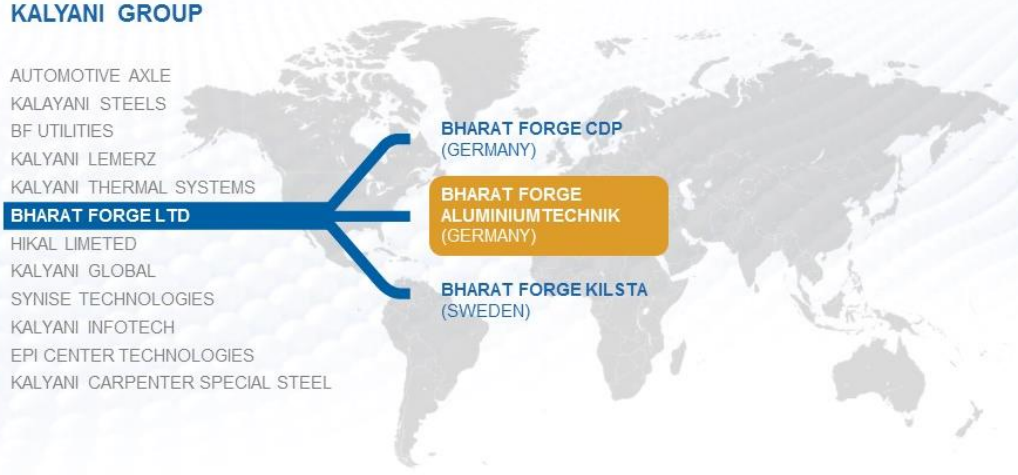
KALYANI GROUP

AUTOMOTIVE AXLE
KALAYANI STEELS
BF UTILITIES
KALYANI LEMERZ
KALYANI THERMAL SYSTEMS
BHARAT FORGE LTD
HIKAL LIMETED
KALYANI GLOBAL
SYNISE TECHNOLOGIES
KALYANI INFOTECH
EPI CENTER TECHNOLOGIES
KALYANI CARPENTER SPECIAL STEEL



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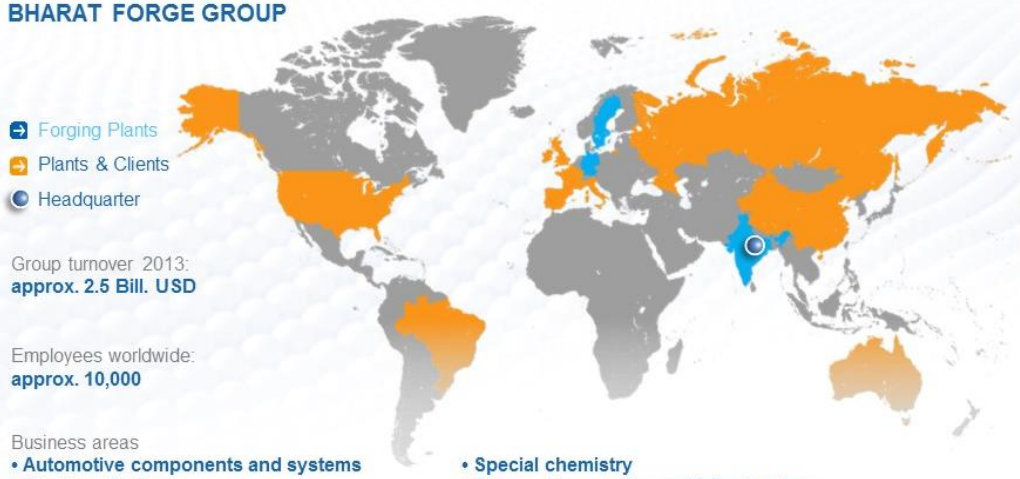
CONTENT | COMPANY | TECHNOLOGY | PROSPECTS

BHARAT FORGE GROUP



- Forging Plants
- Plants & Clients
- Headquarter

Group turnover 2013:
approx. 2.5 Bill. USD

Employees worldwide:
approx. 10,000

Business areas
- **Automotive components and systems**
- **Steel production**
- **Special chemistry**
- **Renewable energies and infrastructure**

BHARAT FORGE ALUMINIUMTECHNIK | KALYANI

CONTENT | COMPANY | TECHNOLOGY | PROSPECTS

GLOBAL LOCATIONS FOR LOCAL CONTENT SUPPLIES

(MULTI NATIONAL EXPERIENCE)

1. **BHARAT FORGE LTD.** (PUNE, INDIA)
2. **BHARAT FORGE ALUMINIUMTECHNIK** (BRAND-ERBISDORF, GERMANY)
3. **BHARAT FORGE CDP** (ENNEPETAL, GERMANY)
4. **BHARAT FORGE KILSTA** (KARLSKOGA, SWEDEN)
5. **BHARAT FORGE AMERICA** (DETROIT, USA)
6. **BHARAT FORGE ALUMINIUMTECHNIK US** FUTURE ALUMINIUM FORGING PLANT

Bharat Forge Aluminiumtechnik

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CONTENT | COMPANY | TECHNOLOGY | PROSPECTS

BHARAT FORGE IS SPECIALIZED IN

Al forged chassis parts based on HCM primary material

HCM – Horizontal Casting Material

BHARAT FORGE ALUMINIUMTECHNIK | KALYANI

CONTENT | COMPANY | TECHNOLOGY | PROSPECTS

BHARAT FORGE ALUMINIUMTECHNIK (BFAT) - GERMANY

- Turnover: 44 Mio. EUR (2014)
- Material consumption: 12,000 t (Aluminium)
- Employees: 280
- Key products: control arms, knuckles
- Forging capacity: 3,5 Mio parts p.a.
- Parts weight: 2 - 7kg

Bharat Forge Aluminiumtechnik

BHARAT FORGE ALUMINIUMTECHNIK | KALYANI

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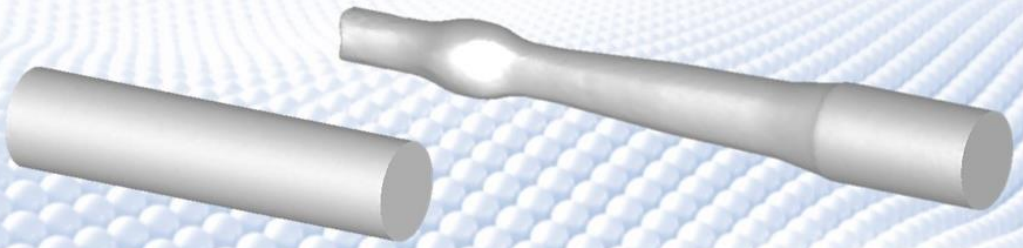
BHARAT FORGE ALUMINIUMTECHNIK | KALYANI

CONTENT | COMPANY | TECHNOLOGY | PROSPECTS

ROLLING



Rolling (fully automated)

- Chamfering of material bars
- Heating in continuous furnace
- Rolling in 4 passes
- Transfer to main press

BHARAT FORGE ALUMINIUMTECHNIK | KALYANI

CONTENT COMPANY TECHNOLOGY PROSPECTS

ROLLING

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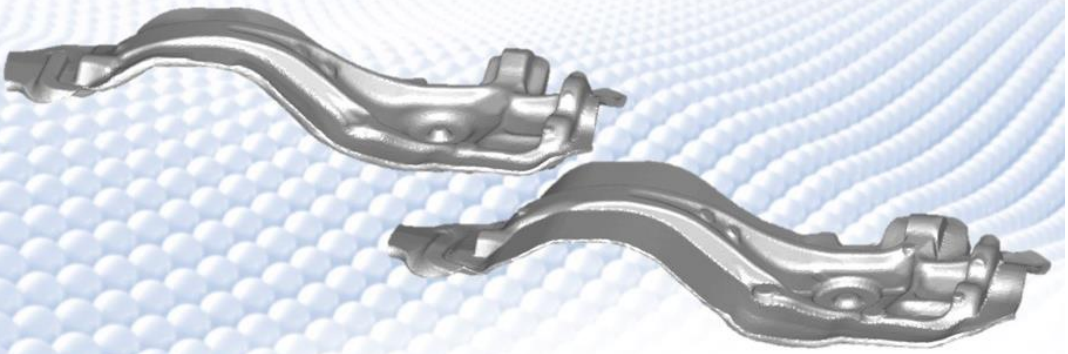
CONTENT COMPANY TECHNOLOGY PROSPECTS

FORGING



- Forging process contains pre-forming and finish forging
- Repeatable, fully-automatic chained process
- Hot trimming

Bharat Forge Aluminiumtechnik

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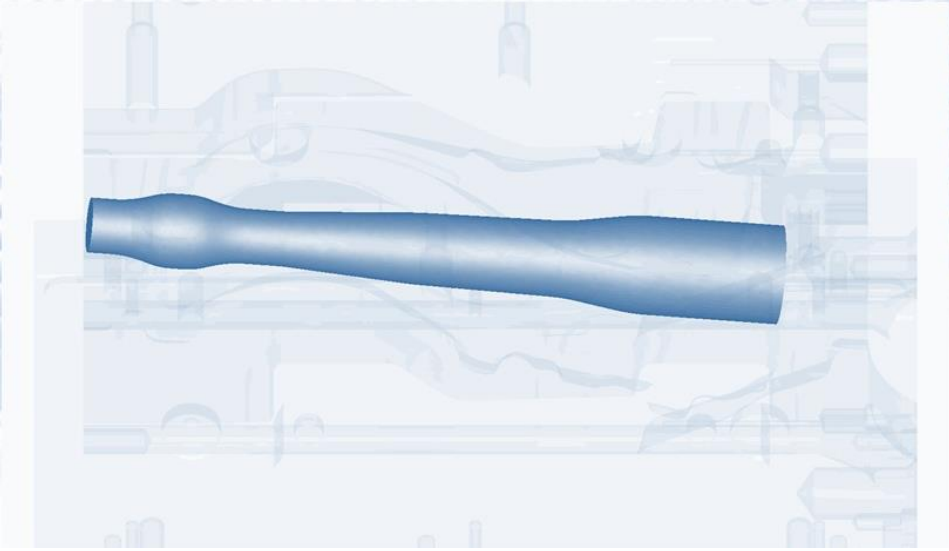
CONTENT COMPANY TECHNOLOGY PROSPECTS

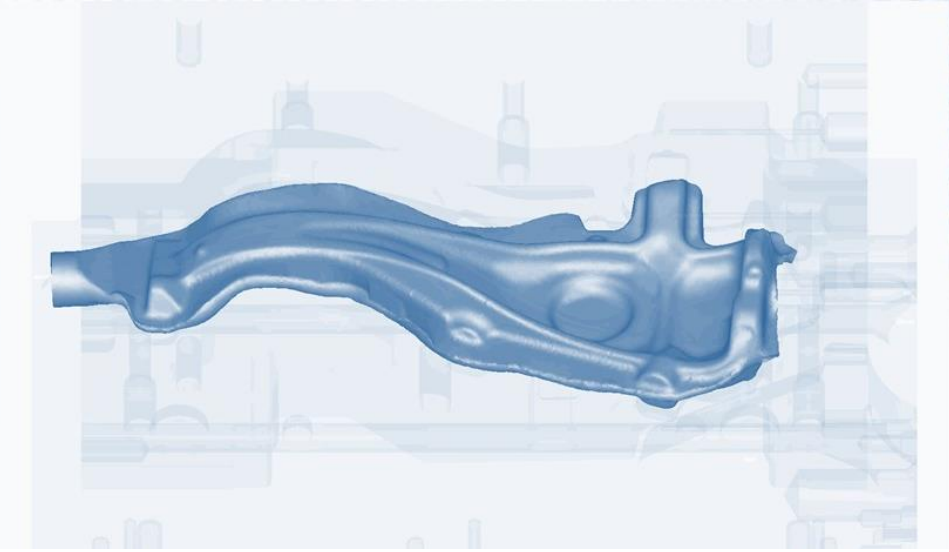
FORGING (PRE FORGING)



BHARAT FORGE ALUMINIUMTECHNIK

CONTENT COMPANY TECHNOLOGY PROSPECTS

FORGING (FINISH FORGING)



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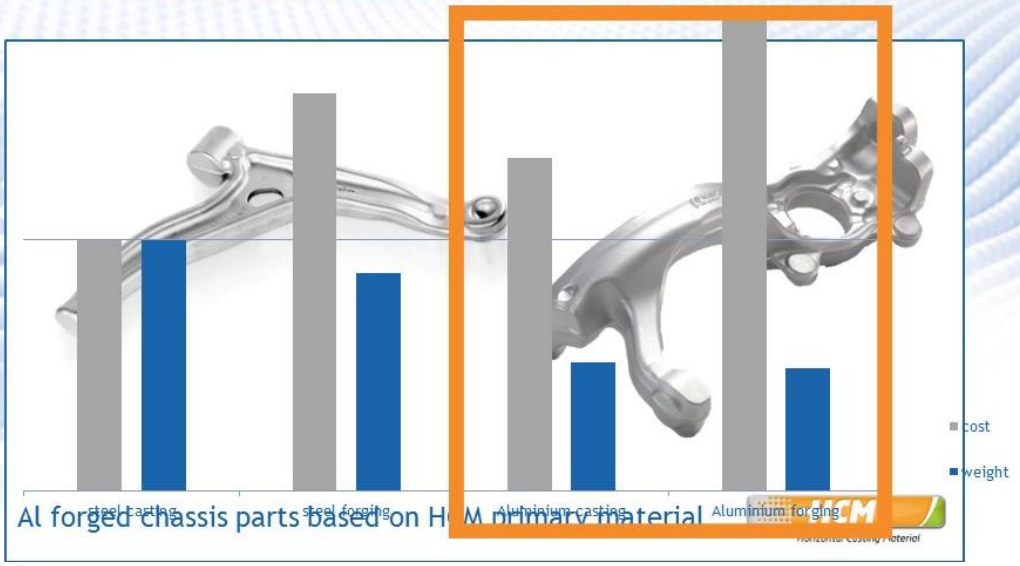
CONTENT COMPANY TECHNOLOGY PROSPECTS

STEEL TECHNOLOGIES VS. ALUMINIUM TECHNOLOGIES

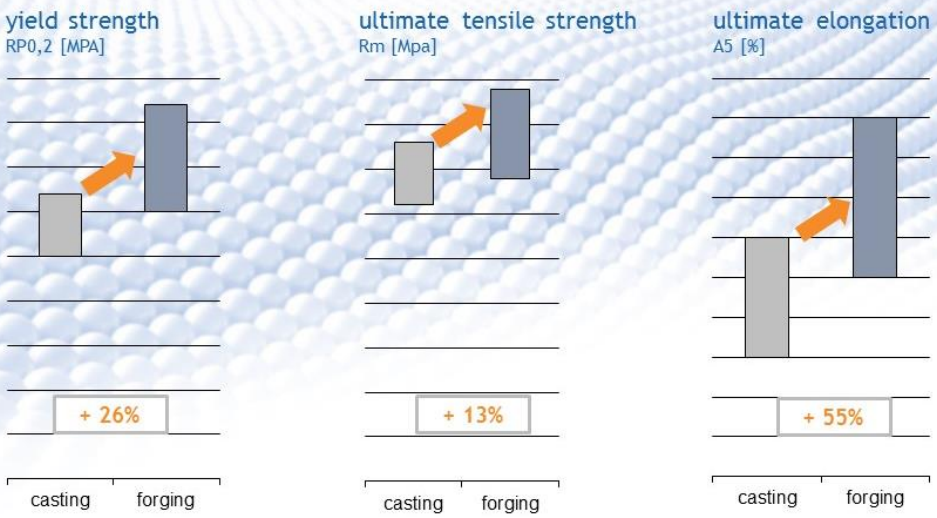


Al forged chassis parts based on HCM primary material

BHARAT FORGE ALUMINIUMTECHNIK

CONTENT COMPANY TECHNOLOGY PROSPECTS

ALUMINIUM CASTING VS. FORGING - CARACTERISTICS



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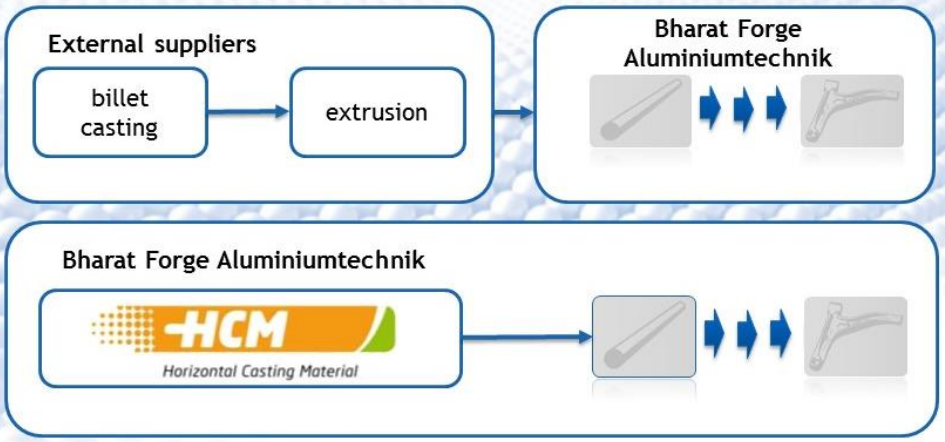
COMPARISON EXTRUSION VS. HCM AS PRIMARY PROCESS FOR FORGING



- Independence from external extrusion suppliers
- Closed material loop - more economical - environmentally friendly

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CONTENT COMPANY TECHNOLOGY PROSPECTS

OUR INNOVATION – HCM (HORIZONTAL CASTING MATERIAL)

already used for: Volkswagen Group, Maserati, GM, Daimler

HCM Horizontal Casting Material

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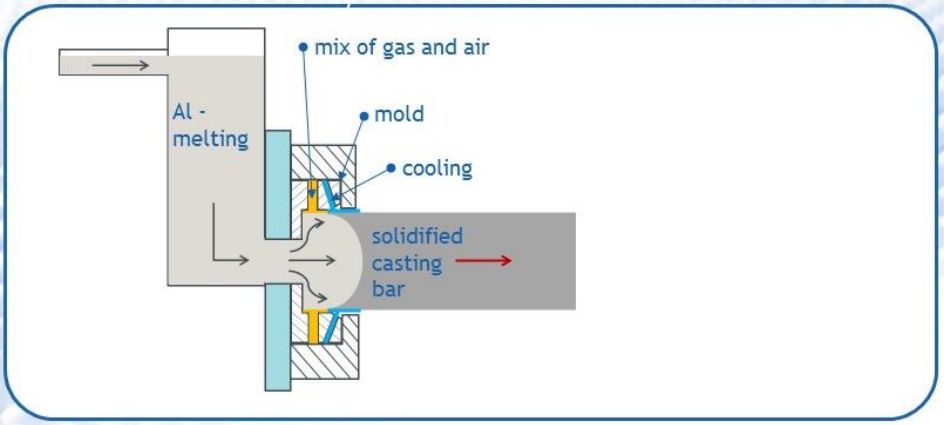
CONTENT COMPANY TECHNOLOGY PROSPECTS

TECHNICAL BACKGROUND OF HCM



- Continuous casting process - very efficient
- Very smooth surface - no additional peeling effort

HCM Horizontal Casting Material

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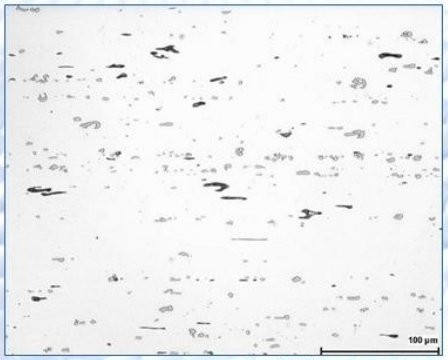
CONTENT COMPANY TECHNOLOGY PROSPECTS

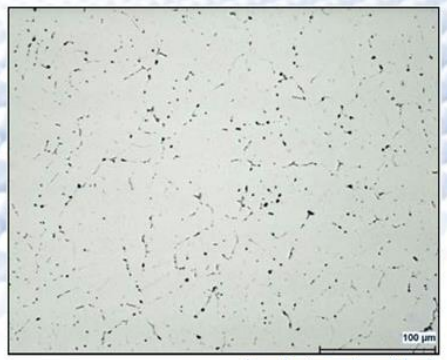
PRECIPITATION IN EXTRUDED AND HCM - PRIMARY MATERIAL

Extruded material

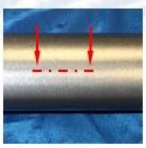


lengthwise cut; polished

HCM material



lengthwise cut; polished



lengthwise cut

- Precipitation equally distributed
- Not directionally

HCM Horizontal Casting Material

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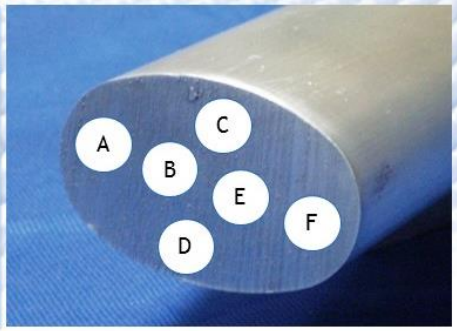
CONTENT COMPANY TECHNOLOGY PROSPECTS

MECHANICAL CHARACTERISTICS OF HCM- MATERIAL AFTER T6 PROCESS

sample area	direction	Rp0,2 [MPa]	Rm [MPa]	A5 [%]
A	lenght	331,1	393,8	15,2
B		339,9	393,5	14,6
C		328,3	391,9	13,6
D		331,1	393,7	15,6
E		339,8	393,1	14,2
F		332,3	395,3	16,5
A - F	crosswise	328,7	390,7	13,8

tensile according to DIN EN ISO 6892-1
sample form acording to DIN 50125 – B5x25



Sample position in the HCM material

- High mechanical characteristics already in heat-treated cast state
- No directional dependence

HCM Horizontal Casting Material

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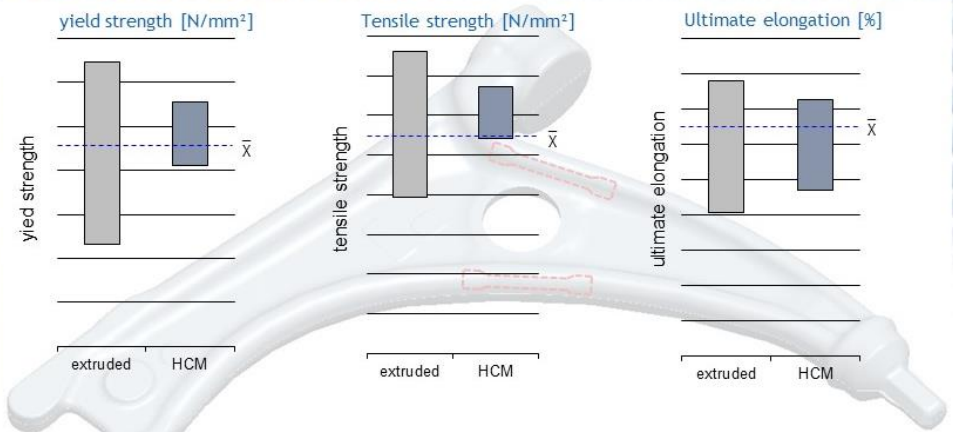
MECHANICAL CHARACTERISTICS - FORGED CONTROL ARM LINKED TO RAW MATERIAL PROCESS



analysis of longterm series production (appr. 2.000 parts)
Comparison of forged parts based on extruded and HCM - raw material

HCM Horizontal Casting Material

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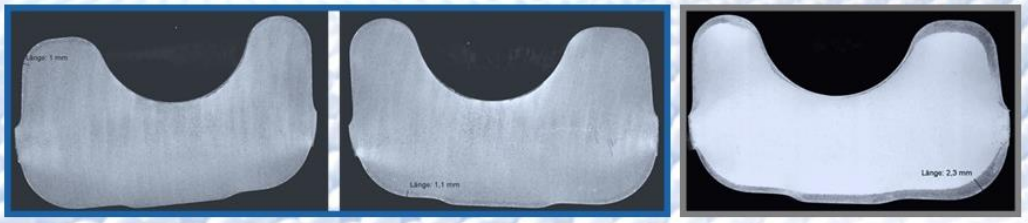
CONTENT COMPANY TECHNOLOGY PROSPECTS

STRUCTURE ANALYSIS AT FORGED PART

Forged profil based on HCM primary material

Forged profil (extruded primary mat.)



HCM - effects a very small marginalized layer of recrystallisation (appr. 1mm)

- Safety buffer for long life fatigue strength
- Perfect material characteristics to enable assembling of bearings (rolling)

HCM Horizontal Casting Material

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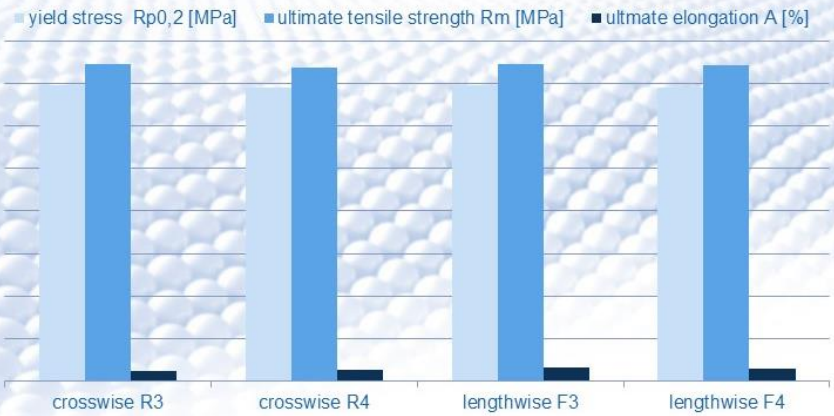
CONTENT COMPANY TECHNOLOGY PROSPECTS

MATERIAL CHARACTERISTICS – LINKED TO SAMPLE POSITION



- Using HCM - there are no important effects for the material characteristics linked to the sample position
- very safe designing process fulfilling the request of function

HCM Horizontal Casting Material

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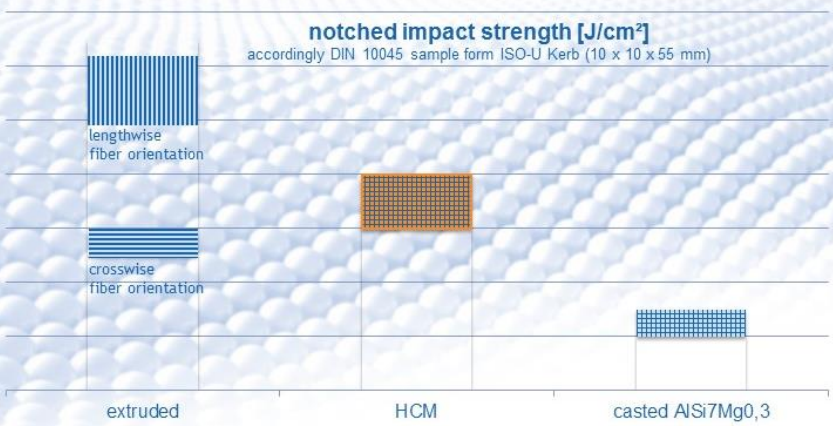
MATERIAL CHARACTERISTICS – OVERLODING EFFECT LINKED TO FIBER ORIENTATION



- HCM enables independent from fiber orientation a uniform performance on a respectable level in case of overloading

HCM Horizontal Casting Material

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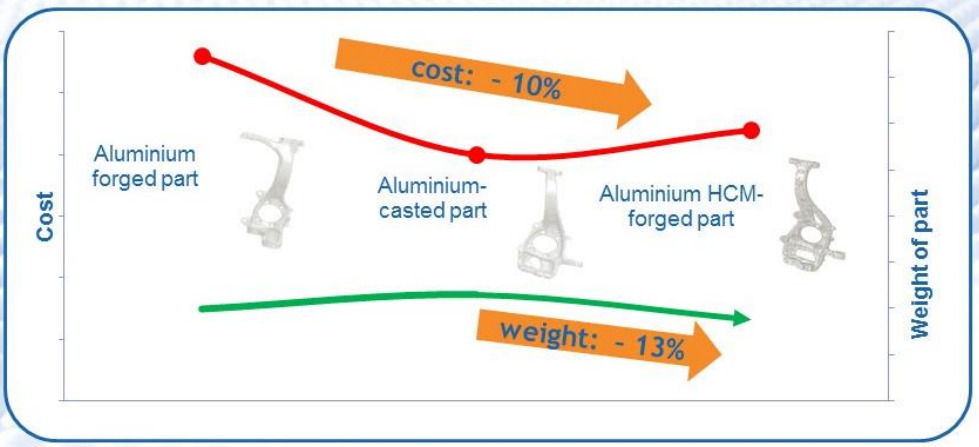
WEIGHT AND COMMERCIAL EFFECT OF HCM AND FORGING



- HCM - forged chassis part will not replace all the other solutions but will add a well performing and cost efficient solution to solve our challenges

HCM Horizontal Casting Material

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BHARAT FORGE – FULL SERVICE FOR LIGHT WEIGHT CHASSIS

Costumers' needs

- COx reduction
- NOx reduction
- Driving pleasure
- Safety
- Economical cars

→

... lead to

OEM needs regarding chassis

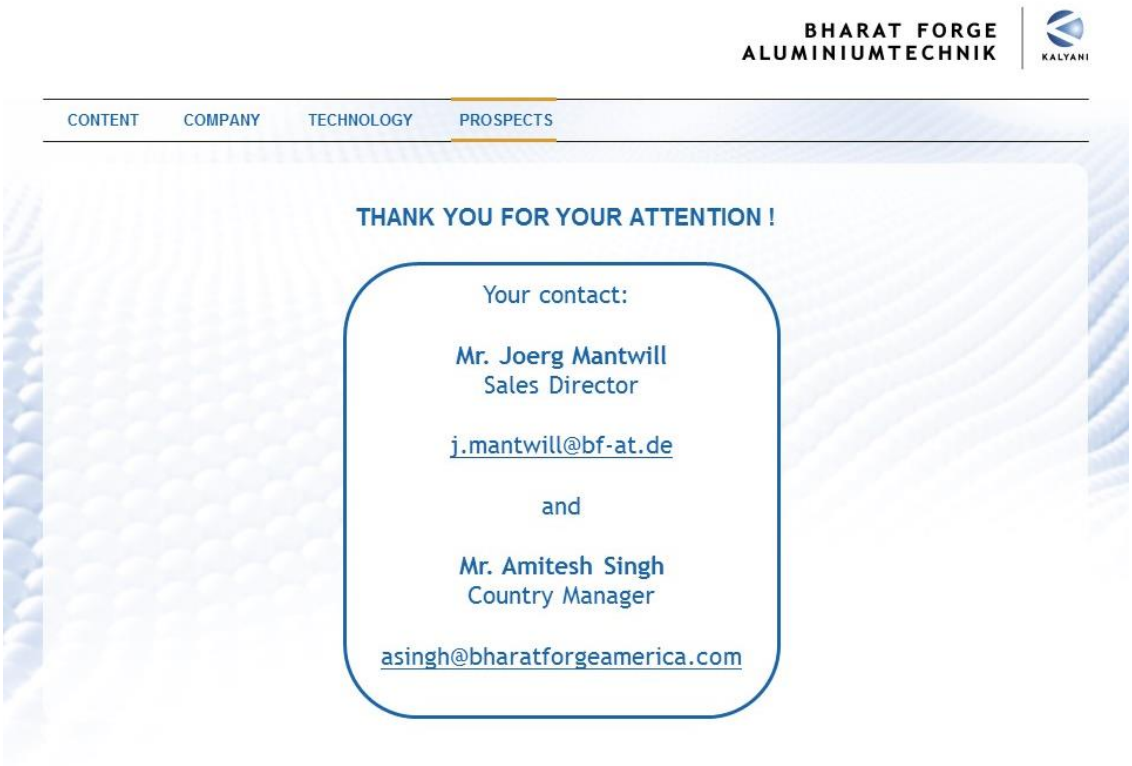
- Weight reduction
- Premium performance
- Safety reserve
- Reliable parts
- Competitive suppliers

→

... are challenging us as

Your partner with

- Light weight design
- Optimized material properties
- Reliable production processes
- Efficient production technology


BHARAT FORGE
ALUMINIUMTECHNIK
KALYANI
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TECHNOLOGY
PROSPECTS
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Mr. GARY F. RUFF
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TITLE

Advanced Counter Pressure Casting Process for Light-Weighting of Auto and Truck Chassis and Suspension Components

ABSTRACT

1. Background of “Light-Weighting” Automotive and Truck Components
2. Advanced Counter Pressure Casting

Advanced Counter Pressure Casting for Light-Weighting of Auto and Truck Chassis and Suspension Components

North American Automotive Lightweight Procurement Symposium
Detroit, Michigan
November, 2015

Gary F. Ruff
Ruff & Associates, LLC

Why Light-Weighting?

- Variability in Fuel Prices
- Additional Safety Feature Requirements
- Increased Operating Performance
- Need to Support Alternate Propulsion Systems (hybrid, electric, fuel cell, etc.)
- Latent Desire for “Muscle” cars and “Retro” styles
- Ongoing CAFE Regulations for Improved Fuel Economy

Evolution of Light-Weighting

- Vehicle Size and Associated Weight Reduction
- Part Size and Wall Thickness Reduction
- Direct Conversion of Components to Lighter Weight Materials
  - Initial Focus was Powertrain and Drivetrain Components, Along with Wheels
- Use of Existing Processes with Lightweight Materials

…mostly "low-hanging fruit"

Need for Ongoing Light-Weighting

- *Continued Increasing CAFE Targets Required More Dramatic Actions*
  - Increased Use of Computer Aiding Engineering to Optimize Designs for Weight Removal and Improved Performance
  - Initiation of Work on Higher Integrity, Safety-Critical Structural Components Involving the Chassis, Suspension, and Brake Systems, Up to this Point Almost Untouchable
  - Entirely New Materials Such as Metal Matrix Composites, Carbon Fiber Composites and others
  - Introduction of Entirely New Processes to Provide the Ability to Produce the Thinnest Sections, Unique Geometries and Utilize Advanced Materials

Production of High Integrity, Structural Castings for Chassis and Suspension Applications

High Integrity Structural Castings

- High Integrity Structural Castings, "definition":
  - Consistent & reliable, with in-process real time testing and analysis
  - Most often, high tensile and yield strength, plus high ductility
  - Good fatigue life
  - Sometimes, moderate strength, with *very* high ductility (e.g. subframes, crossmembers)
  - Good impact resistance
  - Good surface finish

High Integrity Structural Castings

Example: General Motors rigidly defines the expectations for structural aluminum castings in GMW 16704 and 16705, along with the following print requirements:

- Tensile Strength and Yield Strength obtained from specific in part locations are required to meet Weibull B_1 minimum values of 290 MPa and 220 MPa, respectively
- Elongation must be greater than 8%
- The Manufacturing Process and PPAP must be Validated using out-of-part Overstress Probe and Staircase Fatigue Tests, also to B_1 minimum values.
- Part integrity via 100% x-ray based upon FEA Analysis with areas defined as Highly Critical classified as Grade A of ASTM B 686-95, moderately stressed as Grade B and remainder Grade C. This equates to ASTM E155 exceeding Level 1, Level 1 and Level 2, respectively.
- 100% Fluorescent Liquid Particle Inspection with No Linear Defect Indications Allowed

Metallurgical Parameters That Must Be Addressed to Meet These Specifications

- The Casting MUST be:
  - Sound (No gas, inclusions or similar defects)
  - Grain refined
  - Modified
  - Solidified as Rapidly as Possible (to support grain refinement and silicon modification)

Keys to Achieving Optimum Aluminum Casting Properties

1. Prevent the formation of oxide films or folds
2. Eliminate shrinkage
3. Eliminate inclusions
4. Eliminate gas bubbles
5. Modify or refine the eutectic silicon
   -Finer SDAS
6. Refine the grain size
   -More, small dendrite trees

High Integrity Casting Processes

- Vacuum Die Casting (vs Conventional)
- Permanent Mold & SPM, Tilt, Reverse Tilt
- Low Pressure
- Squeeze
- SSM
- Vacuum Low Pressure
- ***Advanced Counter Pressure Casting***

What is Advanced Counter Pressure Casting?

Advanced Counter Pressure Casting™ (ACPC) is a *unique and advanced* adaptation of low pressure casting using the Counter Pressure process that is capable of producing *high integrity aluminum structural and safety parts*

Typical parts include:

- Steering knuckles/spindles
- Control and swing arms
- Structural brackets
- Yokes-chassis and suspension
- Subframes and crossmembers
- Others Under Investigation

Consequently, Advanced Counter Pressure Casting has evolved as the fastest growing process globally for the production of high strength and ductility, lightweight steering knuckles and control arms.

How Did "Counter Pressure Casting" Evolve?

Evolution-Counter Pressure Casting (CPC)

- Invented at the Institute of Metal Science and Technology of the Bulgarian Academy of Sciences
- Additional research and development was done at the University of Sofia in Bulgaria in the 1980's
- First commercialization was to replace die-casting
- CPC/Ilinden obtained the patents and know-how in the 1990's, improved the process and redesigned the machines
- The CPC Group initially targeted the specialty wheel market because the high integrity allowed aluminum wheels to be chrome-plated and cast in larger sizes
- Because of the high quality and low cost of CPC's process and equipment, high volume production vehicle wheels started being made using this process
- The CPC Group became the global leader in aluminum wheel production equipment

How Did Advanced Counter Pressure Casting Evolve?

Evolution-Advanced Counter Pressure Casting (ACPC)

- Conversion of many aluminum structural and safety parts, such as knuckles, began in earnest in the 1990's
- Starting with conventional low pressure, advancements were made by using squeeze casting (CMI) and vacuum/pressure riser-less casting (A-CMI), particularly for front knuckles and control arms
- Short comings and quality issues with these processes led to further development to provide a better, more risk-free process with lower costs
- The original process used by the CPC Group to make wheels was evaluated but judged to need improvements to make it capable of providing the structures and properties required for parts such as front knuckles and control arms

How Did Advanced Counter Pressure Casting Evolve?

Evolution-ACPC

- In 2000, Intermet, which was the largest supplier of iron knuckles worldwide, decided to develop with a process based on CPC to produce aluminum knuckles, but integrate in the strong points of the other processes
- The ACPC process then was developed by adding significant mold/part cooling capability, more sophisticated pressure controls, and improved metal treatment and chemistry control to counter pressure filling, the sealed chamber, and controlled, uniform fill of the CPC process
- A demonstration cell was constructed and based on the quality, properties and strict controls, many customers became interested
- The first high volume production started in September, 2001 with the GM U/W front knuckle which had annual volumes of approximately 2 million knuckles per year

First ACPC Cell (circa 2000)

PCPC Desirable Process Features

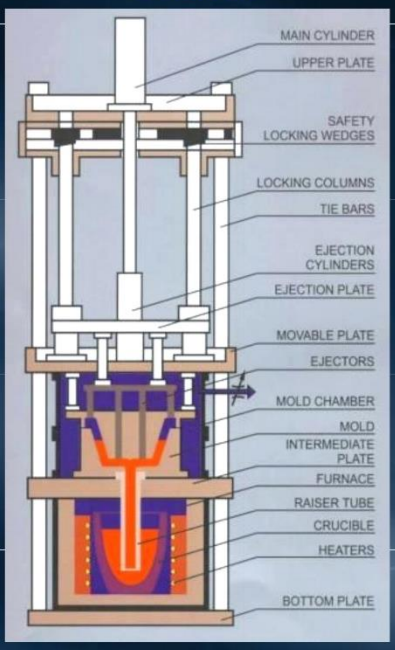
- Metal enters die cavity from bottom
- Metal flow is controlled against pressure head (counter pressure)
- Flow is smooth and non-turbulent (tranquil)
- Metal is filtered two times during the casting process (bottom of inlet tube and at sprue)
- Solidification is controlled via thermally modeled mold design and directional cooling
- Once metal enters the heated crucible furnace, and is degassed and de-drossed, it is never disturbed again throughout the entire casting process

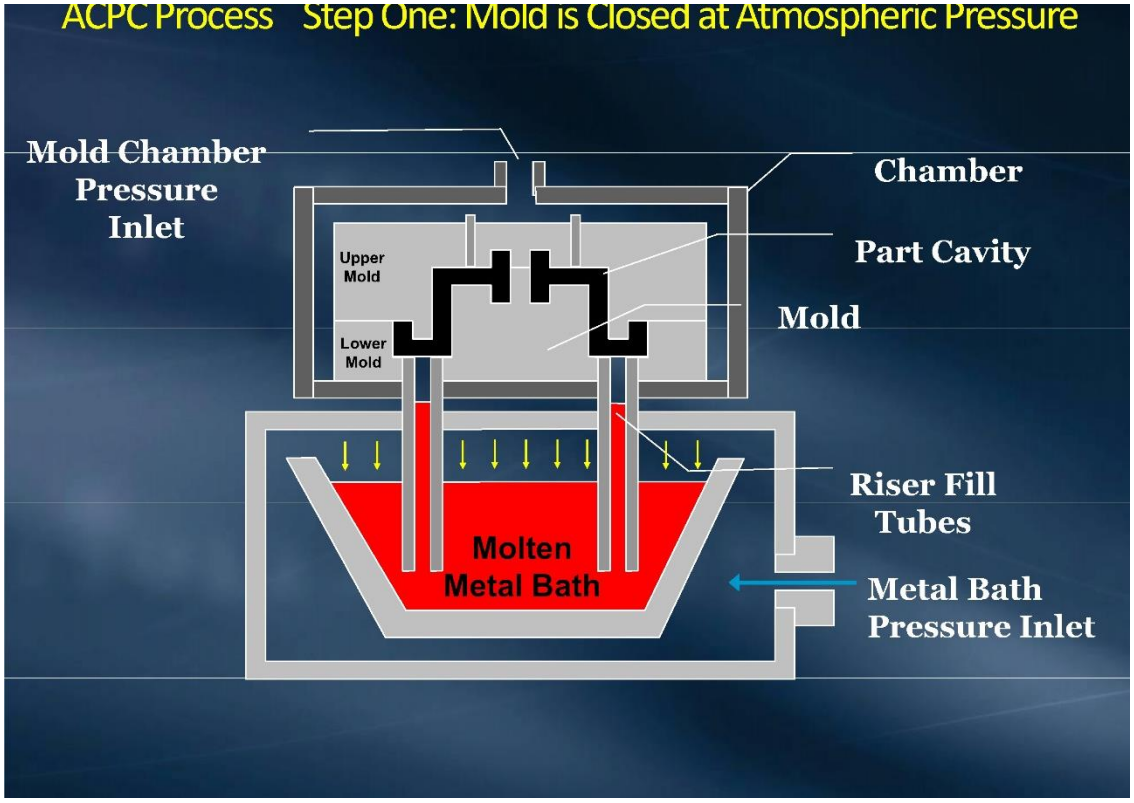
How Does ACPC Work?

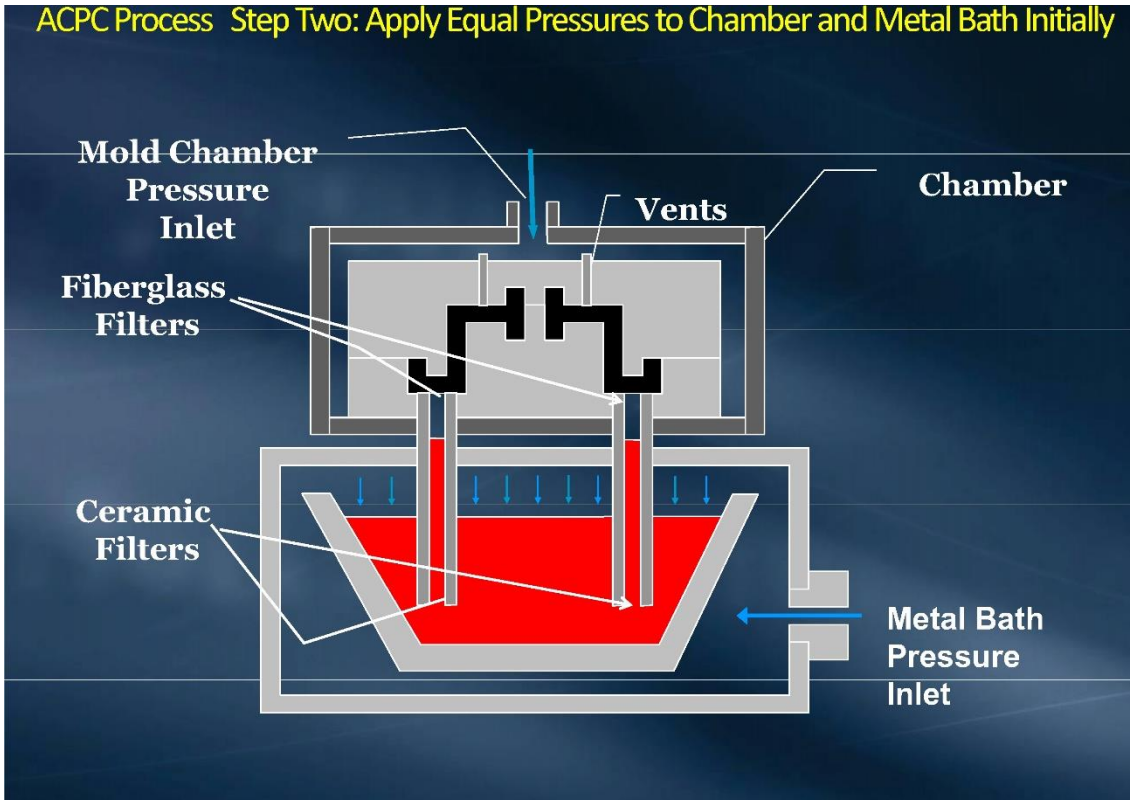
Casting Machine

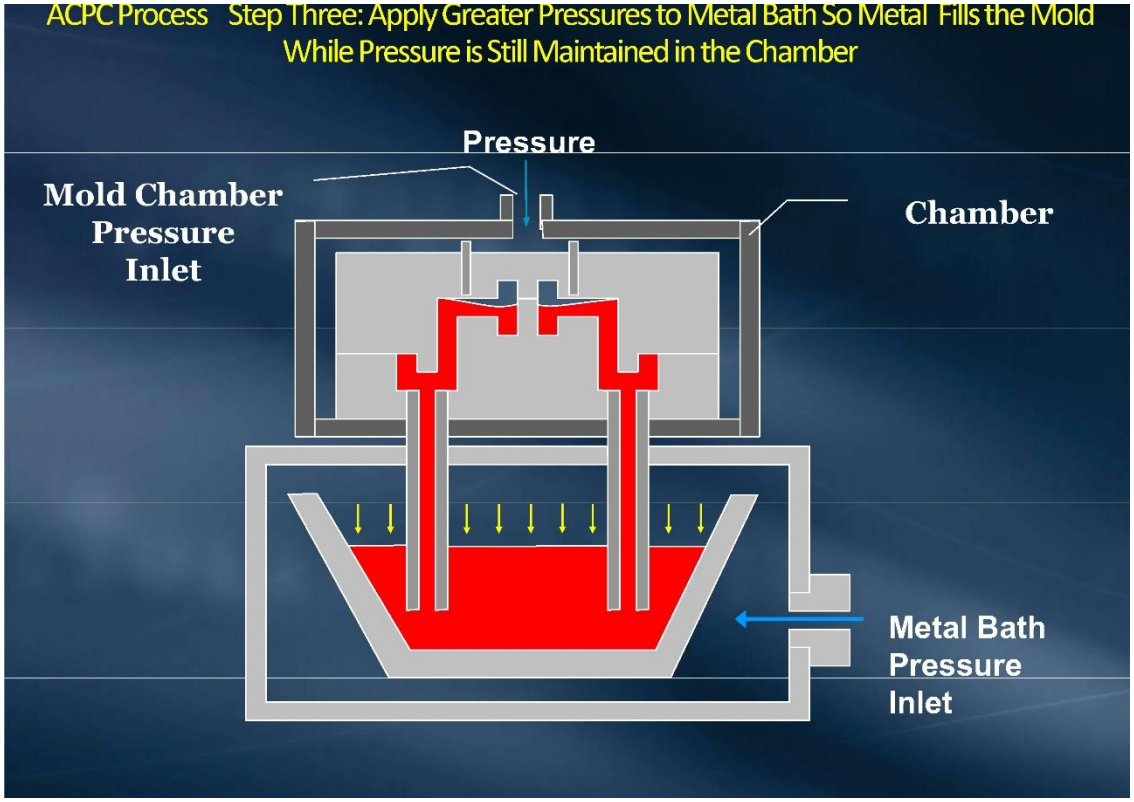
- A process utilizing a ***double sealed*** metal mold and a ***sealed*** crucible of molten aluminum below the mold.
- An initial ***Counter Pressure*** is applied to both the mold cavity and the molten metal in the crucible.
- Both volumes are stabilized to the same pressure and then the two volumes are separated by closing an isolation valve.
- The pressure in the furnace is increased in mbar increments to fill the mold cavity using a computer controlled fill profile.

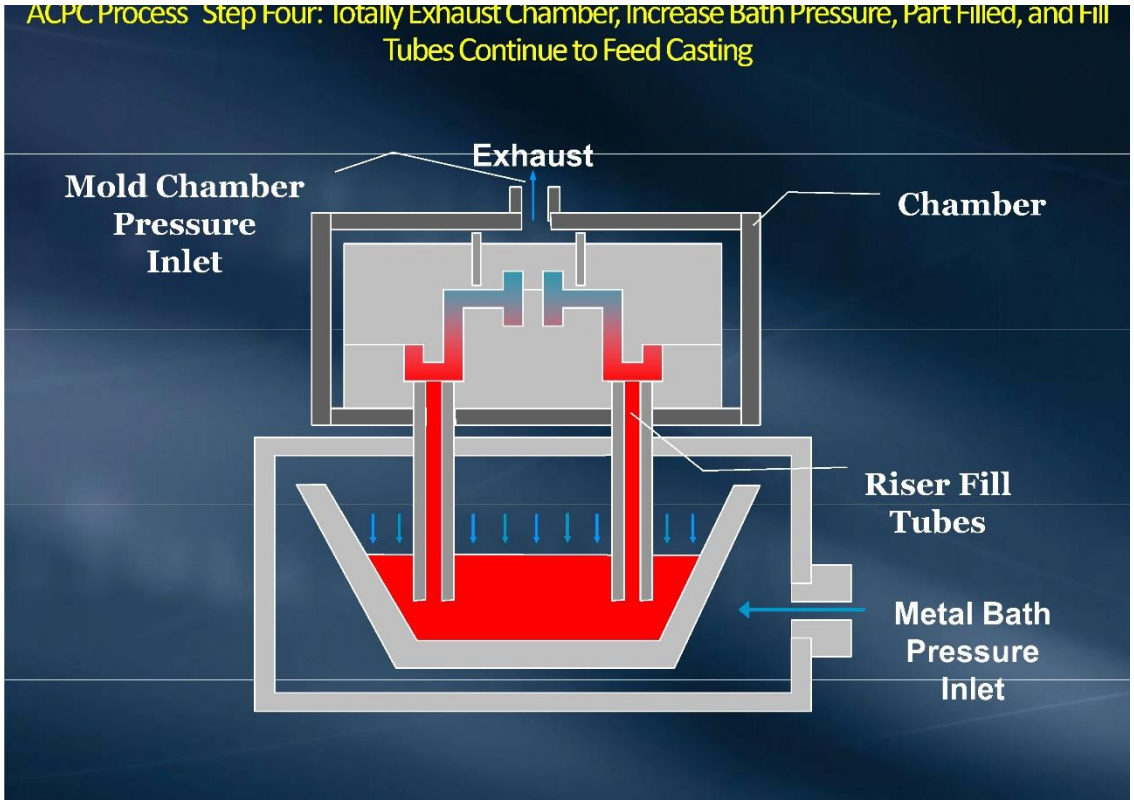
Schematic



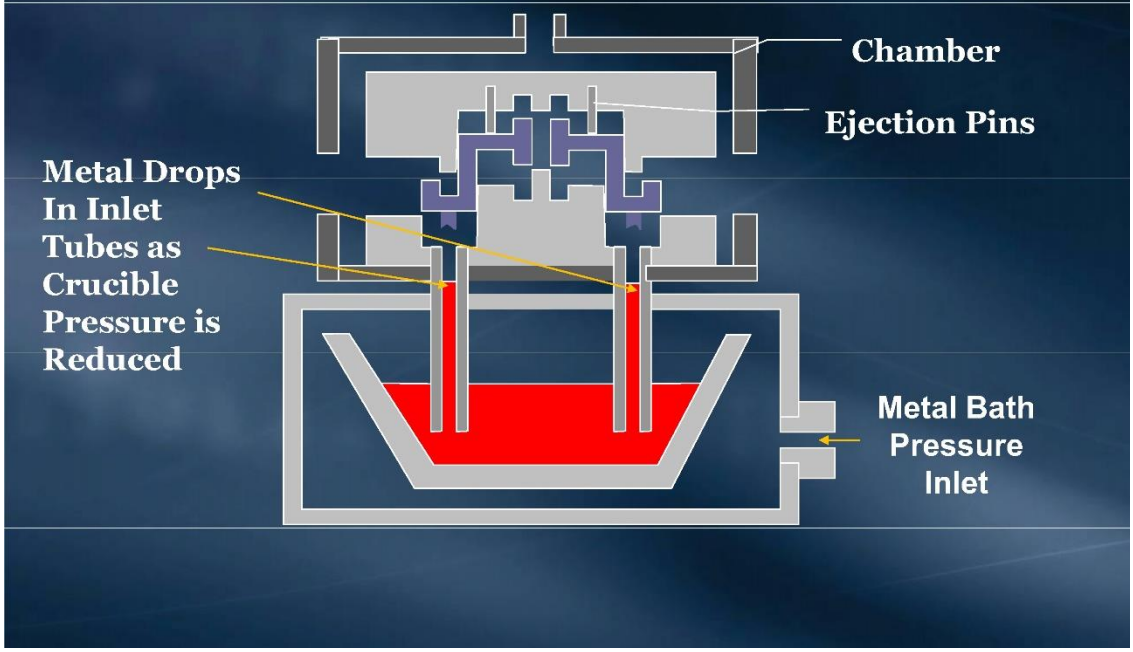

ACPC Process Step One: Mold is Closed at Atmospheric Pressure
Mold Chamber Pressure Inlet
Chamber
Part Cavity
Mold
Upper Mold
Lower Mold
Riser Fill Tubes
Molten Metal Bath
Metal Bath Pressure Inlet


ACPC Process Step Two: Apply Equal Pressures to Chamber and Metal Bath Initially
Mold Chamber Pressure Inlet
Vents
Chamber
Fiberglass Filters
Ceramic Filters
Metal Bath Pressure Inlet

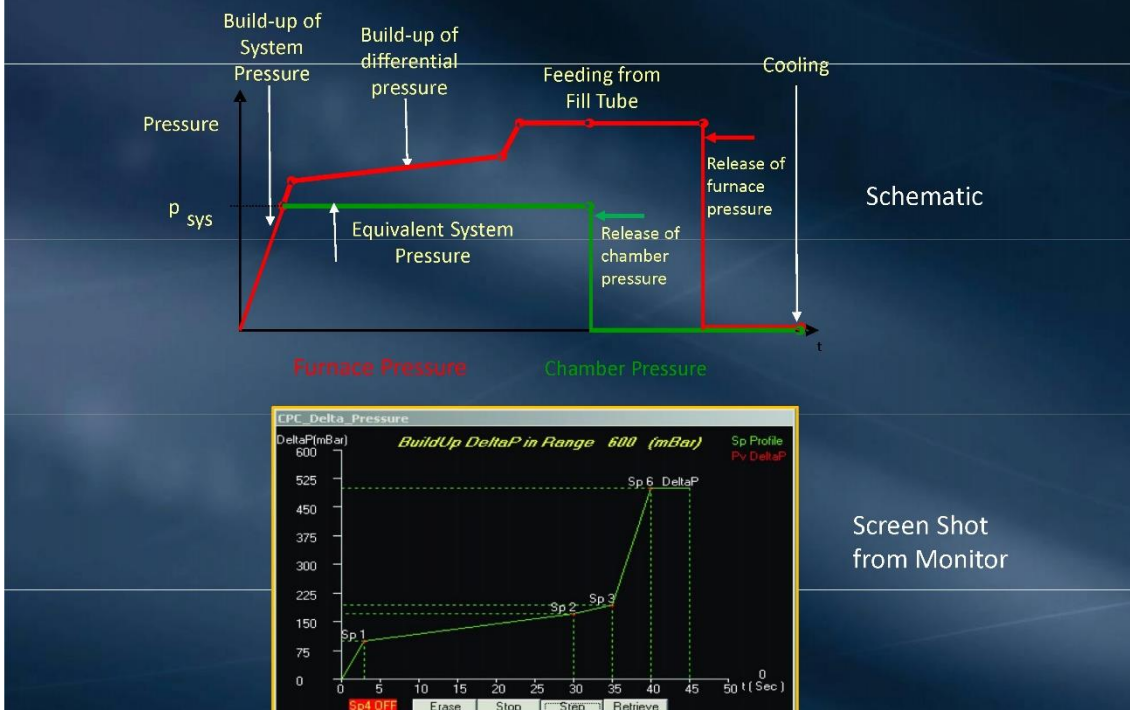

ACPC Process Step Three: Apply Greater Pressures to Metal Bath So Metal Fills the Mold While Pressure is Still Maintained in the Chamber
Pressure
Mold Chamber Pressure Inlet
Chamber
Metal Bath Pressure Inlet


ACPC Process Step Four: Totally Exhaust Chamber, Increase Bath Pressure, Part Filled, and Fill Tubes Continue to Feed Casting
Exhaust
Mold Chamber Pressure Inlet
Chamber
Riser Fill Tubes
Metal Bath Pressure Inlet

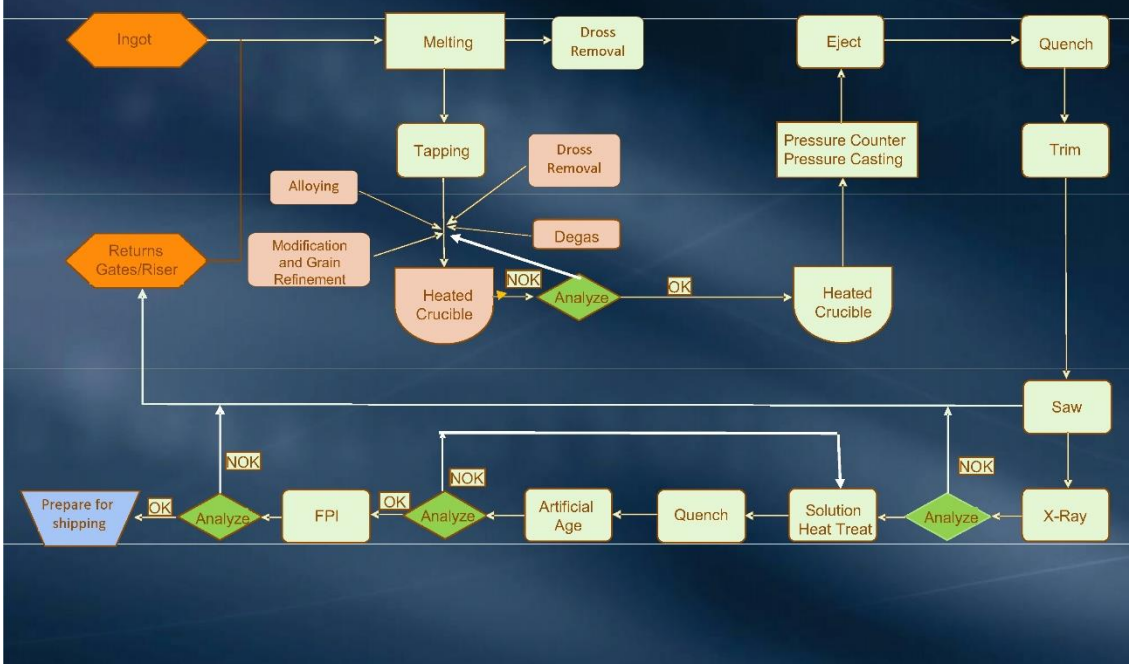
ACPC Process Step Five: Reduce Pressure on Bath, Metal Drops in Inlet Tubes Ready to Fill Next Mold, Mold is Opened, Part is Ejected and Removed



Advanced Counter Pressure Casting Pressure Changes



Advanced Counter Pressure Casting Process Flow



Advanced Counter Pressure Casting

Since that starting point, continuous improvements and advancements have been made with the CPC Group to the ACPC casting process

- Increased tie bar spacing and larger platen sizes to permit more parts per mold and larger components to be manufactured
- Increased number of cooling circuits to 96 from 64
- Larger and optimally designed crucibles to allow for fewer metal changeovers
- Improved mold cooling system
- Quick mold change system techniques
- More and improved controls and data collection capabilities
- Special access to back of mold for large cavities, plus tiltable movable molds for easier maintenance
- Ability to cast cored parts using either metal core pull techniques or sand cores

Advanced Counter Pressure Casting

Since that starting point, continuous improvements and advancements have been made with the CPC Group to the APCPC casting process

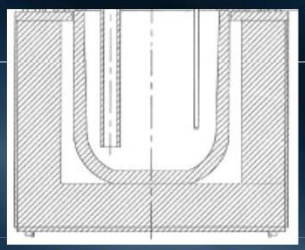
- Increased tie bar spacing and larger platen sizes to permit more parts per mold and larger components to be manufactured
- Increased number of cooling circuits to 96 from 64
- Improved mold cooling system

Latest CPC 1600-C96 Large Platen Machine

Increase to 96 Cooling Circuits with Improved Control and Monitoring

Advanced Counter Pressure Casting

- Larger and optimally designed crucibles to allow for fewer metal changeovers and more parts per mold



Straight wall crucible with 900kg capacity

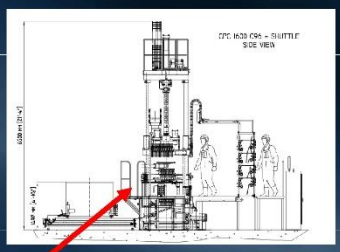
Larger crucible provides space for more fill tubes

- Improved mold cooling system more and improved controls and data collection capabilities

Touch Screen Monitor Screen Shots

Advanced Counter Pressure Casting

- Special access platform to back of mold for large cavities, plus tiltable movable upper mold half for easier maintenance



Access Platform for Large Molds

Tiltable Upper Mold Half

- Quick mold change system techniques using shuttle system and quick disconnects

Advanced Counter Pressure Casting

- New Filter Concepts to prevent inclusions and fluid dross from entering the mold cavity

Fiberglass Screen Filter Which is Placed Between the Sprue (bottom mold half) and Sprue Spreader (upper mold half)

- Advanced tooling with integrated water cooling, plus the ability to cast cored parts either using metal core pulls or sand cores

Advanced Counter Pressure Casting

Keys to Producing Optimum Knuckles and Control Arms

- ✓ Prevent the formation of oxide films or folds
  - ➢ Counter Pressure in chamber results in non-turbulent flow, level filling and no films or folds forming
- ✓ Eliminate shrinkage
  - ➢ Extensive, selective water cooling of the mold and part, plus the continued pressure applied through the fill tube essentially eliminate shrinkage
- ✓ Eliminate inclusions
  - ➢ Removal of dross during metal preparation, along with using filters at the bottom of the fill tube and at the sprue inlet eliminate inclusions from entering the mold cavity
- ✓ Eliminate gas bubbles
  - ➢ Degassing the metal with Argon to specific gravities >2.60 gm/cc, non-turbulent metal transfer using the shuttle system, and use of Counter Pressure in the mold result in no gas entering or being formed in the mold cavity or part
- ✓ Modify or refine the eutectic silicon
- ✓ Refine the grain size
  - ➢ Both accomplished during metal processing by using calculated Strontium and TiB_2 additions and monitored by microstructural analyses

Advanced Counter Pressure Casting

- *The Results…*
  - These actions and their results have lead to the ACPC process presently being the most widely selected process worldwide for the production of high integrity aluminum steering knuckles and control arms
    - Over 90% of the casting machines now being produced by the CPC Group are now ordered to produce ACPC aluminum knuckles, control arms and other structural parts
    - There have been 11 ACPC plants constructed and placed in operation since the original plant in Stevensville, Michigan started production in 2001, and the building of at least another 3 plants has been announced
    - Plants are located in the United States, China, Korea and Germany, and consideration is being given to facilitizing in Brazil, India and Eastern Europe
    - Originally, most ACPC parts were conversions from steel and aluminum forgings, and ductile iron castings—however, now a large percentage of knuckles and control arms are being designed directly as aluminum castings, particularly those made using ACPC

Advanced Counter Pressure Casting

- *The Results from actual production parts…*

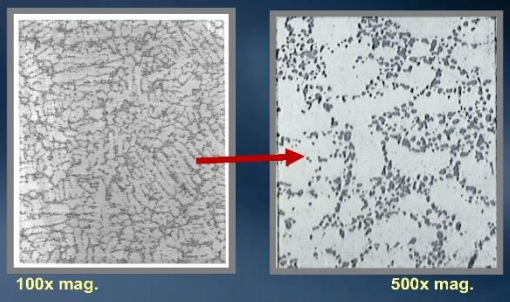
Typical ***In-Part*** Mechanical Properties and Hardness

- A356 - T6
  - UTS - 320-360 MPa
  - YS - 230-260 Mpa
  - %EL - 9-12 %
  - BHN - 92-102
  - SDAS - 20-35 microns

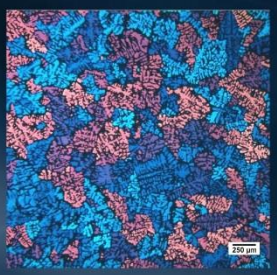
Results vary based on the locations selected for specimens, section thickness, water cooling and proximity to the inlet

Advanced Counter Pressure Casting

- Results from typical microstructure evaluations



Eutectic Silicon Modification
SDAS ~ 25-30 microns



Aluminum Grain Refinement
Grain Size ~ 250 microns

- Uniform distribution of microstructure
- Absence of porosity and oxides
- Small SDAS and fine Grain Size

Advanced Counter Pressure Casting

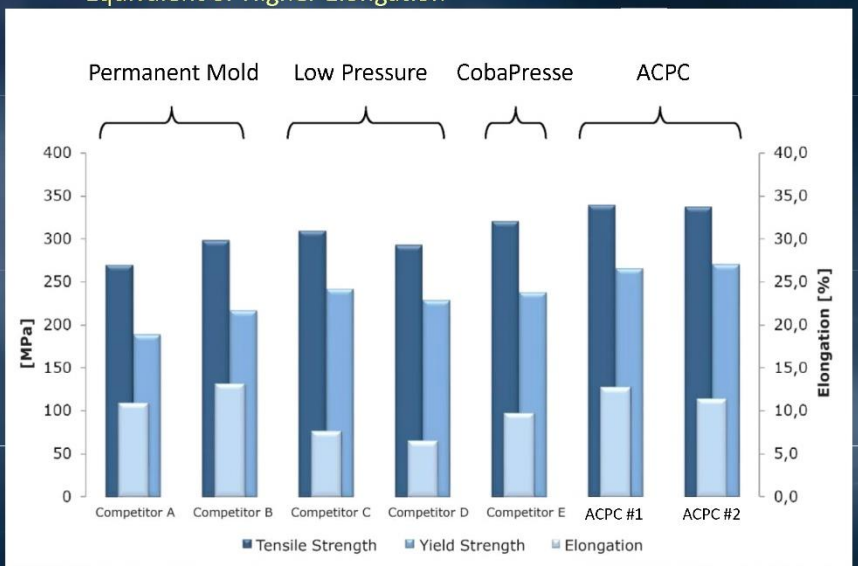
Process Assessment - Aluminum Steering Knuckles-Structural Castings

Attributes	Manufacturing Processes: Gravity Perm Mold	Low Pressure	ACPC	VRC/PRC	Squeeze Casting	RheoCast	ThixoCast	Forging
Properties								
UTS (Mpa) Tensile Strength	260	276	330	310	290	310	300	320
YS (Mpa) 0.2%Offset Yield	180	207	240	220	220	240	230	270
% Elongation	5	7	10	9	9	10	10	10
Fatigue (Mpa) $n=10^7$	70	75	90	85	90	100	100	110
Microstructure								
Grain Size[1]	1000 micron	800 micron.	250 micron	750 miron.	500 micron.	150 micron	150 micron	200 micron.
SDAS (dendrite)	40 micron	40 micron	25 micron	25 micron	15 micron	globular	globular	not applicable
Oxides (risk factor)	Moderate	Moderate	Very Low	Moderate	Moderate	Low	Low	Low , lap issues
ADVANTAGES	lower cost	extensive use, wheels	high quality, strength & ductility	quality & strength	quality & strength & history	high quality, strength & ductility	high quality, strength & ductility	high quality, strength & ductility
DISADVANTAGES	manual operator control, lower ductility, issues on tranquil filling	usually 1-on, issues on controlling filling and longer cycle times	limited number sources, but part design interchangeable with other processes	proprietary process & seal issues on dies cause seam defects	potential for oxides from die lube, eutectic segregation, equip & tooling cost high	limitation on current shot weight size, new process	High material cost using special billet and reuse of returns	Properties are often directional, reduced net shape potential and material/process cost is high
Process Info[2]								
Seconds/part	75	240	37	37	50	25	25	unknown
Pieces/mold	4	1-2	4	4	2	2	2	1-2
Typical Parts	rear knuckles, crossmembers	wheels, crossmembers, lower control arms	front & rear knuckles, lower control arms	knuckles, crossembers, lower control arms	front knuckles	upper control arms, ABS housings	upper control arms	upper control arms
Size Limits	1.5 meters	1.0 m	0.5-1.0 m	0.5-1.0 m	0.5 m	0.4 m	0.5 m	0.5 m
Cost & Investment[3]	1	1.1	1.2	1.3	1.4	1.4	1.5	2
Lead Time (weeks)[4]								
-Prototype	10	11	12	14	18	16	16	24

1. Note Grain Size depends on process additions and control, the data listed in table are from observations, va;ues for individual parts and sources may vary.
2. Process information represents **typical data** and is from benchmarking studies, results may vary from individiual sources and equipment..
3. Base set at 1.0 for Gravity Permanent Mold, individual part cost w ill vary by size, volume, material specification, etc.
4. This is estimated timing for parts from metal 'hard' tooling, assuming design freeze, and part not requiring pulls. Secondary processing, support equipment, etc. may take longer.

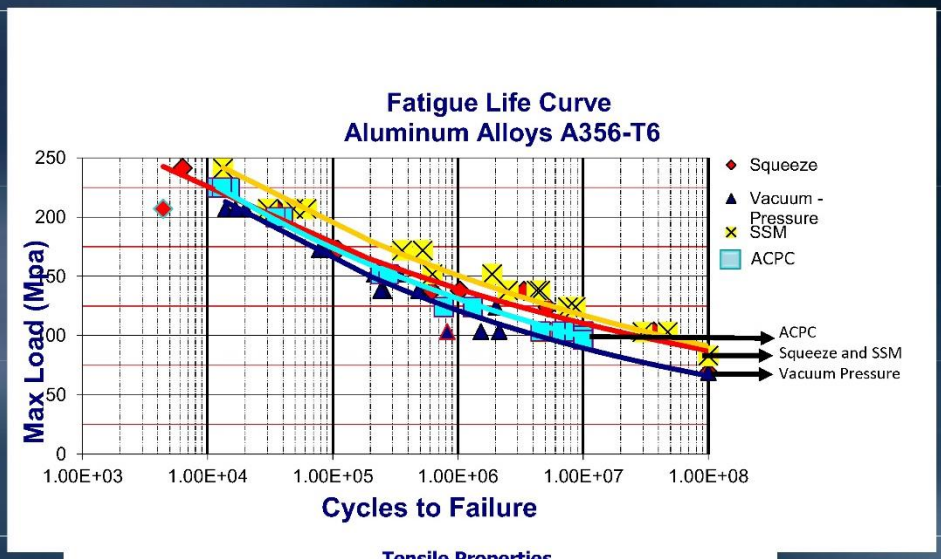
Advanced Counter Pressure Casting

- How does ACPC Compare to Competing Processes Used to Produce Aluminum Knuckles and Control Arms?
  - Higher Ultimate Tensile Strength
  - Higher 0.2% Offset Yield Strength
  - Equivalent or Higher Elongation



Advanced Counter Pressure Casting

- Comparison of Fatigue Life for Various Aluminum Casting Processes- USCAR Data



Tensile Properties

PROCESS:	SSM	Squeeze	VRC/PRC	ACPC
UTS (MPa)	307	312	323	325
Yield (MPa)	210	243	243	245
% Elongation	15.2	11.0	11.3	14.3

Advanced Counter Pressure Casting

- Examples of Aluminum Steering Knuckles Produced Using ACPC

Advanced Counter Pressure Casting

- Examples of Other Aluminum Structural Parts Produced Using ACPC

Lower Control Arm

Upper Control Arm

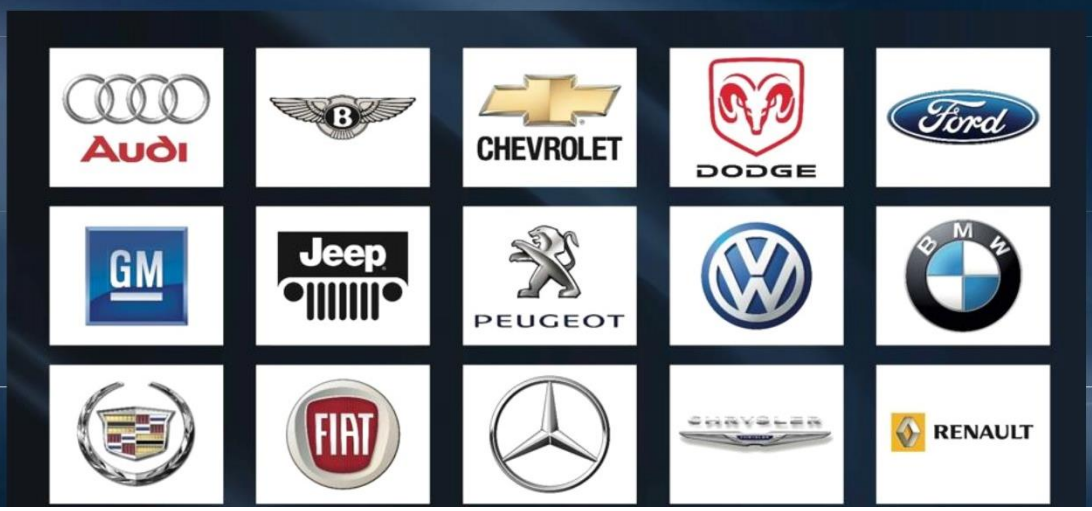
Suspension Yokes

Upper Control Arm

Structural Brackets

Advanced Counter Pressure Casting

- It is estimated by the CPC Group that over 50 million knuckles, control arms and other structural parts will be cast using the ACPC process in 2015
- Below are a number of "Western" OEM's that will have ACPC parts installed on their vehicles worldwide
- In addition, many Chinese OEM's are beginning to use ACPC components, or are in the prototype or design phase of implementation



Advanced Counter Pressure Casting

- ACPC Success Stories

High Volume Knuckle Conversion from Squeeze to ACPC Casting

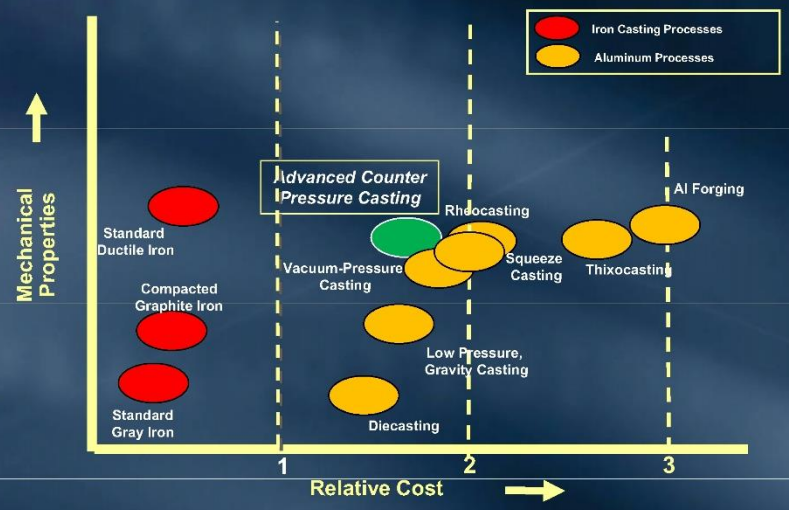
High Volume Front Lower Control Arm Conversion from Ductile Iron to an Aluminum ACPC Casting

High Volume Front Lower Control Arm Conversion from a Welded, Multi-Piece Steel Stamping to and Aluminum ACPC Casting

High Volume Steering Knuckle Conversion from Ductile Iron to an Aluminum ACPC Casting

Advanced Counter Pressure Casting

Casting Process/Material Continuum



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TITLE

Key Factors to achieve Mechanical Properties in Lightweight Structural Parts

ABSTRACT

Market demands in a vehicle and government emissions regulations have increased over the years. Technology is a big part of the business, when it comes to all single levels of the Automotive Industry. In order to achieve the pursuit of developing better vehicles, the components supplied by Tier companies have increased in complexity and importance, changing simple production processes into every day high complex tasks.

A well planned development phase creates the opportunity to analyze and visualize a complete picture of the project needs and requirements. The right design of tooling, state-of-the-art equipment, and collaboration with world class suppliers are fundamental to accomplish a successful and flawless start of production.

Development and Control of processes to achieve OEMs requirements are the Key factors to constant improvement, competitive costs and success in the industry.

Weight reduction is the trend and requirement.

How to guaranty the integrity and quality of the parts, is the challenge.

Key Factors to achieve Mechanical Properties in Lightweight Structural Parts

Introduction

Market demands in a vehicle and government emissions regulations have increased over the years.
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In order to achieve the pursuit of developing better vehicles, the components supplied by Tier companies have increased in complexity and importance, changing simple production processes into every day high complex tasks.

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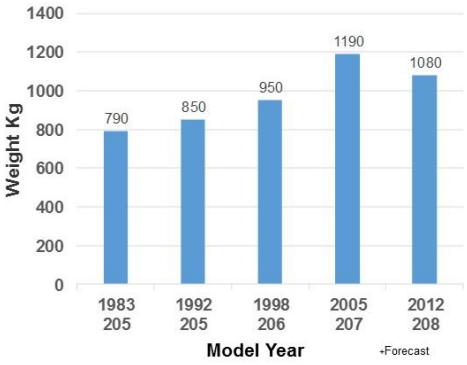
Development and Control of processes to achieve OEMs requirements are the Key factors to constant improvement, competitive costs and success in the industry.
Weight reduction is the trend and requirement.
How to guaranty the integrity and quality of the parts, is the challenge.

Weight increase over the years



Comfort
Safety
Performance
↑
Weight

Peugeot 205

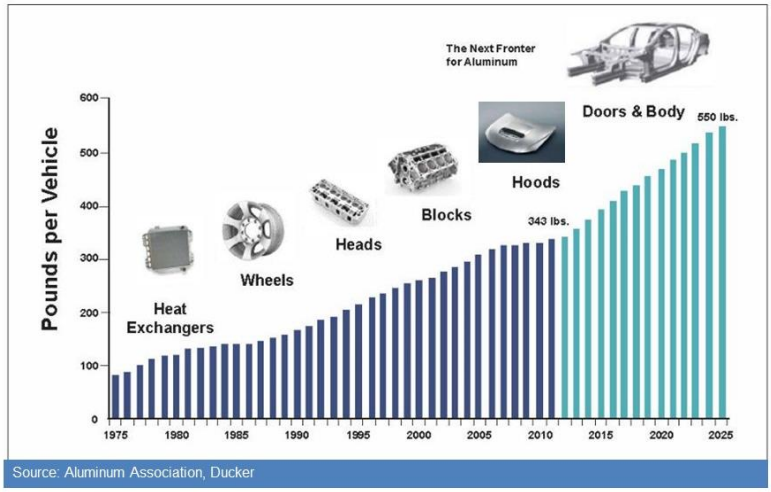
Peugeot 208

"Excess weight kill any self-propelled vehicle. There are a lot of fool ideas about weight… Whenever anyone suggests to me that I might increase weight or add a part, I look into decreasing weight and eliminating a part!" Henry Ford, 1922

Environmental requirements

- Environmental requirements are becoming Guvernamental demands.
- Many countries have already clear goals, in order to reduce emissions in the following years.
- Weight plays a significant direct role in the emissions of internal combustion engines.
- Less weight, less required force, less energy used, which all end up in releasing less emissions and warm gases.

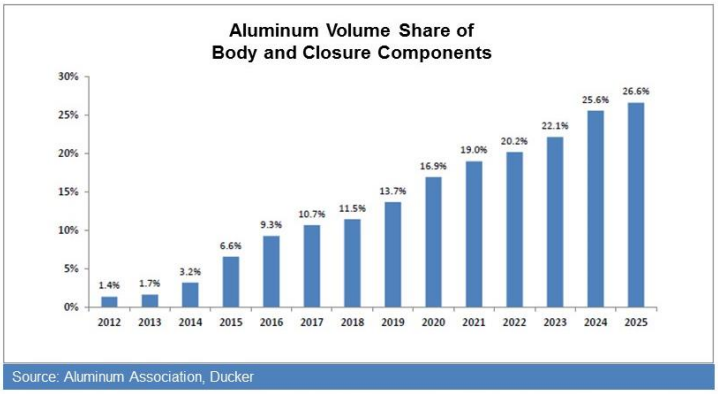
Aluminum content in automotive



Source: Aluminum Association, Ducker

Body and closure components share

- By 2025, 26.6% of all the body and closure parts for light vehicles in North America will be made of aluminum (measured by volume rather than weight).
- A burst of aluminum activity is expected in the few year leading up to the 2025 EPA mandate of 161 grams of C02 per mile talking full effect.

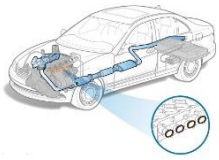


Source: Aluminum Association, Ducker

Improving weight conditions

Differential - Automotive Sector	Differential - Bocar Group
• **Material:** Iron casting • **Weight approx.:** 51 lb	• **Material:** Aluminum A-356- T6 Treatment • **Process:** Gravity Casting Process • **Weight approx.:** 34 lb • **Reduction weight:** 33% less than iron casting

Wall thickness



Intake Manifold- Bocar Group	Intake Manifold- Automotive Sector
• **Material:** Aluminum A-332 • **Process:** Gravity Casting Process • **Wall thickness:** 2 mm	• **Material**: A-332 • **Wall thickness:** 3.5 mm

Different purposes

The ones we all know:

SPORTS AND HIGH END CARS:
Less weight helps to improve vehicle dynamics in a car.

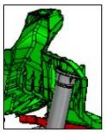
ECONOMY CARS:
Weight reduction of the vehicle impacts directly to the mileage of a car.

Why in a Truck/SUV?:

LESS ASSEMBLIES:
In a Shocktower, there are 7 to 10 Steel parts put into 1 aluminum part.
This improves the interaction with highly automated assembly lines.

REDUCTION OF PART NUMBERS
Assembly plants will have a significant reduction of part numbers to control.

HOUSING FUNCTION
Some parts can save an extra housing or holding part in a mechanical system.
(eg. Shocktowers as a housing for shock absorbers or suspension's springs)
These being directly assembled to the component.

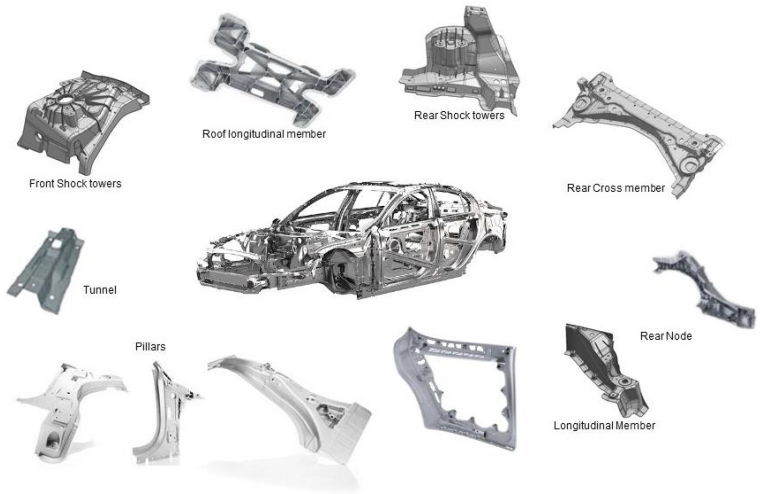


HPDC Aluminum Structural parts

Advantages

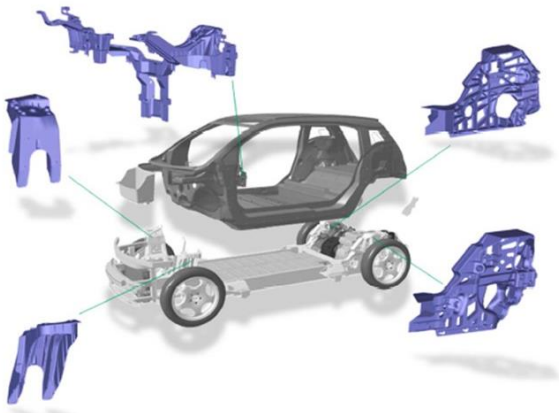
- Weight reduction through geometric freedom
- Integration of several steel sheet parts
- Integration of suspension components
- Less emmisions
- Weight reduction, better vehicle dynamics

Applications of Structural parts



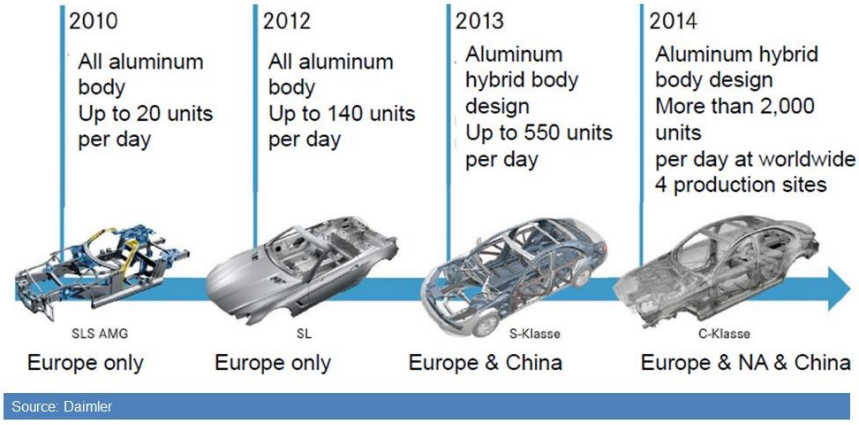
Structural parts integration in EV

Integration of light weight material in the Electric Vehicles



Source: BMW

1Mercedes Benz car body structures



C-Class Structural parts

Front Shocktowers LH & RH
Weight aprox. 3.23 Kg
Dimensions 450 x 420 x 330 mm^3
Central Ingate on a 3 Plate Die
Shock Absorber support and suspension fixture

Rear Shocktower LH & RH
Weight aprox. 2.46 Kg
Dimensions 530 x 295 x 410 mm^3
Integrated support for Shock Absorber

C-Class W205 Chassis

Rear Cross Member
Weight aprox. 5,20 Kg
Dimensions 425 x 1140 x 125 mm^3
Attachment to rear cross axel and integration to the suspension fixture.

Longitudinal Member LH& RH
Weight aprox. 1.40 Kg
Dimensions 480 x 315 x 290 mm^3
Integration to Rear Axel

Mechanical Properties

Why are Mechanical Properties critical to achieve?

- Ductility in a structural parts (High elongation)
- High density (Low porosity)
- Collapsible characteristics, in case of a collision (Safety property)
- Structural features (Yield and UTS)
- Light and thin construction

Structural parts characteristics

- Weight reduction (thin walls)
- Part integration
- High mechanical properties
- Crash performance
- Welded, riveted, glued, nailed, punched, clinching, etc.
- Distortion free with tight tolerances (+/- 1 mm)
- Corrosion resistance
- Pressure tightness

Source: NADCA

Key Processes and Q-Gates

Key Processes and Q-Gates to achieve required mechanical properties

- Alloy → Specification, Adjustment, Degasing → Q-Gates → Spectral Analysis, Density Test
- High Pressure Die Casting → Parameters Control, Vacuum, Thermo Regulation, Die Development, Lubrication
- Q-Gates → X Rays, Wall Thickness Analysis, Blister Test
- Heat Treatment → Equipment, Curve Parameters, Rack Development
- Testing Mechanical Properties → Tensile Test, Bending Test, Ductility Test

Adjusted elements and their influence

Elements commonly adjusted in the alloy:

Strength and hardness development in Heat Treatment AlSi alloys

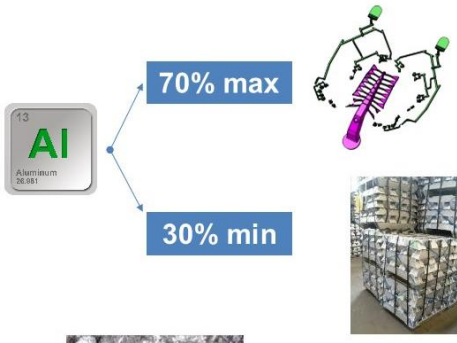
High resistance to corrosion, high strength and hardness

Helps to modify Si structure, rounding the element grain, to avoid notches and stresses.

Other elements and their impact:

Element	Effect
Si	Good HPDC feeding characteristic (fluidity), good hot tear resistance
Mn	Helps to avoid intermetallic elements and works as a released agent.
Zn	Increase resistance to corrosion
Ti	Grain structure refinement, reduce cracking tendencies
P	Low trace element

3.3 Return recycling



eg. of intermetallics.

eg. of muds and impurities.

Alloy testing and monitoring

Spectral Analysis:

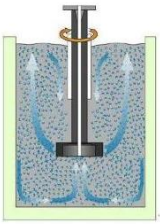
1. Equipment with 22 Channels
2. Frequently tested at the Melting and Holding furnaces
   - At Melting Furnace: Every hour
   - At Holding Furnace: Every shift

Degasing

Degasing:

Degasing Impeller

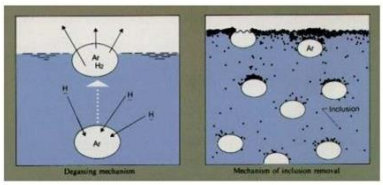
Inert gas



Holding furnace:

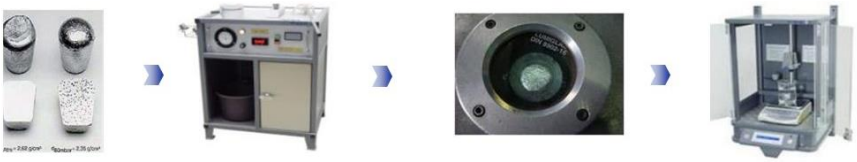
Oven with porous plug system to circulate and degas the material with an inert gas.

The porous plug will maintain the optimal density of the material.

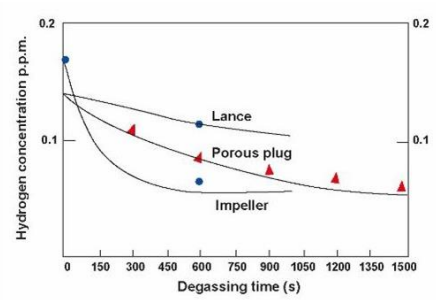


The ilustration shows how the inert gas is mechanically removing air, metallic and non-metallic inclussions.

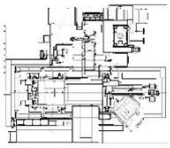
Density test



Target Value:
Density Index below 2



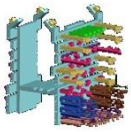
Die Casting and Trimming



High Pressure Die Casting Machines 1400T & 2200 T
Specific release agent
Vacuum system
Jet Cooling system
Thermoregulation system in dies
Lubrication head
Dosage furnace
Reis press

Parameters to monitor
Cycle time
Dosage temperature
Switchover
Compaction pressure
Biscuit thickness
Piston velocity
Vacuum Pressure

Die Casting and Trimming



Spray technology:

Automated lubricating heads.

Lubricant

Wax based release agent.

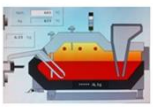
Trimming press

Jet Cooling

Quenching after die casting:

Tub with spray system and thermoregulation.

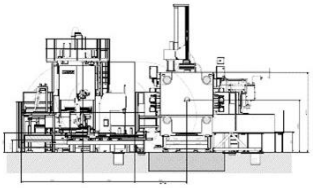
Robot

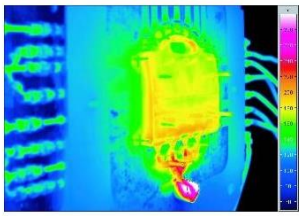


Dosage Furnace

Main features of High integrity Casting

- Optimized HPDC machine
- High vacuum system
- Complete process control
  - Critical Parameters to control:
    - Cycle time
    - Dosage temperature
    - Switchover
    - Compaction pressure
    - Biscuit thickness
    - Piston velocity
    - Vacuum Pressure
- Optimized tooling
- Die temperature control
- Proper lubricant and application
  - Release agent wax based (not oil)
- Fully automated production cell
- State of the art dosage furnace
- Thermo regulated injection sleeve
- Piston sealing

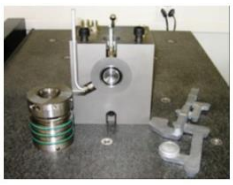


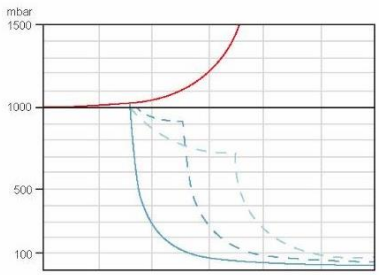


Vacuum System

Vacuum System:

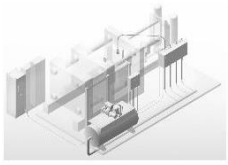
- Higher density in diecast parts
- Improved surface (ideal for a surface treatment)
- Clear reduction of porosity
- Perfect for parts with a complex geometry to be filled
- Heat treatable
- Essential for weldable parts
- Helps to reduce scrap
- Vacuum system makes posible to achieve a stable, efficient and profitable production.



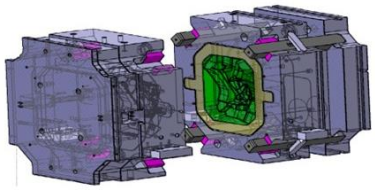


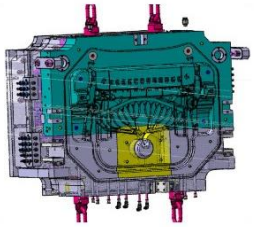
Change of air pressure in cavity of the mold during casting process

- Standard evacuation (without vacuum)
- Standard evacuation
- regulated vacuum examle A
- regulated vacuum examle B



Die development



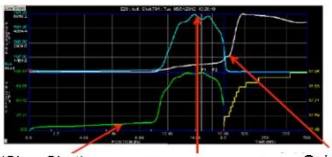


- 3 Plate die concepts.
- Central ingate to achieve a homogenous and complete filling.
- Smaller machine size/tonnage needed.

- Design development in conjunction with tool supplier.
- Developlement and manufacturing proposals.

HPDC Process control

- Successful high vacuum die cast process requires advanced process controls and monitoring systems.
- Shot control
  - Smooth metal flow & flexibility of adjustments (slow shot & low impact to eliminate flash and avoid premature wear of the die)
  - Velocity of injection is crucial to avoid micro porosity problems, which directly affects mechanical properties.
- Vacuum Monitoring/Control system
  - Apply vacuum during fast shot – repeatability is key
  - Detecting leaks or blockages is crucial
  - Monitoring system can be used to quickly troubleshoot equipment

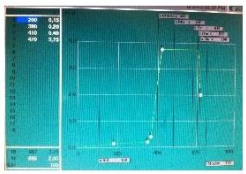


Ramp (Slow Shot) Speed Control to control turbulence in the shot sleeve

Power to control shock waves from dynamic forces

Quick response required for intensification of thin Wall castings

Source: NADCA



Distance Vs Velocity

Shot end components and lubrication

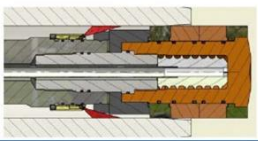
Tip lube application to control gas levels

Shot alignment to maintain the entire shot end performance

Tip sealing to assure high vacuum

Thermo regulated shot sleeve to avoid deformation and maintain vacuum levels.

Same release agent used for the die, is used for the shot sleeve, but higher is concentration.

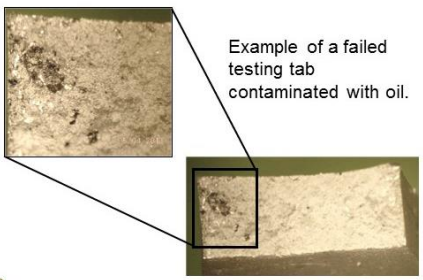


Source: NADCA

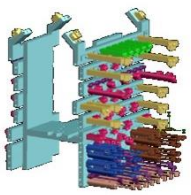
Shot end components and lubrication

Release agent for Casting:

- Separating film between die and metal melt.
- Uniform wetting of the mold surface.
- Lubricate the ejectors.
- Reducing the friction during the ejection.
- Thermal control of tooling.
- Corrosion protection of the die.
- Must be wax based lubricant in order to avoid negative effect in the mechanical properties.



Example of a failed testing tab contaminated with oil.



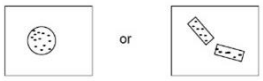
Lubrication head

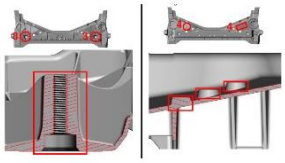
X-Ray control

Detailed and specific x-rays check plan.
Specifications according to Control Plan and Client requirements.

Fig. 3: Clusted porosity, spongy microstructure

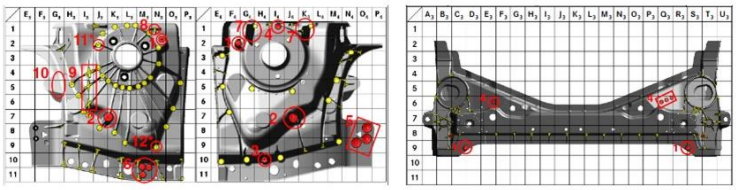
Example:





Max. Size of individual imperfection: 50 mm² / 8mm diameter
Max. Cumulative imperfections per 500mm²: 10% per 500mm², t.e. 50 mm² imperfections

Mercedes Benz DBL4918-2014-09



Blister test

BLISTER TEST

Quick blister test at min. 520° C and for at least 45 minutes with subsequent visual inspection by operator with the naked eye.

Mercedes Benz DBL4918-2014-09

Blisters	Joining and contact surfaces	Blisters shall not be higher than the general Surface defects, in addition, the following rules aplly: - Diameter 1,0mm - Number in case of fewer than 10 blisters with diameter 1,0 to 5,0 on joining surfaces, rework in accordance with Section 6.2 is aceptable
	All	Maximum height: 1,5 mm

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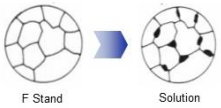
Stages of a 2-Step Heat Treat process

Solution

1.Solution: The solution heat treatment process involves heating the material to an elevated temperature (above the solvus, the closest to the eutectic phase) and soaking at this temperature for sufficient time.

A globalization comes in, and all material redistribute homogeneously, creating a supersaturated structure.

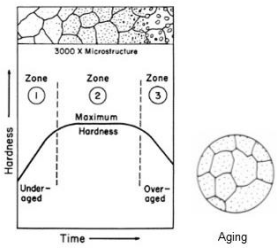


Quenching

2.Quenching: Once achieved the right and desired supersaturated structure, the material must be rapidly cooled at low temperature, in order to maintain the mentioned properties.

Aging

3.Aging: It is in the Aging process, where the precipitates appears and grow. The correct mechanical properties are achieved reinforcing/hardening the structure.



Source: American Society for Metals

Average Curve parameters

Solution 480° C

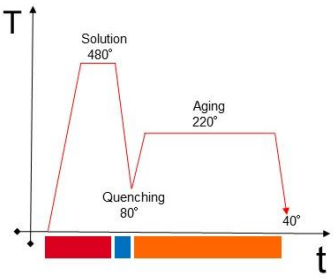
Quenching 80° C

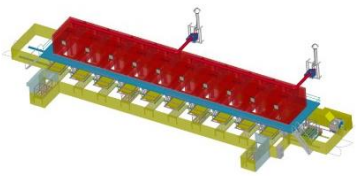
Aging 220° C

aprox. 1 hour

aprox. 5 Minutes

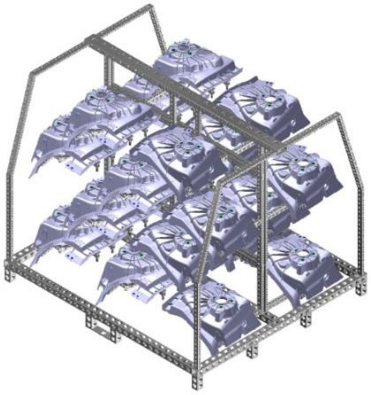
aprox. 2 hours





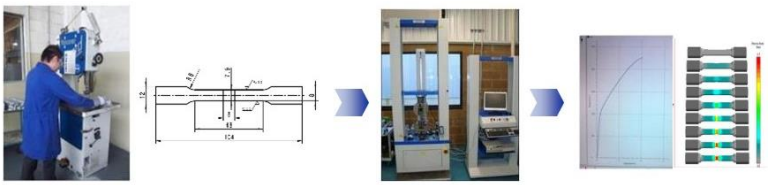
Heat Treatment Furnace

Rack development

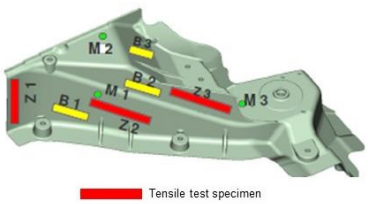


MB C-Class Shock tower

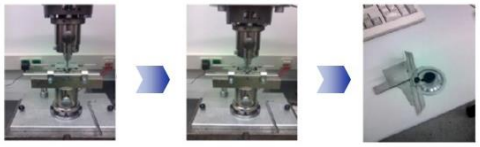
Tensile test

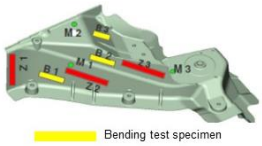


TEST	AA.30
0,2 Yield $R_{p0,2}$ (Mpa)	≥ 120
UTS Rm (MPa)	≥ 180
Elongation A30 (%) bzw.A5 (%)	≥ 10
Bending α ° (d=2 mm)	≥ 60 (average)*



Bending test (Mercedes Benz)





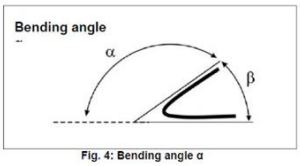


Fig. 4: Bending angle α

The standard specimen size for the bending test shall be 60 x 60 mm. If it is not possible to remove specimens of this size from the relevant castings, the specimen width can be reduced to 15 mm.

The target values for the bending angle indicated in Table 5 refer to a standard wall thickness of 2 mm. Any deviating wall thicknesses can be corrected using the following formula.

$$\alpha_2 = \alpha_1 \cdot (\sqrt{d_1}/\sqrt{2})$$

α_2: calculated bending angle (for a wall thickness of 2 mm)
α_1: measured bending angle
d_1: wall thickness of measured specimen

Mercedes Benz DBL4918-2014-09

Ductility test (BMW)

Description	Test parameter	Norm/comments
cover plate	EN AW-5182-2,5mm	GS 93013-3
tested material	casting material 2mm to 4 mm	test with cast skin
riveting	H 5,3 x 6,5 - 4	GS 96001-1
geometry of matrix	FM 1002215	Böllhof Company
final position of rivet head	rivet head overlap <0,5 mm	GS 96001-2
velocity of pincer	100-200 mm/s	
velocity of pincer	Visual inspection regarding required properties	 example: free of cracks after ductility tests

Ductility Test:

1. WS02004 once a shift at start and then once a day
2. Riveting Capability according GS 96001 at every inicial sampling

Source: BMW norms

Key Manufacturing Capabilities

	Control:	Tool Design		
Porosity Specification	X-Ray Blister Test Visual Inspection Metallography Analysis Density Analysis		**Jet Cooling** **Three plate die** (Optimal metal flow) **Squeeze Pins** **Sub-core technology** **Vacuum System**	**Cleaner technologies** • Wax based release agent • Porous plug Argon degassing
Wall Thickness	**Control:** GOM Measurement Micrometer Tight thermoregulation control	***Casting*** 	**Key process parameters** • Cycle time • Al Dosage temperature • Switchover • Compaction pressure	• Biscuit thickness • Piston velocity • Vacuum Pressure
Mechanical Properties	**Control:** Universal Machine Test (UTS, Yield, % Elong, Bending Test) Spectral Analysis	***Heat Treatment*** 	**Modular Design** →State-of-the-art construction to avoid loss of temperature →High precision of temperature control →Air quenching →Curve precisely optimized	**Alloy Specification** →Tight monitoring and control →Constant material adjustment
Dimensional	**Control**: GOM Measurement CMM Measurement Straightening Fixtures Klopf Model Manual Gauges (Go/No-Go)	***Straightening*** 	**Straightening process** →RPS system defined with OEM →Electronic Profile Gages	**Minimal part distortion:** →Air quenching →Advanced rack design

Thank you!

Ford Motor Company

Mr. Ali JAMMOUL
Global Director Body Exterior And Safety Engineering

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TITLE

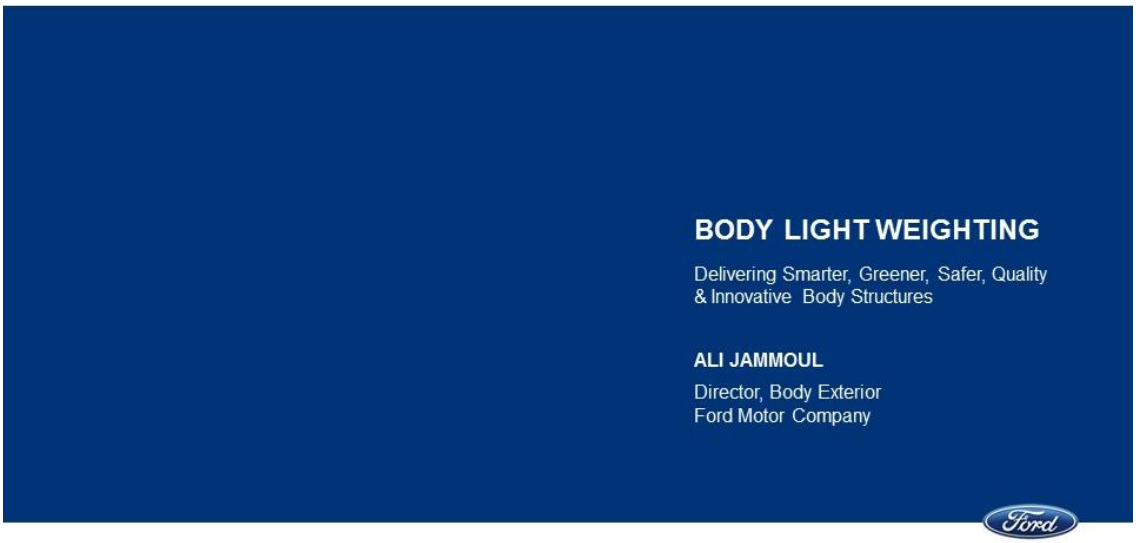
Body Lightweighting

ABSTRACT

OEM's are faced with enormous challenges driven by today's global emissions and fuel economy legislation. Nine governments worldwide, representing 80% of global vehicle market, have established or proposed emissions and fuel economy standards. Lightweight BIW design and manufacturing will play an increasing role in meeting these requirements. Ford will seek to introduce substantial weight savings of up to 340 kg. The recent introduction of the F150 Truck, a high volume, aluminum intensive BIW, achieves 320 kg. vehicle weight savings. Ford will continue to pursue BIW weight reduction actions through the use of advanced materials such as ultra-high strength steels, lightweight metals such as aluminum and magnesium and composites, proliferating them to global platforms.


Ford
Go Further

1


BODY LIGHT WEIGHTING
Delivering Smarter, Greener, Safer, Quality & Innovative Body Structures
ALI JAMMOUL
Director, Body Exterior
Ford Motor Company
Ford
Go Further

2

OUTLINE

FORD BRAND PILLARS

GLOBAL PRODUCT STRATEGY

- Bold, emotive exterior designs
- Great to drive
- Great to sit in
- Comfort & convenience of a 2nd home on wheels
- Remarkably quiet
- **Fuel Economy as a reason to buy**
- Unmistakably a Ford or Lincoln in look, sound, feel
- All with exceptional value
- Vehicles that serve the needs of all customers

Ford Go Further

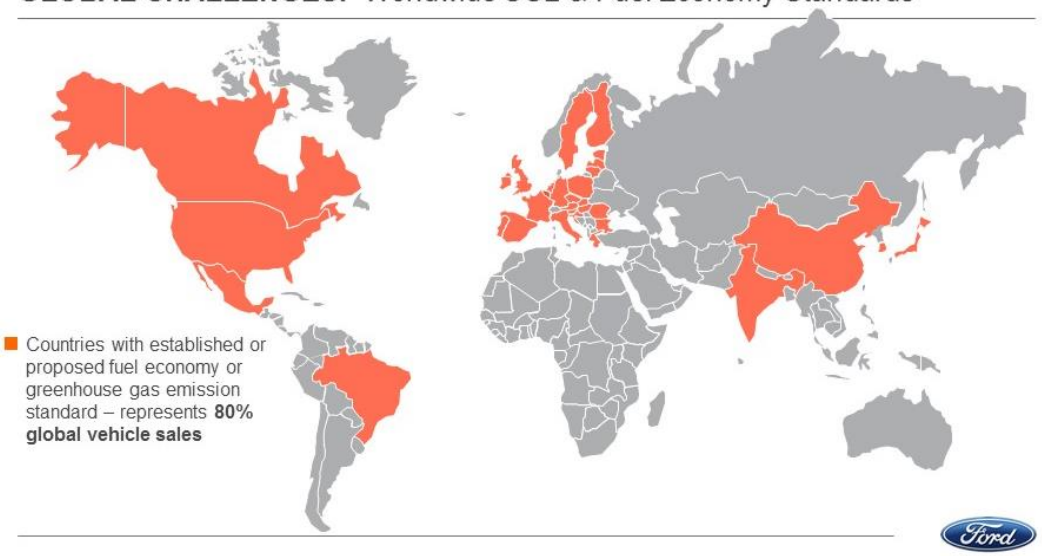
5

SUSTAINABILITY – CLEAR TECHNOLOGY PRIORITIES

Ford Go Further

6

GLOBAL CHALLENGES: Worldwide CO2 & Fuel Economy Standards



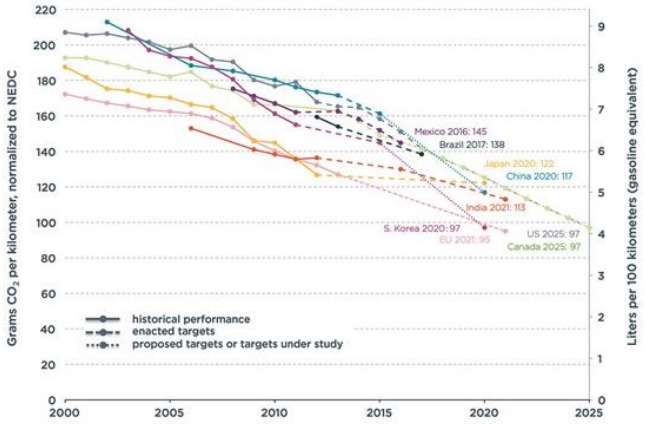
Go Further

7

GLOBAL EMISSIONS LIMITS

CO_2 emissions must be cut in half over the next 10 years.

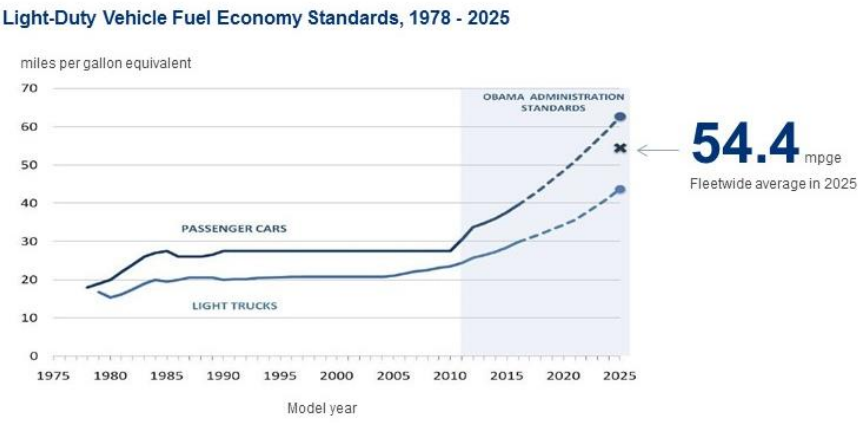
This change demands drastic changes to vehicle structures.



Go Further

8

NHTSA FUEL EFFICIENCY TARGETS

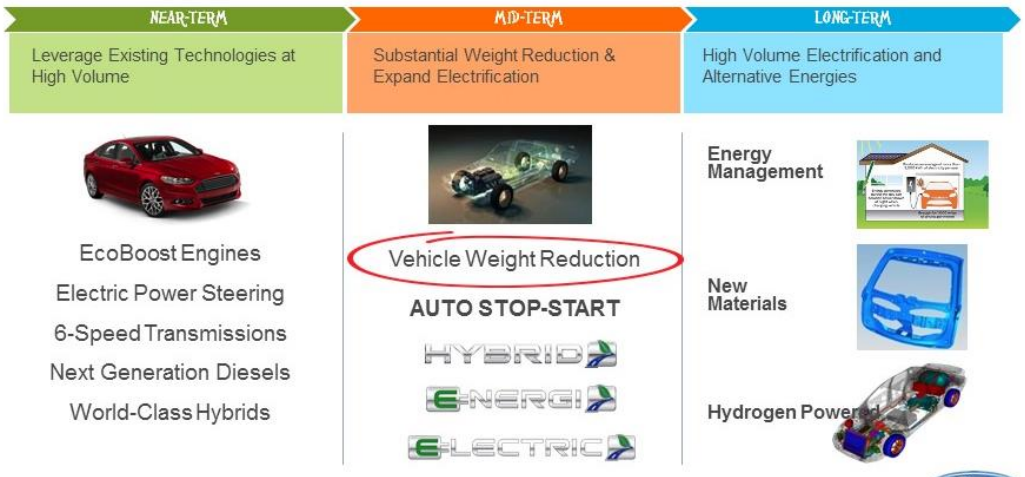


Source: Green Technology, 2011.

Go Further

9

PRODUCT DEVELOPMENT STRATEGY



Go Further

10

NEAR-TERM

NEAR-TERM | MID-TERM | LONG-TERM

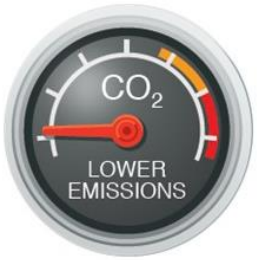
Downsize & Boost

FUEL ECONOMY IMPROVEMENT

ECOBOOST

EMISSIONS REDUCTION

UP TO **20%**



UP TO **15%**

Ford Go Further

11

ECOBOOST TECHNOLOGY

NEAR-TERM | MID-TERM | LONG-TERM

ECOBOOST

I3 1.0 Liter	I4 Family	V6 Family
		

EcoBoost Technology at High Volume Across Global Platforms is the Near-Term Solution to Reduce CO_2 and Provide an Uncompromised Driving Experience for Customers

Ford Go Further

12

ELECTRIFIED VEHICLES

NEAR-TERM | MID-TERM | LONG-TERM

C-MAX HYBRID — **47/47** MPG City/Hwy (Prius V44/40

C-MAX ENERGI — **100** MPGe (Prius PHEV 95

FOCUS ELECTRIC — **110** MPGe City (Leaf 99

Ford Go Further

13

WEIGHT REDUCTION – MID-TERM

NEAR-TERM | MID-TERM | LONG-TERM

WEIGHT REDUCTION
of 250-750 lbs. (113-340) kg

Smaller displacement engines
Smaller components
Lightweight materials

Ford Go Further

14

LONG-TERM

NEAR-TERM | MID-TERM | LONG-TERM

Advances In Powertrain Technology Alone Are Not Sufficient To Meet Long Term Needs

- Mass reduction will play a key role in gaining further fuel efficiencies and extending the range of hybrid and electric vehicles.
- Gasoline based cars and trucks will be a feature for many years to come.

B Segment	C Segment	CD Segment
		
FIESTA ECONETIC	**FOCUS ELECTRIC**	**FUSION / MONDEO**
73.5 MPG 3.2 L /100 km 87 g CO2 / km	110 MPG equivalent	Hybrid : 42 MPG Energi Plug In : 88 MPG

Ford Go Further

15

What adds weight ?

Ford Go Further

16

WEIGHT DISTRIBUTION – TYPICAL SEDAN

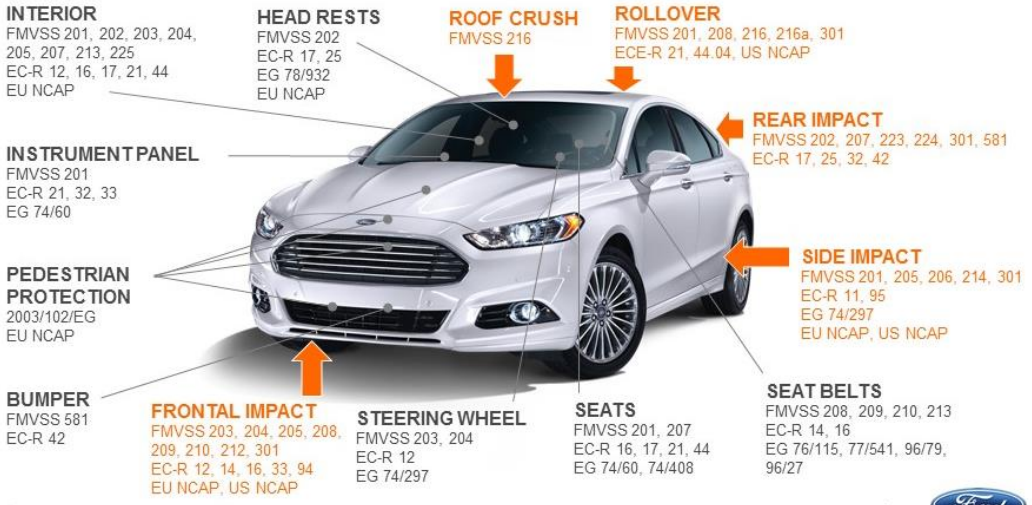
Future Technologies

- Degree of Electrification & Hybridization
- Start Stop Technology
- Boosted Engines
- Low Rolling Resistant Tires
- Aerodynamic Solutions

Go Further

17

REQUIREMENTS ADDING WEIGHT TO VEHICLES



Go Further

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DESIGN & CUSTOMER FEATURES

Go Further

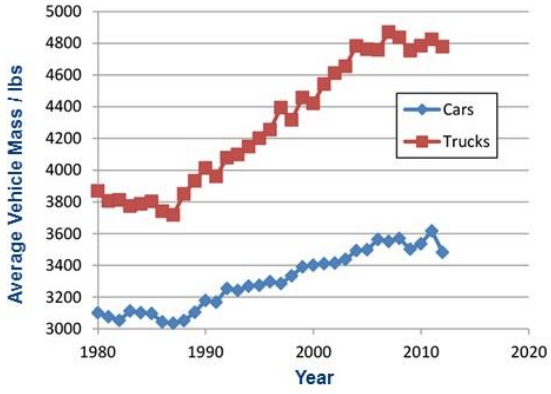
19

AVERAGE VEHICLE WEIGHT 1980-2012 (NA)

Since 1998,
the average vehicle mass has **increased** by…

17 lbs /yr for cars

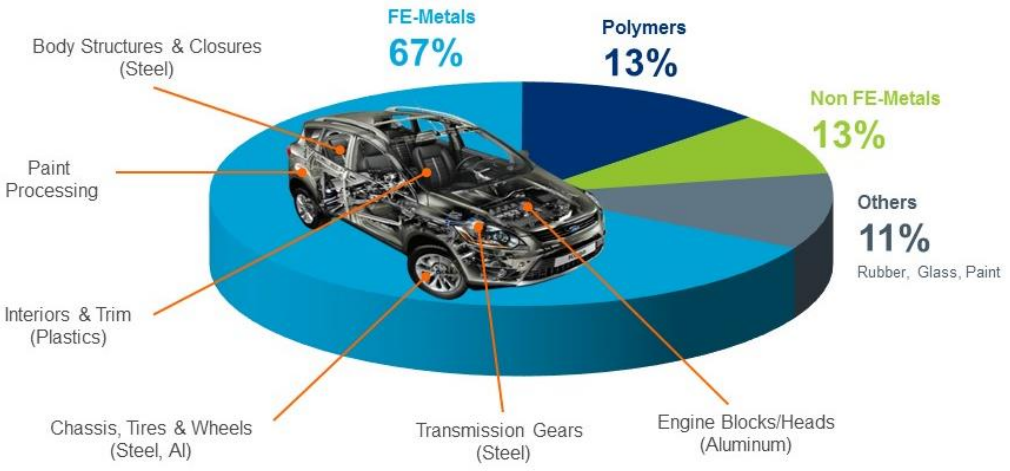
42 lbs /yr for trucks



Go Further

20

AUTOMOTIVE MATERIALS USAGE – TODAY



Ford Go Further

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MATERIAL DELIVER WEIGHT REDUCTION

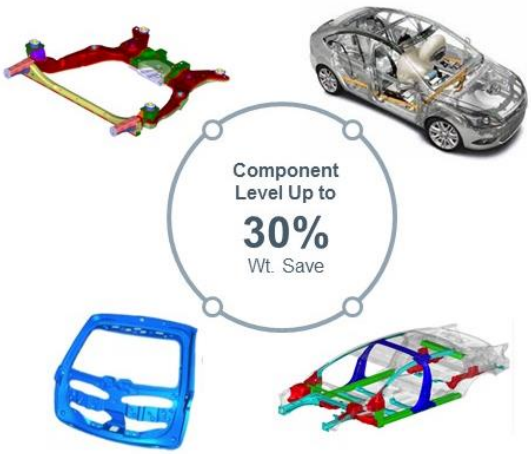
Advanced High Strength Steel – Weight savings potential additional 7 to 10%
- Most mature technology
- Stamping, Joining & Assy Infrastructure Exists
- Lowest cost alternative
- Tooling upgrades required

Aluminum - Weight savings potential 40 to 50%
- Solid experience with Al Sheet (Closures)
- Material cost is higher than advanced steels
- Slight tooling upgrades required
- Extrusions & Castings offer part consolidation opportunities

Magnesium - Weight savings potential 50 to 60%
- Casting is currently the only economically viable manufacturing process
- Corrosion can be an issue in some applications
- Material supply base and converters in a state of flux
- Sheet development in research phase

Polymer Composites - Weight savings potential 10 to 60+%
- Good supply base for Injection Molding & sheet molded composite (SMC)
- Class B surface and semi-structural applications
- Carbon Fiber only starts to look promising @ $5 -8 / lb
- Infrastructure to Make CF small and needs to grow

Multi-Materials Lightweight Vehicles – Optimizing all materials systems



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FORD GLOBAL DESIGN & MANUFACTURING FOOTPRINT

Go Further

23

Go Further

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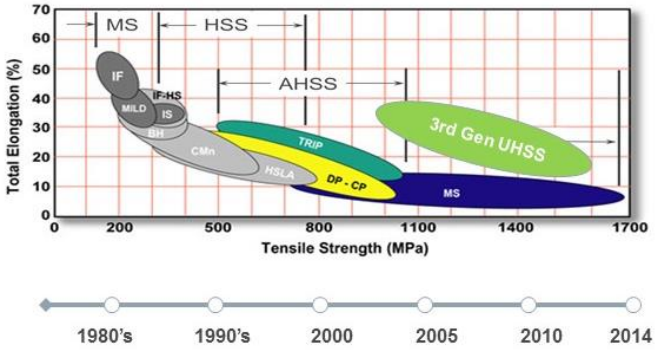
STEEL GRADES

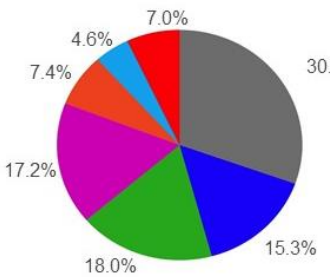


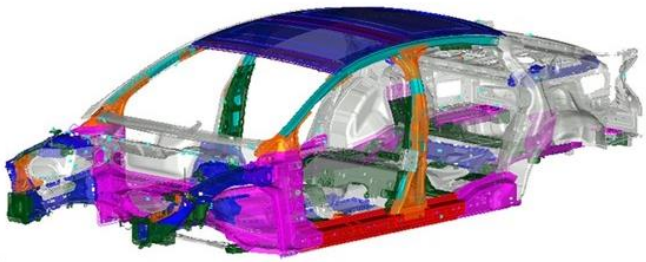
Go Further

25

MATERIAL – BIW

- Mild Steel
- BH – HSLA (YS < 300)
- HSLA (YS > 300)
- DP 600
- DP 800
- DP 1000
- Boron - Martensitic





348 Mpa
CURRENT BIW
avg Yield Strength

410 Mpa
NEXT GEN BIW avg
Yield Strength

Go Further

26

Go Further

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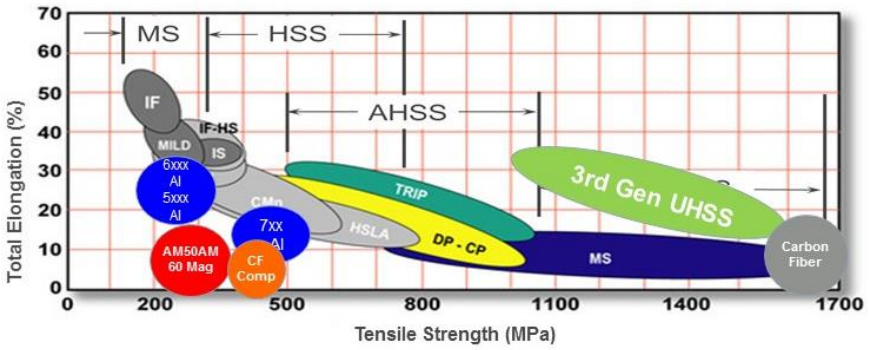
MATERIAL SELECTION



CHOOSING THE RIGHT MATERIAL, ON THE RIGHT PRODUCT, AT THE RIGHT TIME !

Go Further

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ALUMINUM EXPERIENCE – ALUMINUM MILESTONES AT FORD

1908 FORD MODEL 'T' SEDAN
Simple Sheet Aluminum Hood

1992 TOWN CAR
1st returning aluminum panel 100,000/yr

1999 LINCOLN LS
Aluminum Hood, Fenders, Decklid

1900s … | 1980 | 1990 | 2000

1979 LINCOLN VERSAILLES
1st Aluminum Hood Assembly

1996 FORD TAURUS
High volume Aluminum Decklid 300,000/yr

1996 FORD F150
Very high volume Aluminum Hood 900,000/yr

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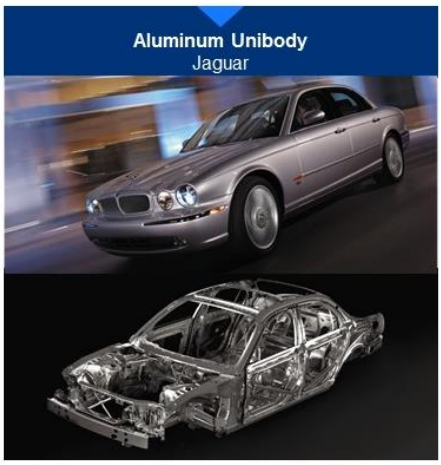
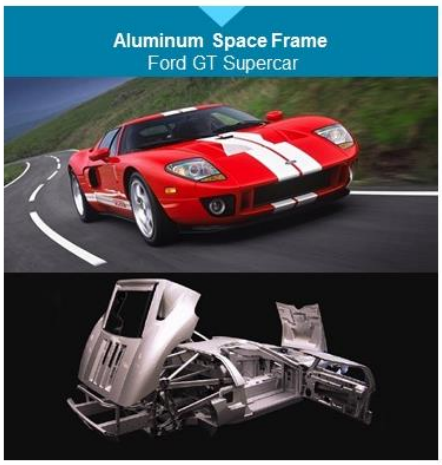
ALUMINUM – PRODUCTION APPLICATIONS





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ALUMINUM F150 – HIGHEST VOLUME PRODUCTION VEHICLE

Go Further

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TECHNICAL CHALLENGES

		HIGH VOLUME	TECHNOLOGY DEVELOPMENT	SUPPLY BASE	CHANGE OVER
DIE DESIGN	• Forming Limits • Yield Strength • Slivers	✓	✓	✓	✓
JOINING TECHNOLOGY	• Laser Welding • Riveting • Flow Drill Screwing • Adhesives	✓	✓	✓	✓
MATERIAL	• 4 - 6 Different Alloys • Material Segregation • Collection / Recycling • Material Aging • Material Properties	✓	✓	✓	✓
HYDROFORMING	• Forming Limits • Post-forming processes	✓	✓	✓	✓

Go Further

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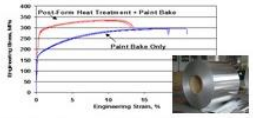
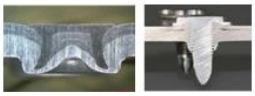
ALUMINUM TECHNOLOGY LEADERS



Higher Strength Aluminum

Advanced Pretreatments & Adhesives



Advanced Joining (SPR's & Flow Drill Screws)

Hydroformed Aluminum

Resistant Spot Welding

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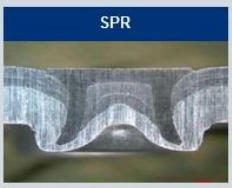
NEW TECHNOLOGY

Mechanical Spot Joining

Self-piercing rivets, flow drill screws and clinches used on complex stacks of thicker and higher strength materials.

- Launched all new Laboratory with SPR, Flow Drill Screw and Clinch capability.
- Implemented Ford-First technology on Flow Drill Screws



Resistance Spot Welding

MFDC resistance spot welding needs to be developed to enable reduction of transformer sizes and to enable high currents required for Al welding.

- Designed, acquired, installed industry-first 2400A aluminum RSW cells.
- New multi-step weld sequence improves weld effectiveness to 99% (similar to steel).

Ford Go Further

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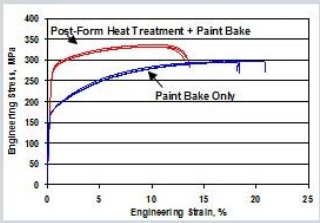
NEW TECHNOLOGY

Post-Forming Heat Treatment

Heat Treatment after stamping but prior to body construction results in significantly higher in service panel strength without introducing new and expensive alloys.

- Novel heat treatment process achieves >70 MPa increase without using new alloys.
- Process has been shown to be compatible with downstream processes.



Lubricants for Improved Formability

New class of stamping lubricant significantly increases formability and enable the forming of traditionally infeasible panels.

- Enhanced formability of aluminum offers breakthrough in craftsmanship.
- Initially demonstrated on the current F-150 door inner panel.

DC2-90 on X0 / X1 Builds

Go Further

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NEW TECHNOLOGY

Lubricants for Improved Formability

New class of stamping lubricant significantly increases formability and enable the forming of traditionally infeasible panels.

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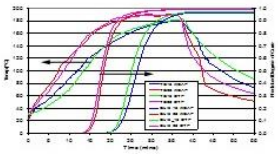
DC2-90 on X0 / X1 Builds

Adhesives and Pretreatments

Adhesive to improve stiffness of aluminum structure is governed by adhesive selection and pretreatment.

- Implementation Readiness for Alcoa 951 pretreatment for coil-applied and batch parts.
- Detailed required Paint Shop modifications to ensure adhesive cure.

Adhesive Cure within DTP & KCAP E-coat



Go Further

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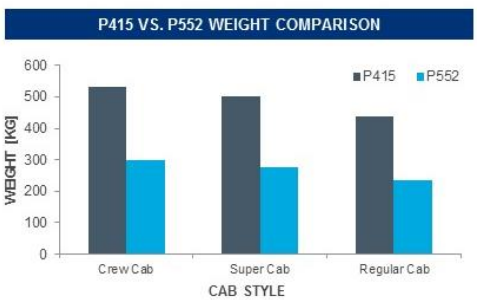
WEIGHT

GOAL
40%



X0 PROTOTYPE
WEIGHT SAVINGS
36%

X1 PROTOTYPE
WEIGHT SAVINGS
40%

F-150
WEIGHT SAVINGS
45%

Ford Go Further

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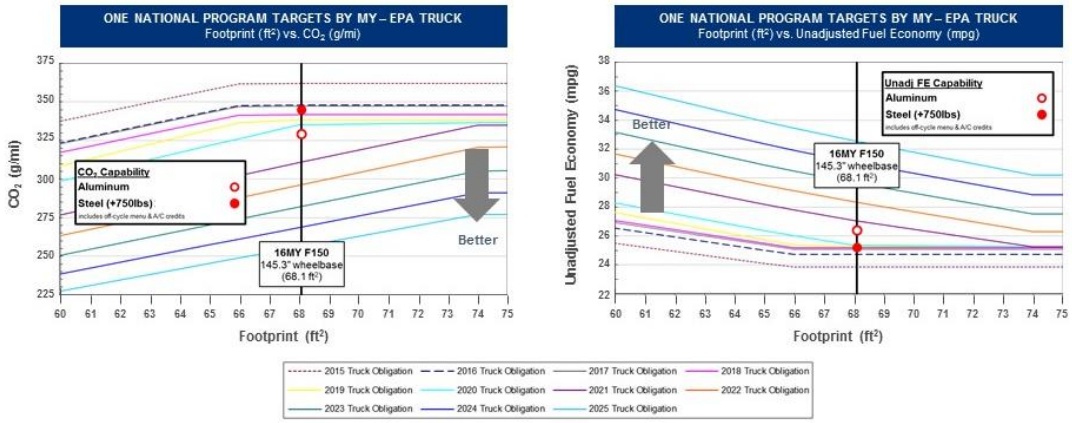
FUEL ECONOMY AND CO2 EMISSIONS STANDARDS



F150 achieves 2020 level Truck Fuel Economy and CO2 Emissions Regulations

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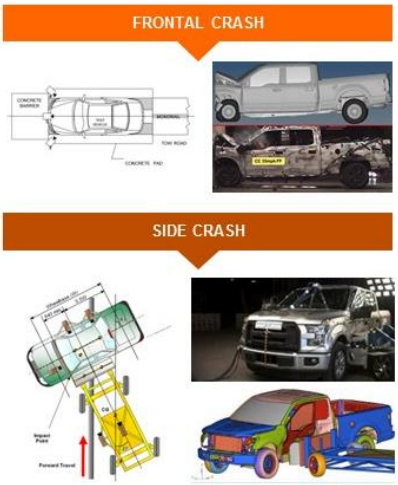
THE TRUTH ABOUT TRUCKS: SAFETY



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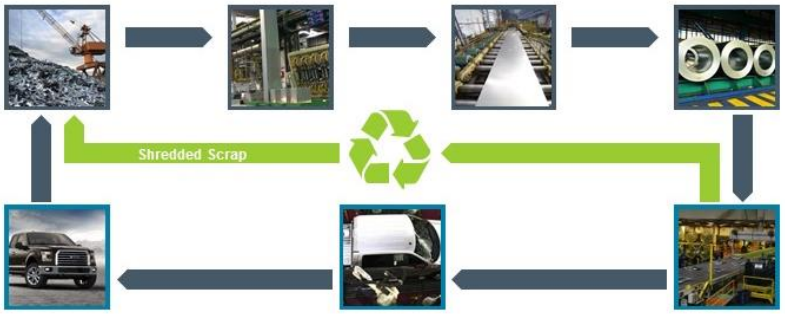
CONVERTING THE BODY SHOP IN 4 WEEKS

Ford
Go Further

40

ALUMINUM INTENSIVE VEHICLES – RECYCLING ISSUES

- Energy to recycle aluminum is approximately 5% of the energy required to extract, process and fabricate new metal
- In order to have "closed-loop recycling", alloys must be segregated by composition.
- Dearborn Stamping has new technology that allows for 4-way segregation.
- 87% of the total stamping scrap is tolled back to the aluminum suppliers
- Displaces 1/3 of the primary aluminum



Go Further

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MOST CAPABLE

BEST-IN-CLASS
TOWING
UP TO 12,200 LBS

BEST-IN-CLASS
PAYLOAD
UP TO 3,300 LBS

MOST FUEL-EFFICIENT
F-150 EVER
26 MPG

Go Further

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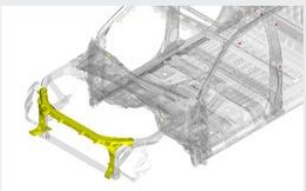
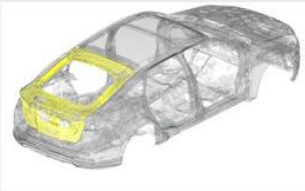
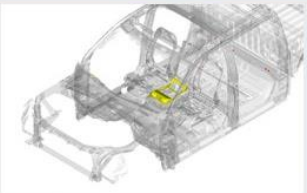
Magnesium Applications

Go Further

Cast Magnesium Body Applications

F-150 Magnesium Bolster	Magnesium Liftgate Fusion/MKT	Seat Frame F-150 & Explorer
		
In production since 2004 Approx. 6.5M units	In production since 2009 Approx. 100k units	In production since 2009 Approx. 2.2M units

Magnesium Summary

- *30% Lower density, plus thinner gage & lower draft angles leads to 40% lighter parts compared to Al castings.*
- *Less machining and not heat treating enables piece price savings compared to Al castings*
- *Longer tool life vs Al enables cost reduction.*

Go Further

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LOW VOLUME CARBON FIBER APPLICATIONS

Aston Martin Vanquish	Current Ford GT	Ford Mustang GT500KR	2016 Ford GT
			
Carbon fiber composite transmission tunnel, braided A-pillar, front end crash structure (400-800 units/year)	Carbon fiber composite rear deck lid and seats (4500 units total)	Carbon fiber hood (<5000 units/yr)	Carbon fiber Supercar

Ford
Go Further

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ONE PIECE CARBON FIBER REAR DECKLID INNER

Aluminum Inner – 12 Kg
Random Carbon Fiber - 6.5Kg

LARGEST MONOLITHIC CF DOOR INNER

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THE ALL NEW FORD GT CARBON FIBER SUPERCAR

Ford
Go Further

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OPTIONS FOR COMPOSITE INTENSIVE APPLICATIONS?

- New applications need to be transparent to existing downstream assembly processes and capable of tolerating e-coat oven bake temperatures.
- Early adoption will be limited to sub-assembly applications that have minimal impact on existing bill of process and assembly plant tooling.
- Longer term applications will include substantial elements of the primary body structure and require changes to the bill of process and new capital investment.

Roof and Floor Structure Panels

Body Side Structure Components

Go Further

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CURRENT ROAD BLOCKS

Current Road Blocks to Widespread Implementation of Carbon Fiber:

- Material Cost & Volatility
- Material availability
- Inadequate manufacturing methods for high volume throughput
- Legacy constraints (existing infrastructure)

Go Further

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SUMMARY

Body Lightweighting Conclusions

- Body lightweighting design will play an increasingly central role in new vehicle development
- Innovative and intelligent solutions are needed in material development and manufacturing technology
- These solutions need to be affordable and scalable to meet the OEM's global footprint, global platforms and volume requirements
- Body lightweighting trends toward higher grade and lighter alloy metals and composites will accelerate

Go Further

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Go Further

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Dr. Gerald COLE
President

Automotive Insight
USA, 48009 Birmigham / MI

Tel.: +1 248 626 3232
www.automotiveinsight.net

TITLE

Light Weighting the Automotive Industry - The Road to 2025 CAFÉ

ABSTRACT

By 2025, the U.S. automotive industry will have to average 54.5 mpg (4.3l/100km) Corporate Average Fuel Economy (CAFÉ). While new/improved powertrain technology is critical, 25-40% of the new CAFE will require significant vehicle mass reduction including using lightweight structural materials. This presentation discusses new developments in light metals (aluminum and magnesium), non-metals (plastics and carbon-fiber reinforced composites), and conventional heavy metals (iron and steel). Aluminum components used to be simple castings, requiring minimal fatigue strength and elongation. Now, vacuum die castings, stampings, forgings and extrusions can be used in structural applications where higher quality processing is required to improve elongation and strength. New grades of lightweight (i.e. thinner) ultra-high strength steels can save over 1/3 the mass vs heavier conventional mild steels but require more expensive processing. Engines can be lighter in compacted graphite cast iron than in aluminum because of its higher strength at higher combustion temperature and pressures. Lightweight materials often require specialized processing and assembly techniques to produce components and hybrid assemblies and require unique joining/bonding, and corrosion-inhibiting techniques. The presentation will examine lightweighting strategies of Asian, American and, European marques and the materials, component designs and assembly techniques to achieve the required corporate CAFÉ.

Light Weighting the Automotive Industry
The Road to 2025 CAFE

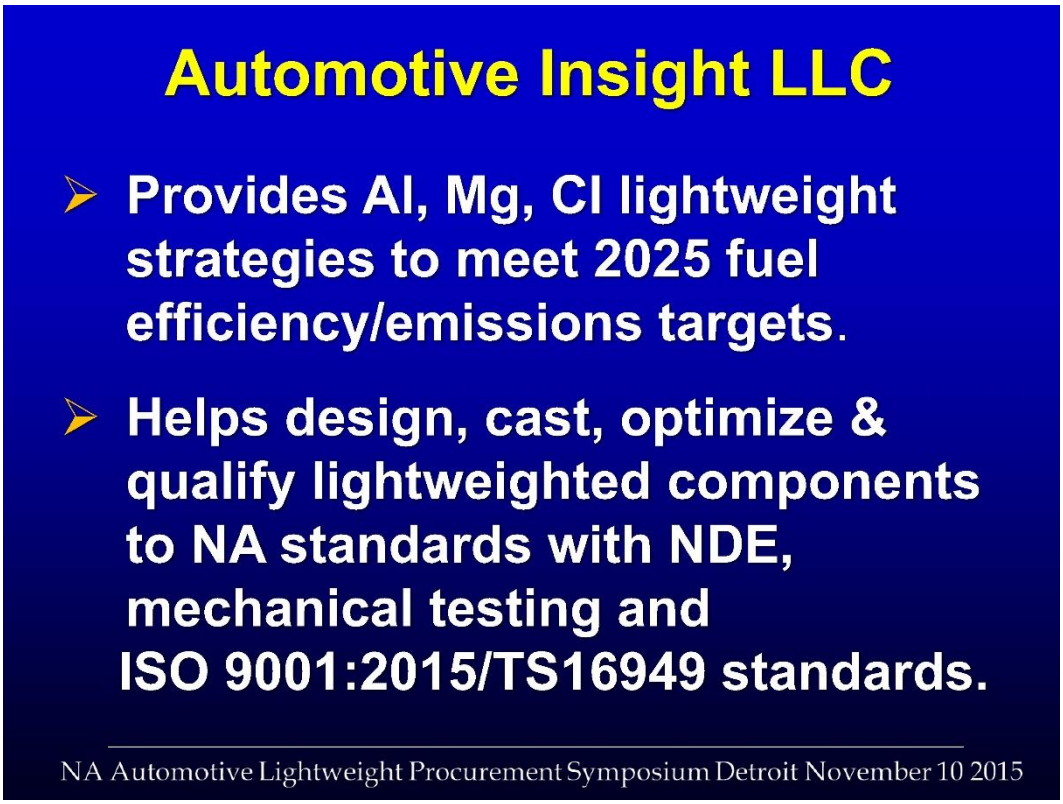
Gerald S Cole, PhD, FASM
Director Lightweight Operations
Automotive Insight LLC, Troy MI USA
Ford Motor Company Sr. Staff Tech Specialist (retired)

gcole@automotiveinsight.net

Organization of Presentation

- Who Is Automotive Insight LLC
- CO_2 emissions, CAFÉ
- Importance of mass reduction
- Automotive materials (S,A,P,M,MM)
- Joining different materials
- MR in select vehicles…Ford F150
- Summary and Conclusion


Automotive Insight LLC
automotiveinsight.net
NA Automotive Lightweight Procurement Symposium Detroit November 10 2015


Automotive Insight LLC
Provides Al, Mg, CI lightweight strategies to meet 2025 fuel efficiency/emissions targets.
Helps design, cast, optimize & qualify lightweighted components to NA standards with NDE, mechanical testing and ISO 9001:2015/TS16949 standards.
NA Automotive Lightweight Procurement Symposium Detroit November 10 2015

Automotive Insight LLC

- Connects die casters with NA OEM's/Tier 1's.
- Facilitates JV/M&A partnering between Asian and NA die casters to enhance NA supply base capabilities.

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There is a major effort by NA governments to reduce emissions via improved CAFÉ

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2010: 22.4 mpg
2011: 27.3 mpg
2012: 33.3 mpg car
25.4 mpg truck
2016: Fleet av 35mpg
39.5 mpg cars
30 mpg trucks.
2025: 54.5 mpg

Actual standards are vague. Credits exist for electric, hybrid, H_2 & E85.

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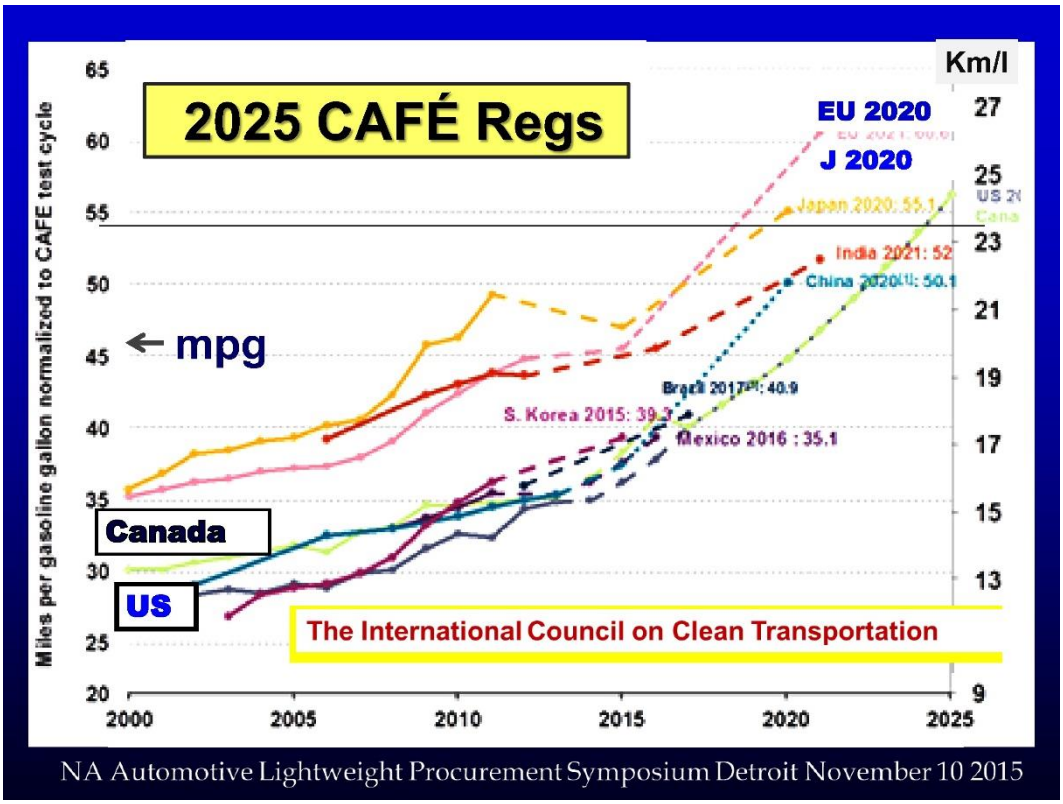

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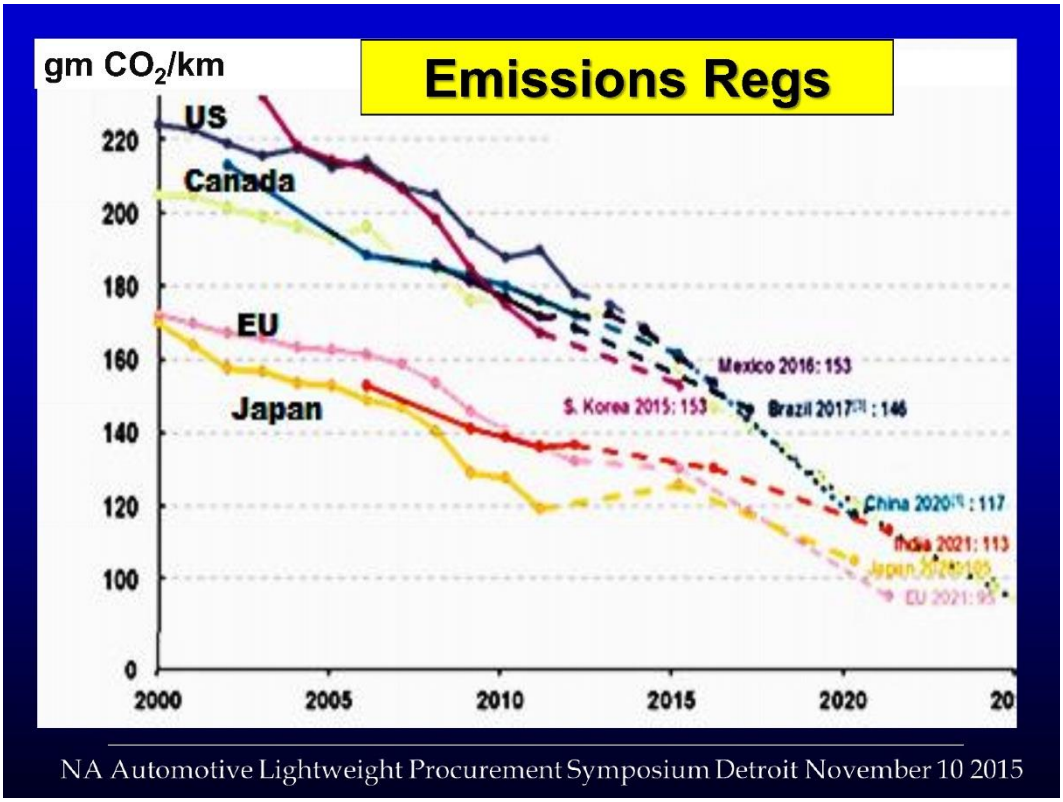
gm CO_2/km
Emissions Regs
US
Canada
EU
Japan
Mexico 2016: 153
S. Korea 2015: 153
Brazil 2017[N] : 146
China 2020[N] : 117
India 2021: 113
EU 2021: 95
220
200
180
160
140
120
100
0
2000
2005
2010
2015
2020
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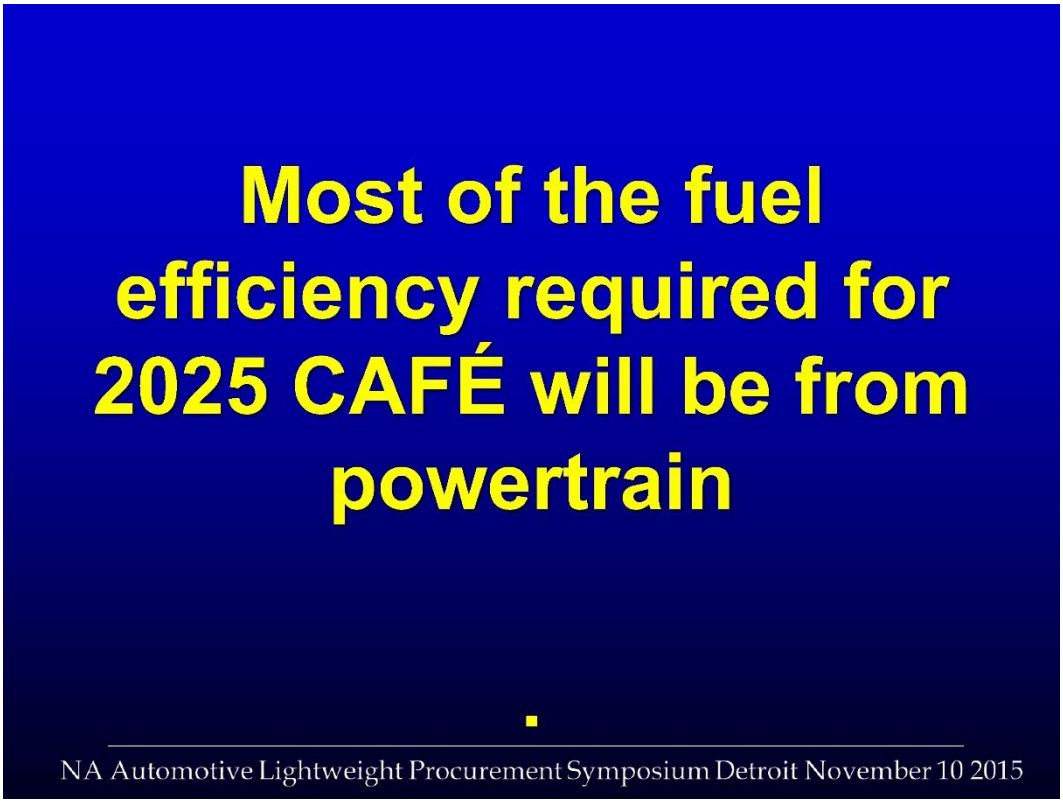
Most of the fuel efficiency required for 2025 CAFÉ will be from powertrain
.
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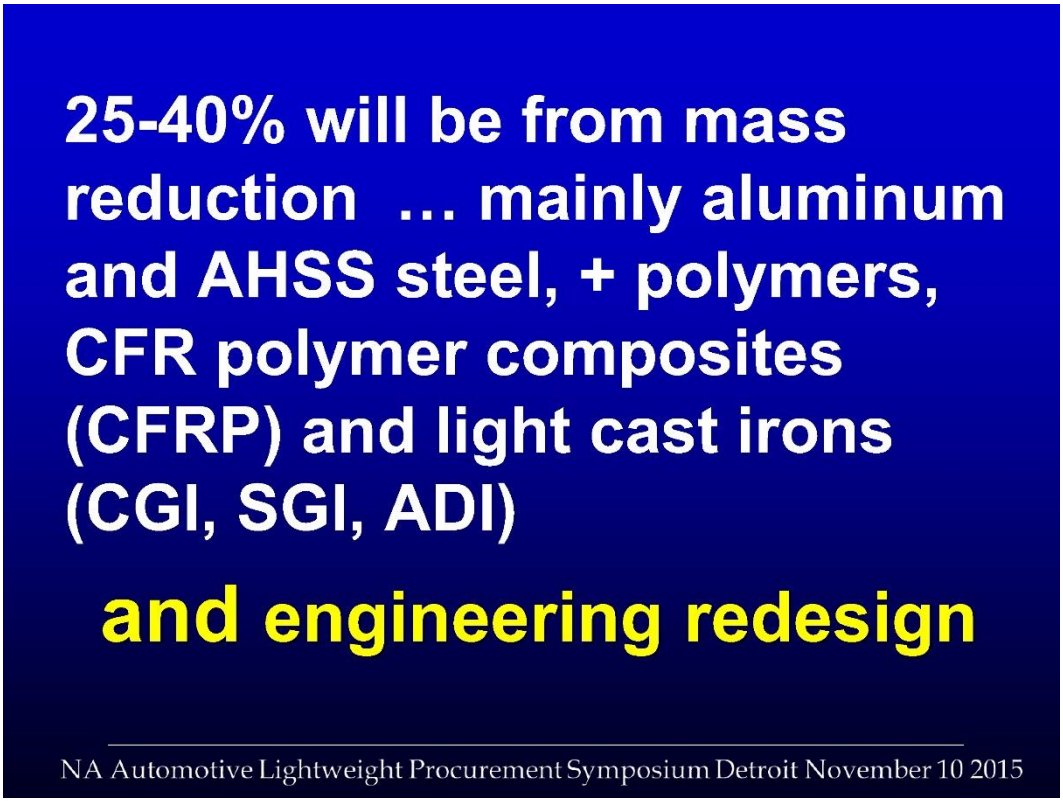
25-40% will be from mass reduction … mainly aluminum and AHSS steel, + polymers, CFR polymer composites (CFRP) and light cast irons (CGI, SGI, ADI)
and engineering redesign
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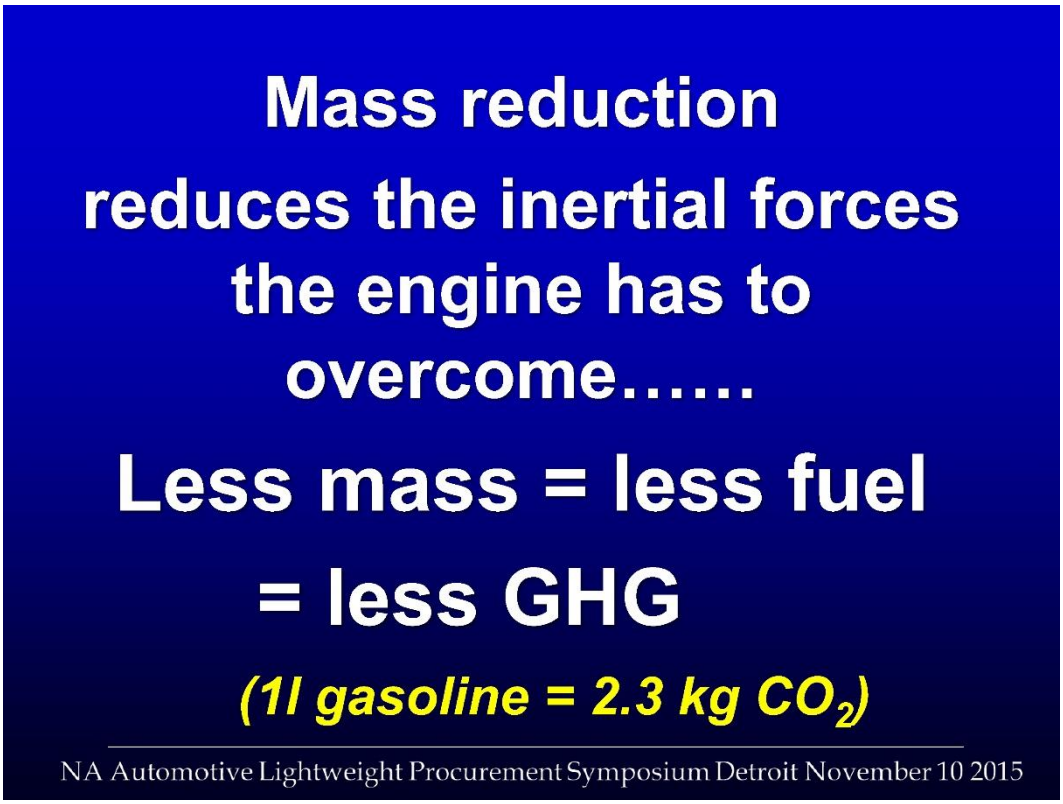
Mass reduction
reduces the inertial forces the engine has to overcome……
Less mass = less fuel
= less GHG
(1l gasoline = 2.3 kg CO_2)
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Typically 10% MR equates to 3-6% FE or ER improvement.

IF THERE IS MASS COMPOUNDING

1 k MR results in secondary MR via downsizing: powertrain, suspension, brakes, wheels, fasteners, a further 0.25-0.5 k

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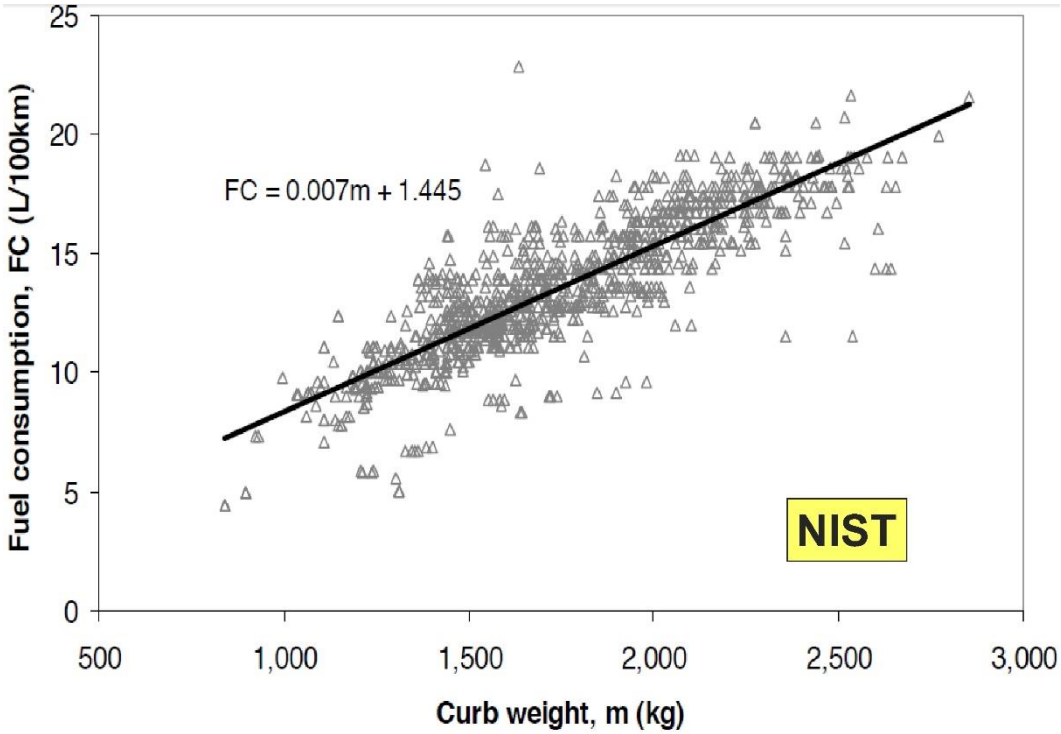

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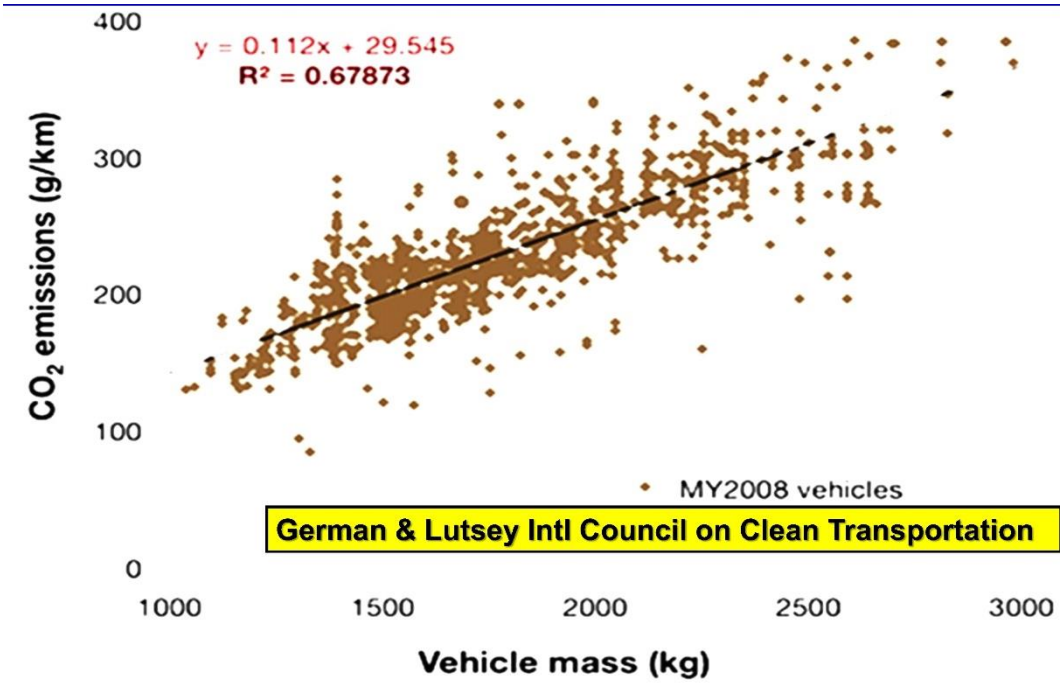

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(6/19/2015) EPA, DOT Proposed GHG/Fuel Efficiency Standards for Heavy-Duty Trucks

10% MR reduces fuel by 5-10%

- 10 Cast Al wheels save 400 #
- Al axle hubs save 120 # vs iron or steel
- Al clutch housing saves 50 # vs iron
- Downsized engine saves over 700 #
- Composite Ft axle springs save 70 #

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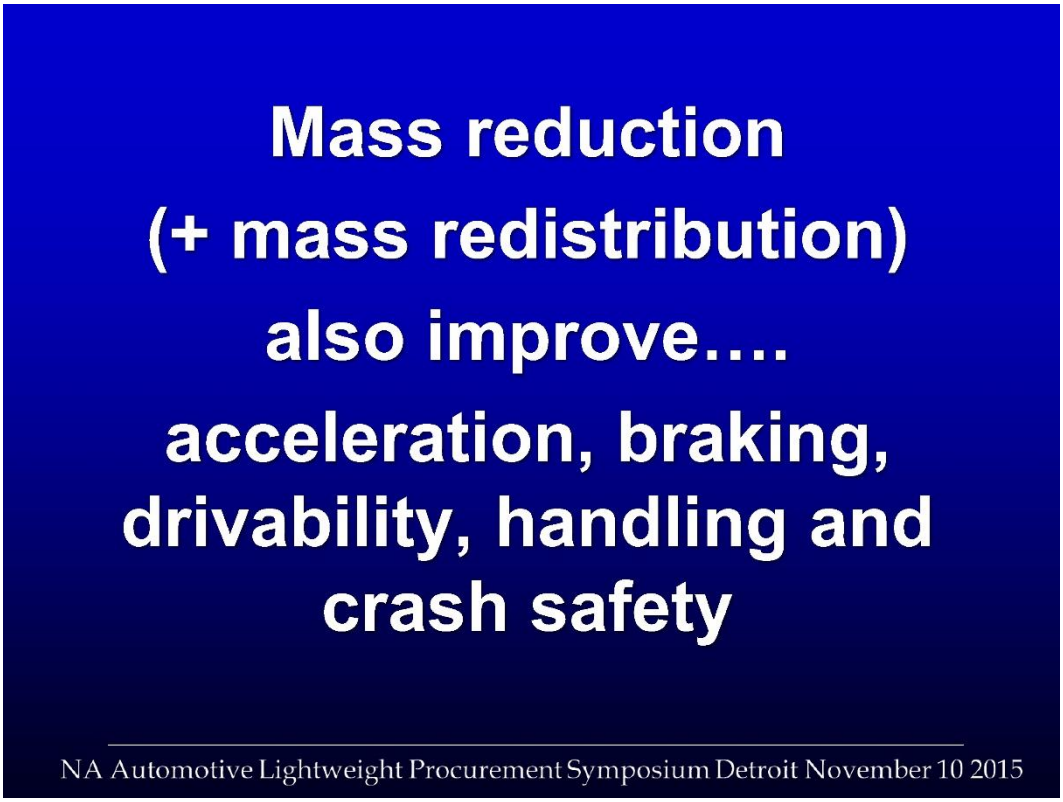
Mass reduction
(+ mass redistribution)
also improve….
acceleration, braking, drivability, handling and crash safety
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All auto companies are now designing 3-5% annual mass reduction as a strategic requirement for new product development.
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Every vehicle component is being scrutinized from door latches to headlights, powertrain, body-in-white & body panels
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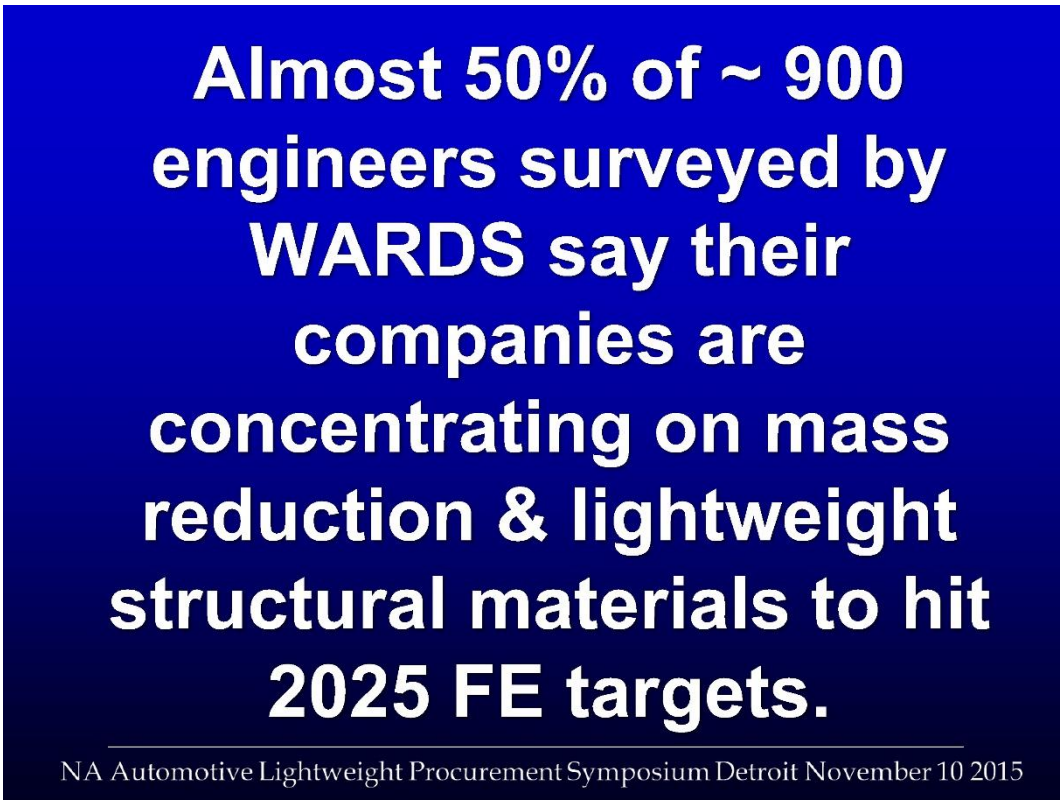
Almost 50% of ~ 900 engineers surveyed by WARDS say their companies are concentrating on mass reduction & lightweight structural materials to hit 2025 FE targets.
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Mazda Strategy

- MR is centerpiece of product planning. It is an essential technology in its environmental performance.
- Δ MR will be 110 kg from next generation of each model = 5 % FE increase for each new car.

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Koichi Kamiji, Sr Chief Engineer for Auto Safety, Honda R&D

The premium of MR requires

- *Not only new lightweight materials*

BUT

- Shaving grams from any component not related to safety"
- New engineering/design architectures,
- Advanced cabin safety technologies

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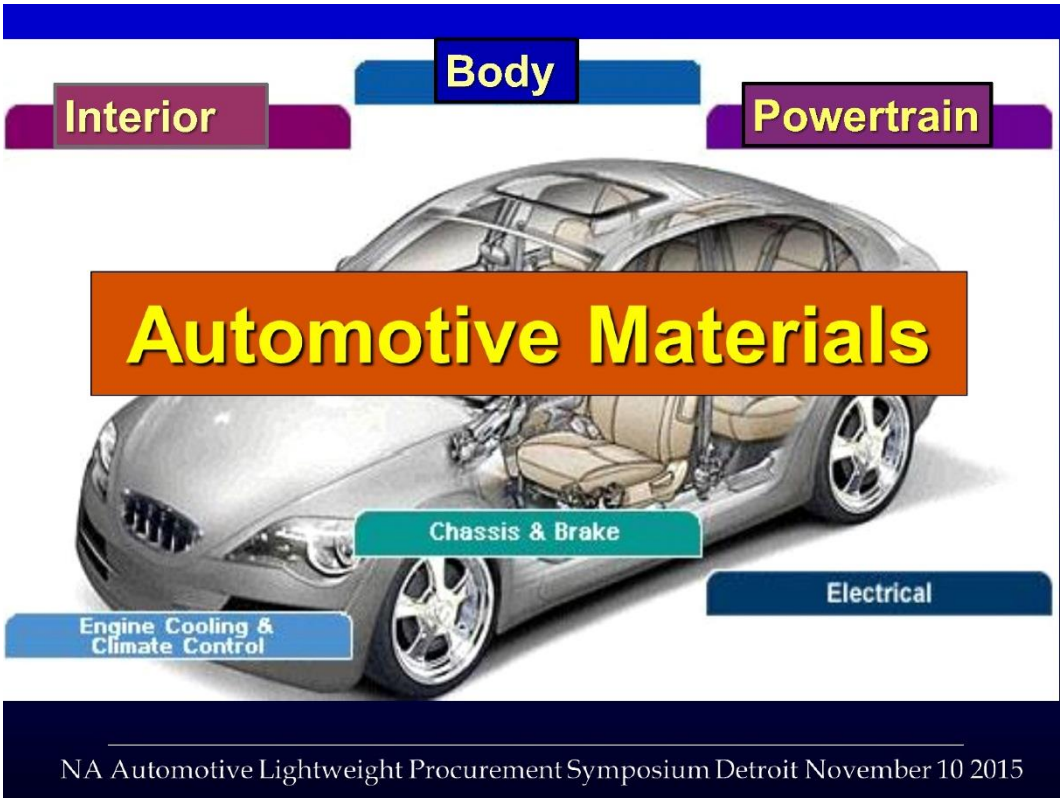
Body
Interior
Powertrain
Automotive Materials
Chassis & Brake
Electrical
Engine Cooling & Climate Control
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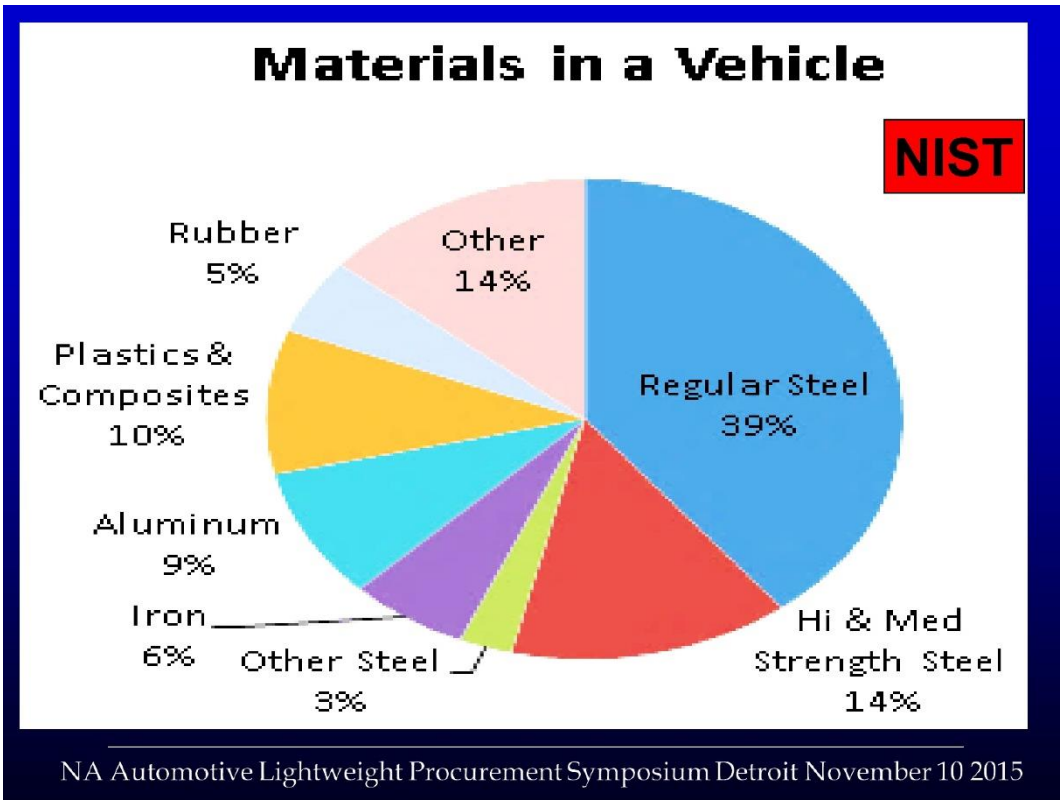
Materials in a Vehicle
NIST
Rubber 5%
Other 14%
Plastics & Composites 10%
Regular Steel 39%
Aluminum 9%
Iron 6%
Other Steel 3%
Hi & Med Strength Steel 14%
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Steel
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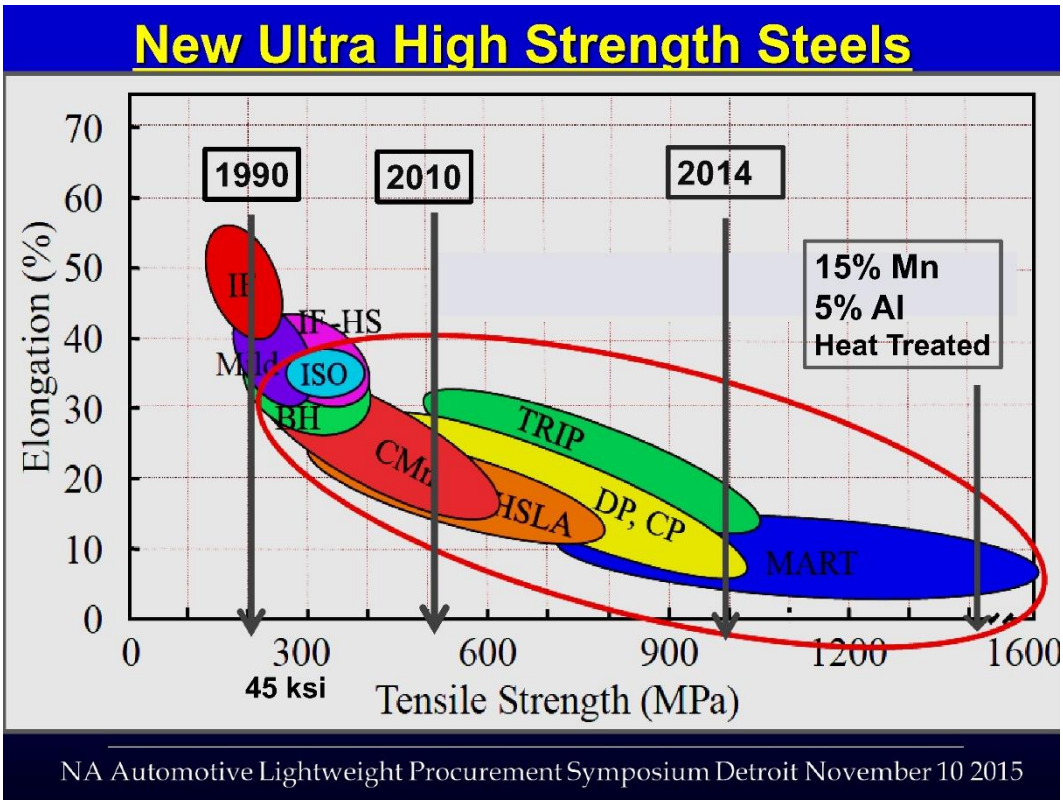
New Ultra High Strength Steels
1990
2010
2014
15% Mn
5% Al
Heat Treated
IF
IF-HS
ISO
BH
CMn
HSLA
TRIP
DP, CP
MART
Elongation (%)
70
60
50
40
30
20
10
0
0
300
600
900
1200
1600
45 ksi
Tensile Strength (MPa)
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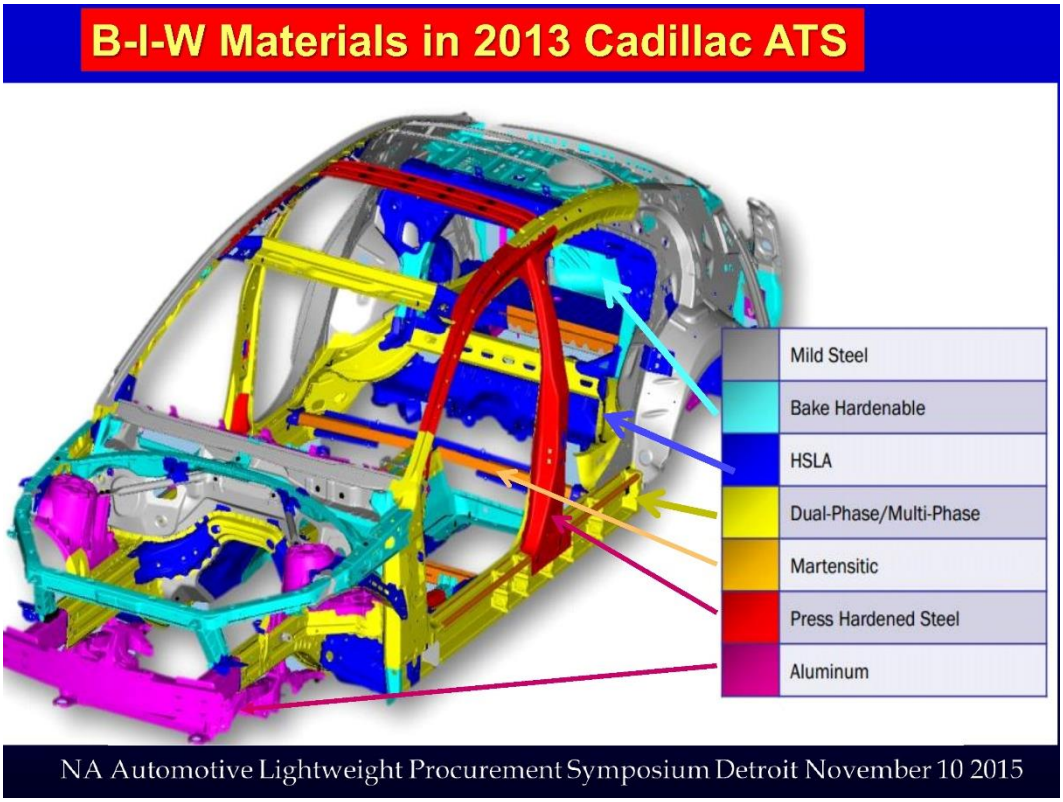
B-I-W Materials in 2013 Cadillac ATS
Mild Steel
Bake Hardenable
HSLA
Dual-Phase/Multi-Phase
Martensitic
Press Hardened Steel
Aluminum
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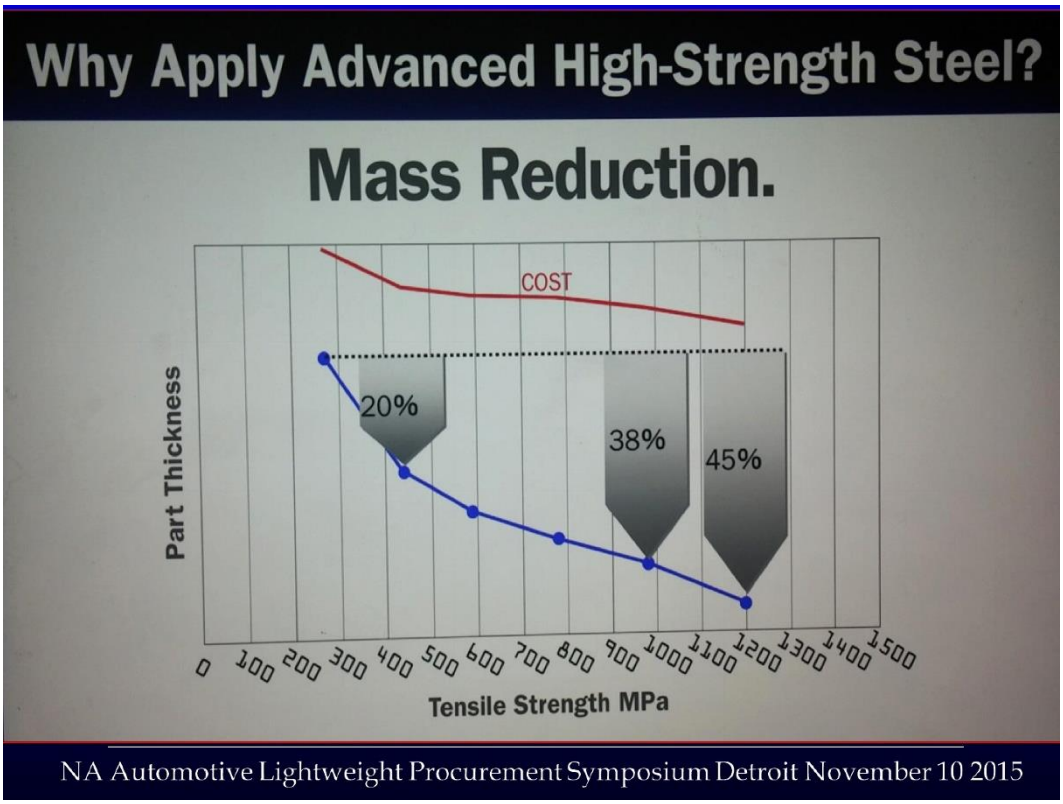
Why Apply Advanced High-Strength Steel?
Mass Reduction.
COST
20%
38%
45%
Part Thickness
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
Tensile Strength MPa
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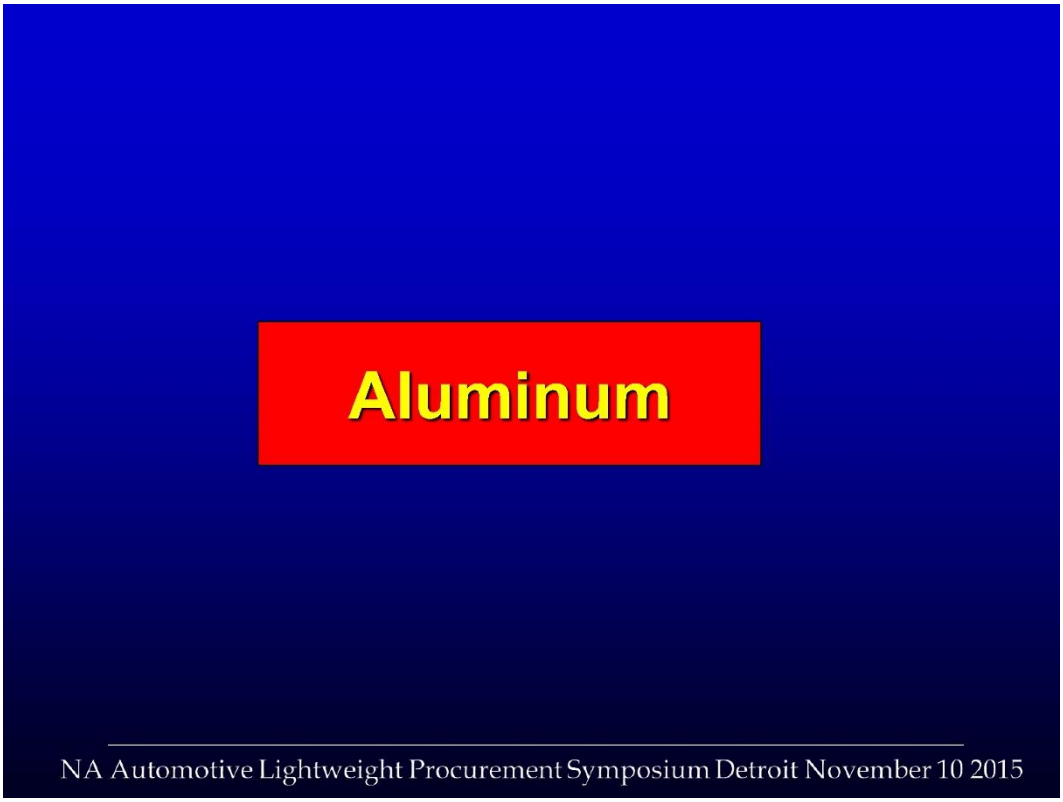
Aluminum
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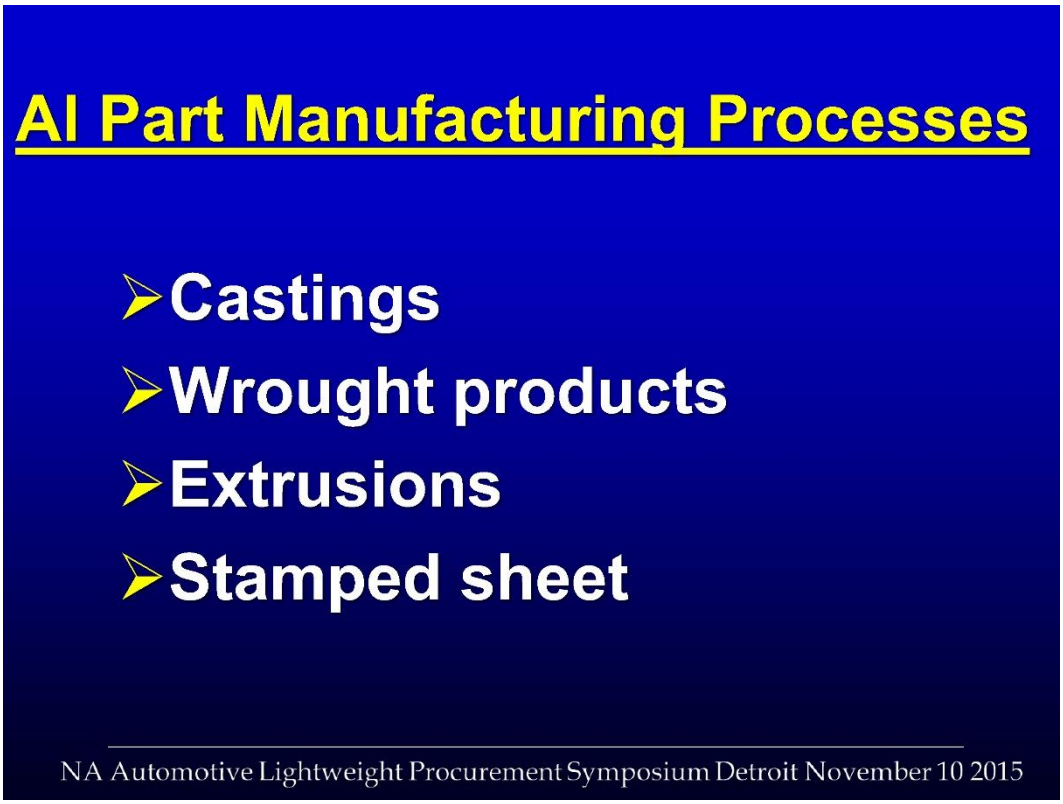
Al Part Manufacturing Processes
Castings
Wrought products
Extrusions
Stamped sheet
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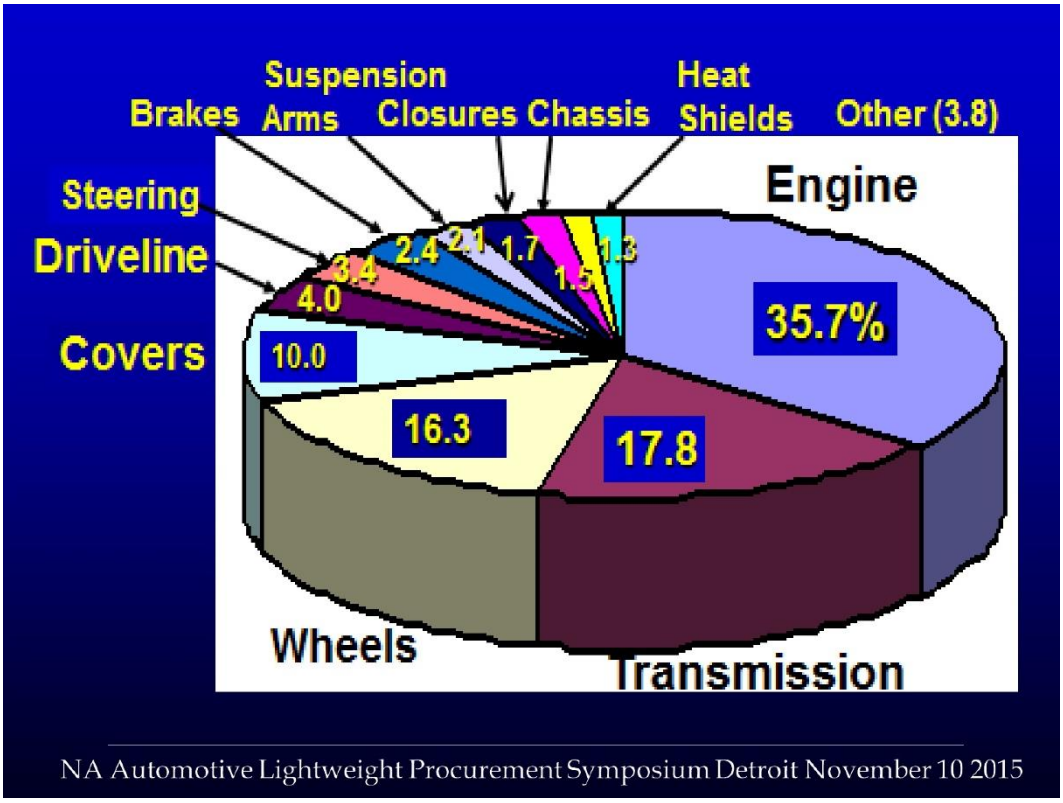
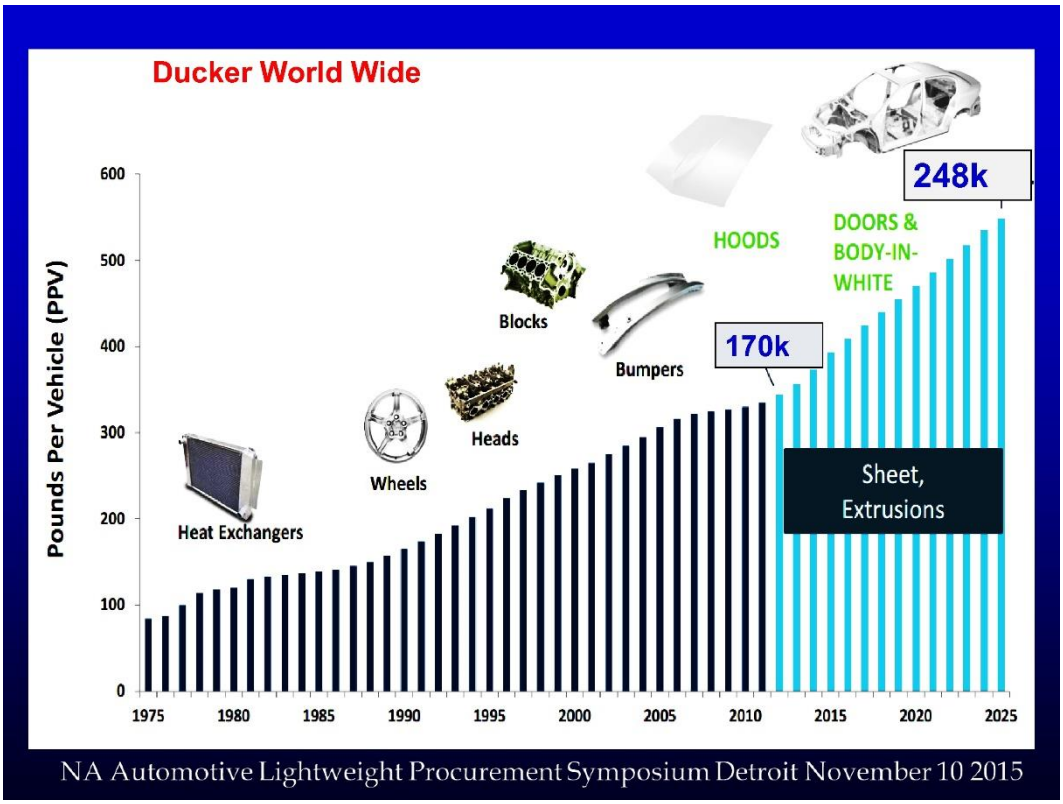
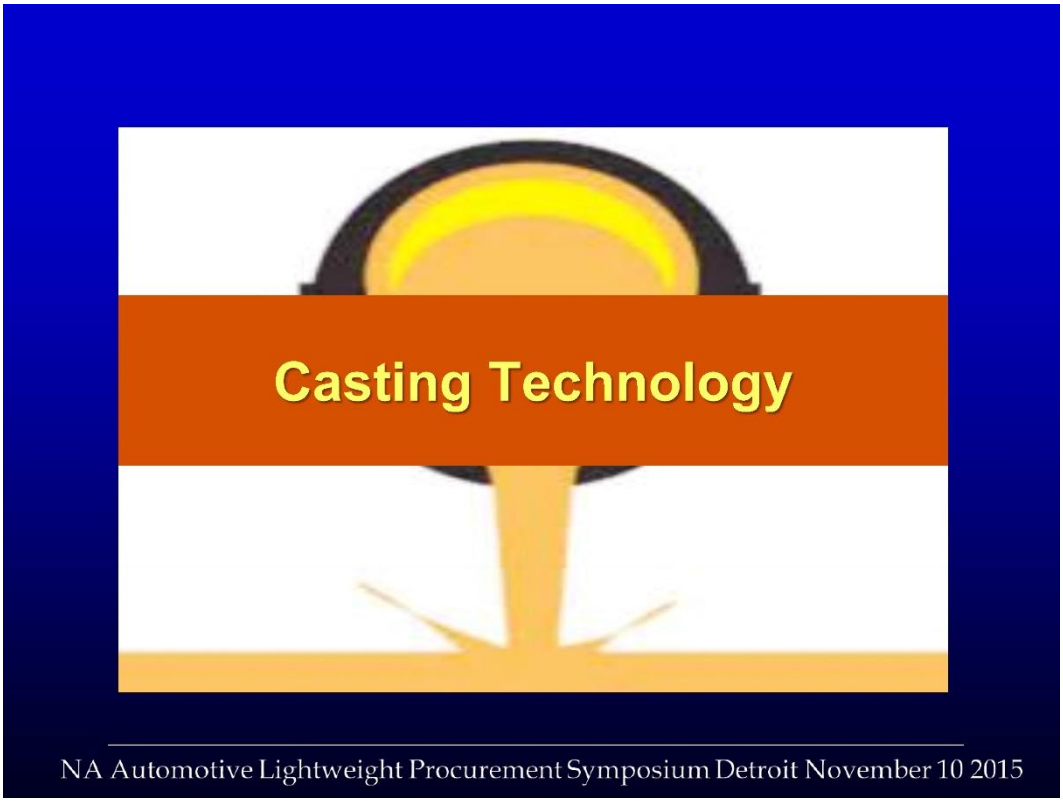
Automotive Insight







- New CAE, casting processes (LP/vacuum HPDC), & heat treat increase quality & improve fatigue & tensile properties.
- HPDC dominates for most engine blocks, heads, manifolds & transmissions .. But there are porosity & fatigue-related defects.

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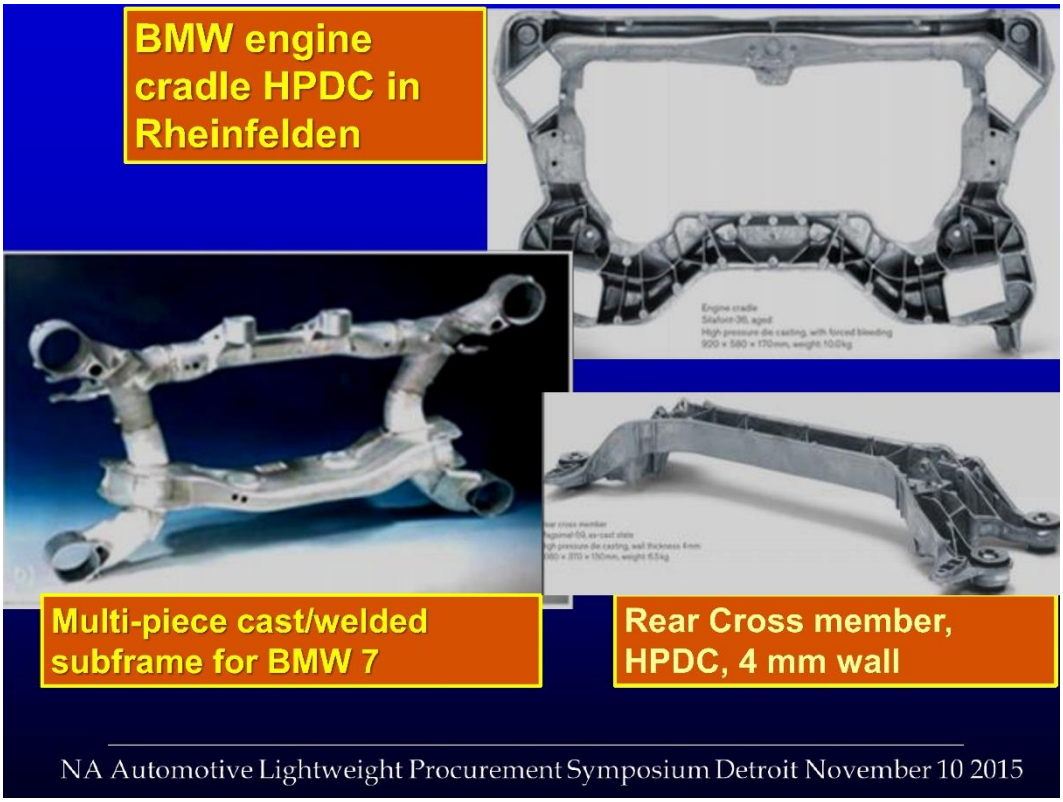
BMW engine cradle HPDC in Rheinfelden
Multi-piece cast/welded subframe for BMW 7
Rear Cross member, HPDC, 4 mm wall
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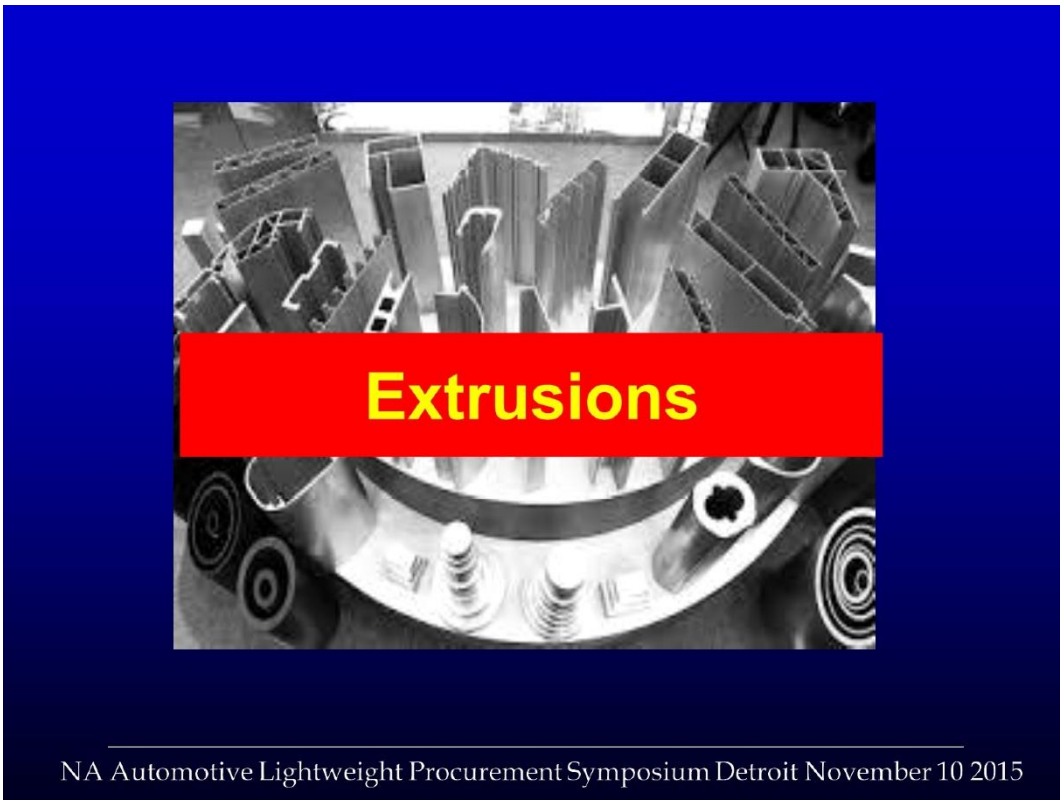
Extrusions
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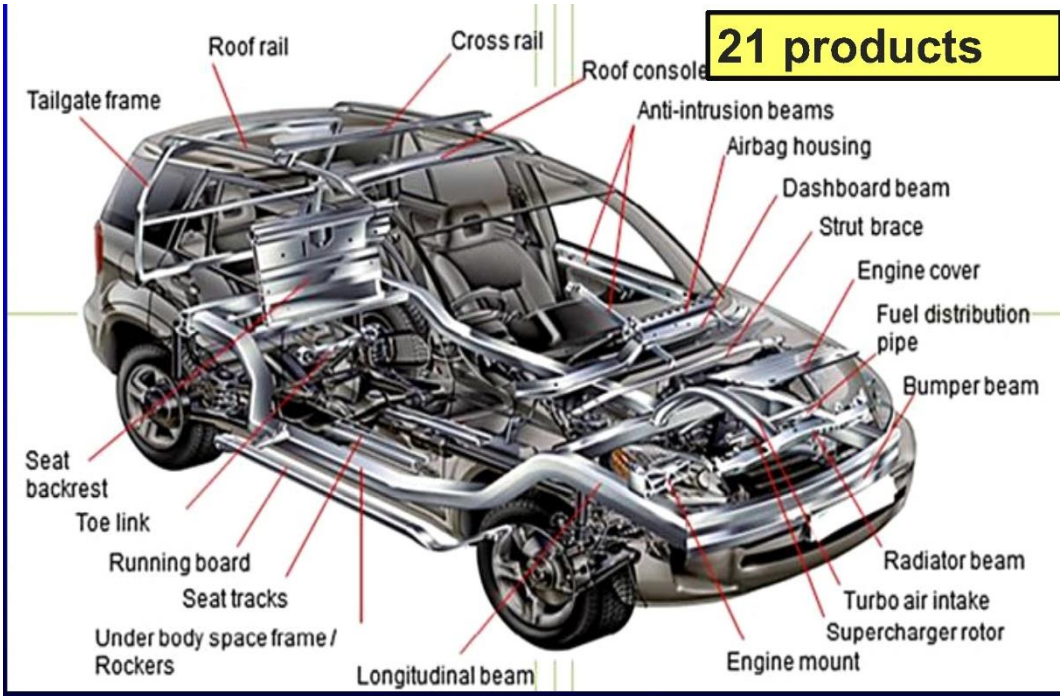
21 products
Roof rail
Cross rail
Roof console
Tailgate frame
Anti-intrusion beams
Airbag housing
Dashboard beam
Strut brace
Engine cover
Fuel distribution pipe
Bumper beam
Seat backrest
Toe link
Running board
Seat tracks
Under body space frame / Rockers
Longitudinal beam
Radiator beam
Turbo air intake
Supercharger rotor
Engine mount
Al Extrusion Council
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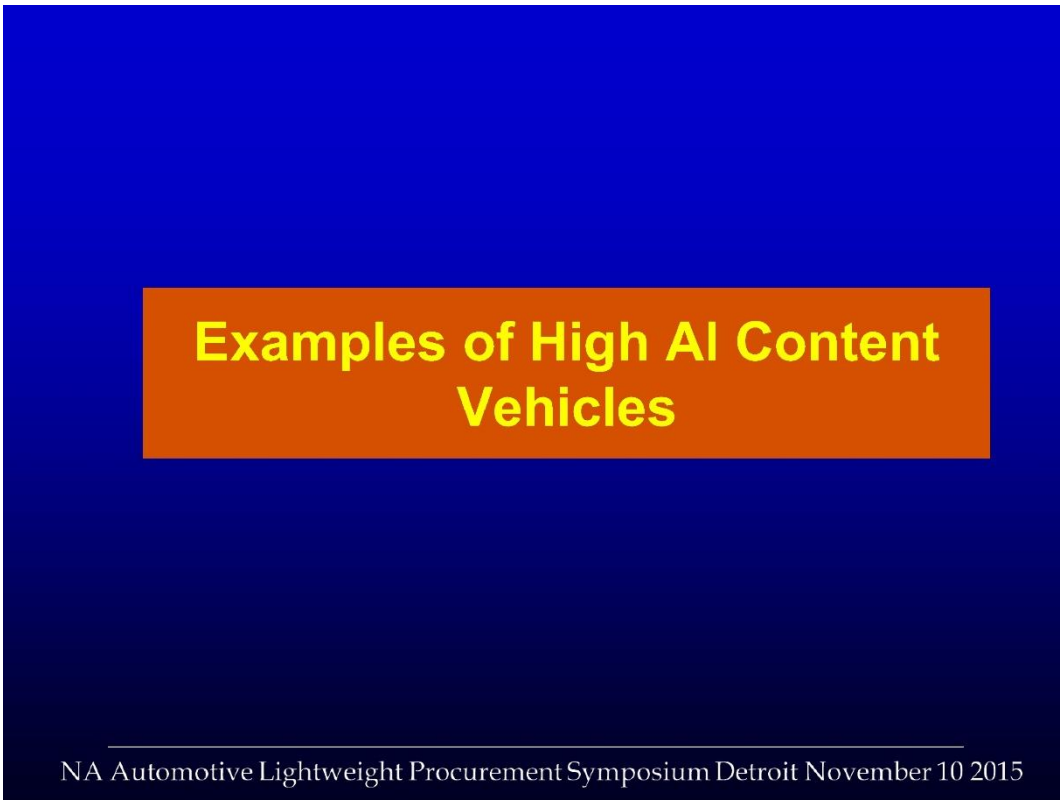
Examples of High Al Content Vehicles
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2013 Range Rover Sport

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- **561 kg** conventional Al & 20% higher strength AC600 PX alloy used in the sheet intensive body.
- Al 356/T6 heat treated cast alloy used for structural applications in control arms, knuckles, sub-frames & instrument panel.
- Fuel efficiency increased by ~15 % from 23 mpg to 26 mpg

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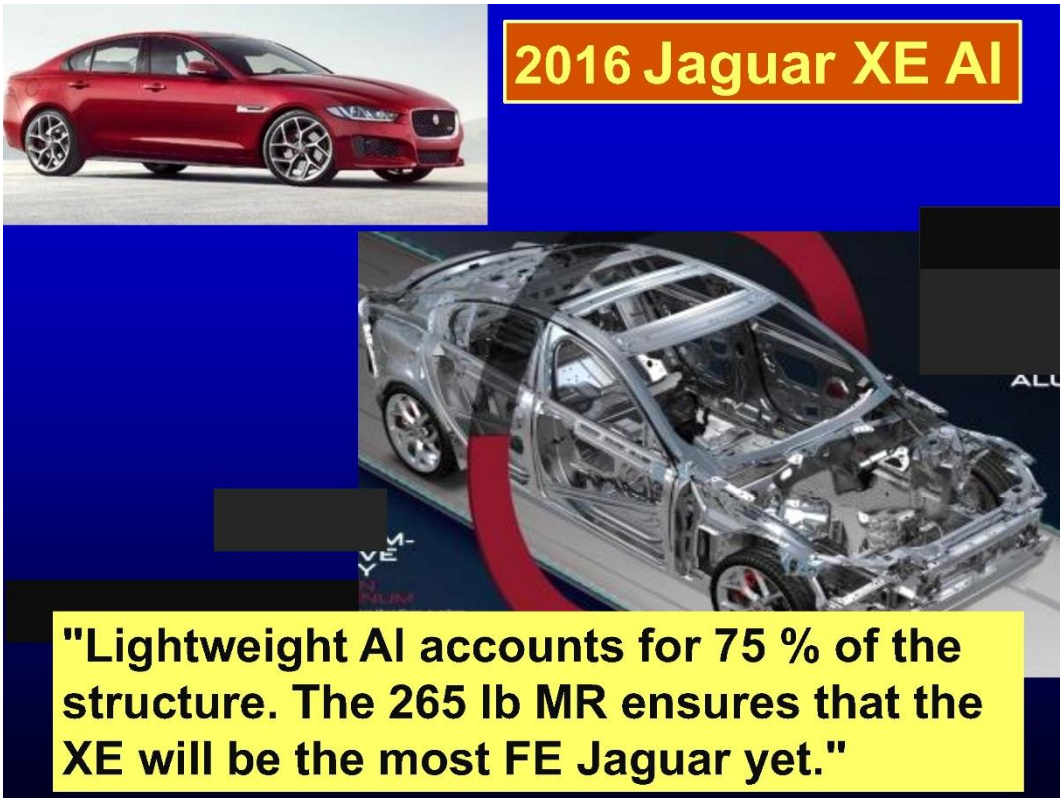

- More Al Vs previous: body sides, hood & fenders are stamped 6000-series. HPDC Al front suspension towers give greater stiffness.
- Self-piercing rivets/structural adhesives.
- Advanced hot-formed B steel in rear members & B-pillar reinfs.
- Mg alloys in front-end carrier & cross-car beam.

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2015 Ford F-150 pickup truck

Most novel Al–intensive vehicle.

@ 770,000 units,

#1 vehicle sold globally

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Al body

AHSS frame

- **High-strength alloy 6000-T4: dent resistant, formable, Class A surface. 30 kg extrusions. All skins collected and recycled by Alcoa**
- **4000 rivets. New Alcoa pretreatment & adhesives.**

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- 450 kg total Al: 300 kg in cargo box, body, hood, tailgate
- Chassis/frame: 77% HSS vs 23%
- Low mass CGI engine block *
- *~318 kg lighter (+ 12-13%)*
- 8-20% better fuel efficiency (~30 mpg)

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Ducker

- By 2025, 18% of vehicles will have all-Al bodies compared with < 1% now. By 2025, 70% of pickups could be Al intensive.
- It's a big risk but worth the effort.

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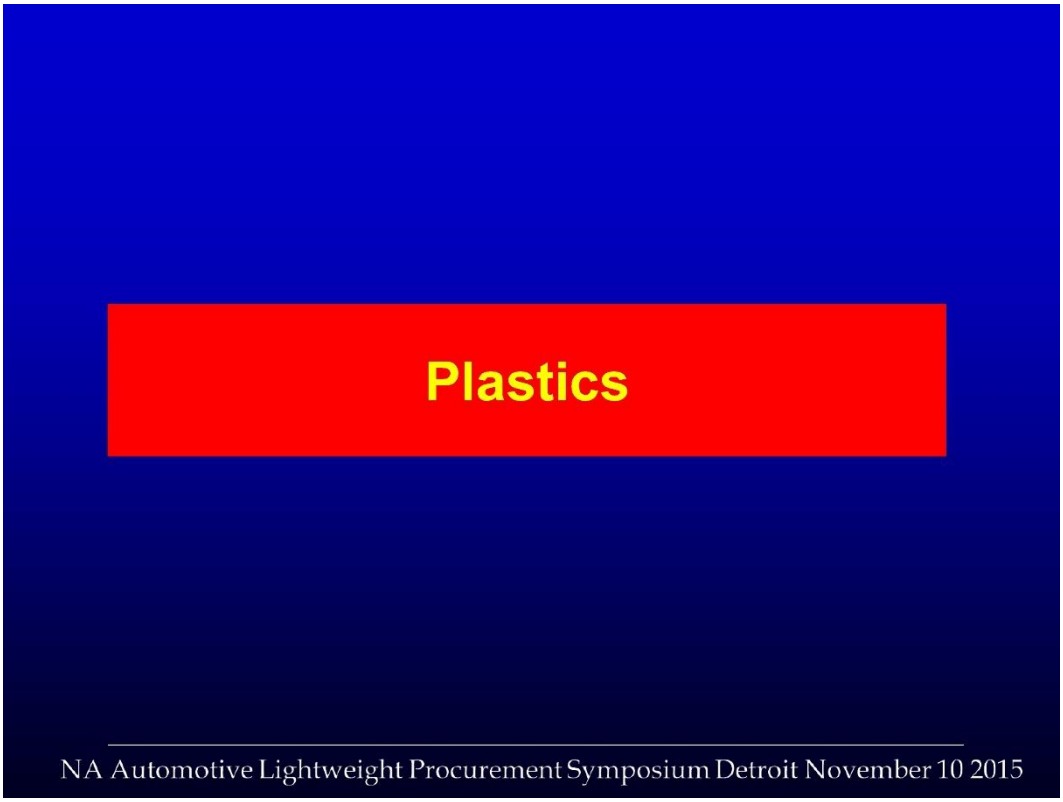
Plastics
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Plastics Poised for Comeback
OEM's intensifying their search for MR ideas. Plastics ~ 50 % lighter vs comparable steel parts in fenders and other exterior pieces on Renault, Peugeot, Citroen, Mitsubishi and Chery vehicles.
But good computer models of crash are lacking
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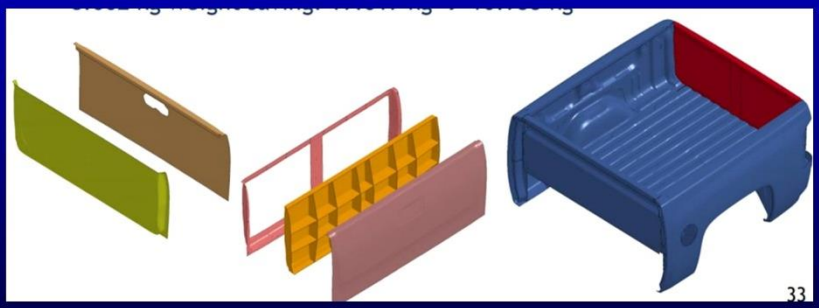
Truck Bed

Steel replaced by blend of PBT or PET & polycarbonate, + polypropylene reinforced with long glass fibers



- **MR 8.66 kg (19.62 – 10.96 kg)**

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Plastic

Door Intrusion Beam

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BMW Lightweighting

"There is no way around making cars lighter. Steel has reached its limit, and carbon fiber reinforced composites (CFRPs) are now

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DCT (a Detroit-based company) developed a 15% C-fiber (7 µm, 50:1 aspect ratio) 85% epoxy resin blend paste.

- 1 mm paste sprayed & cured onto 0.6 mm steel sheet increased dent resistance ~ 0.8 mm thick sheet

= 20% mass reduction at no cost.

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Magnesium
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>170 kg many HPDC Mg parts DVPR certified/ installed on global vehicles over past 35 years
But the average NA vehicle contains only 6 kg
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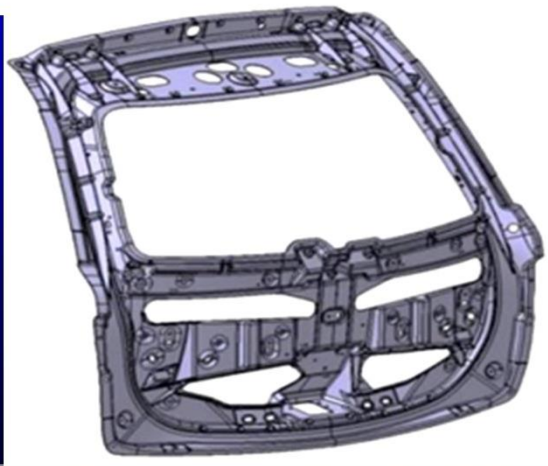
Lincoln MKT liftgate armature

Cast Mg has tooling cost advantage over stamped Al & steel at low volumes.

Mg weighs 10kg vs steel at 20kg



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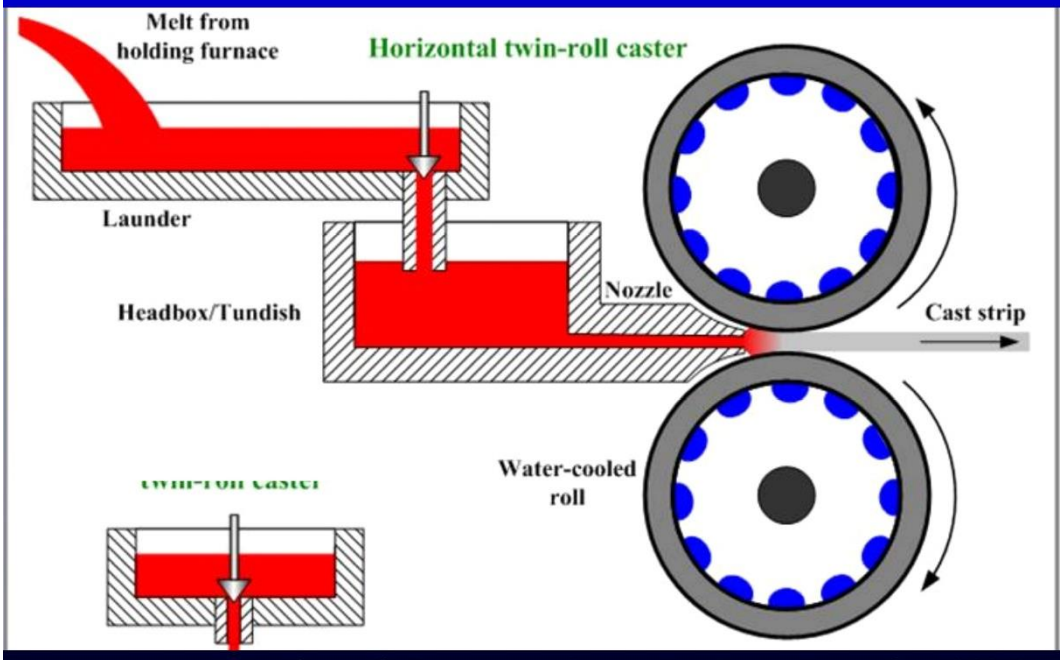
POSCO Next Gen Mg Technology



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Renault Samsung Motors and POSCO invested $1.9 m to develop Mg sheet for a trunk and rear seat that weighed 1.4kg, saving 2.2kg vs the equivalent steel component… a 61 % MR.

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Porsche 911 Uses POSCO Mg Skin for Roof

Vehicle weight reduced by 10 kg. 30 % lighter than Al
Light roof lowers CofG, improves stability.

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Multimaterial Construction
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SAE Survey
Rank which materials will help you reach fuel economy standards
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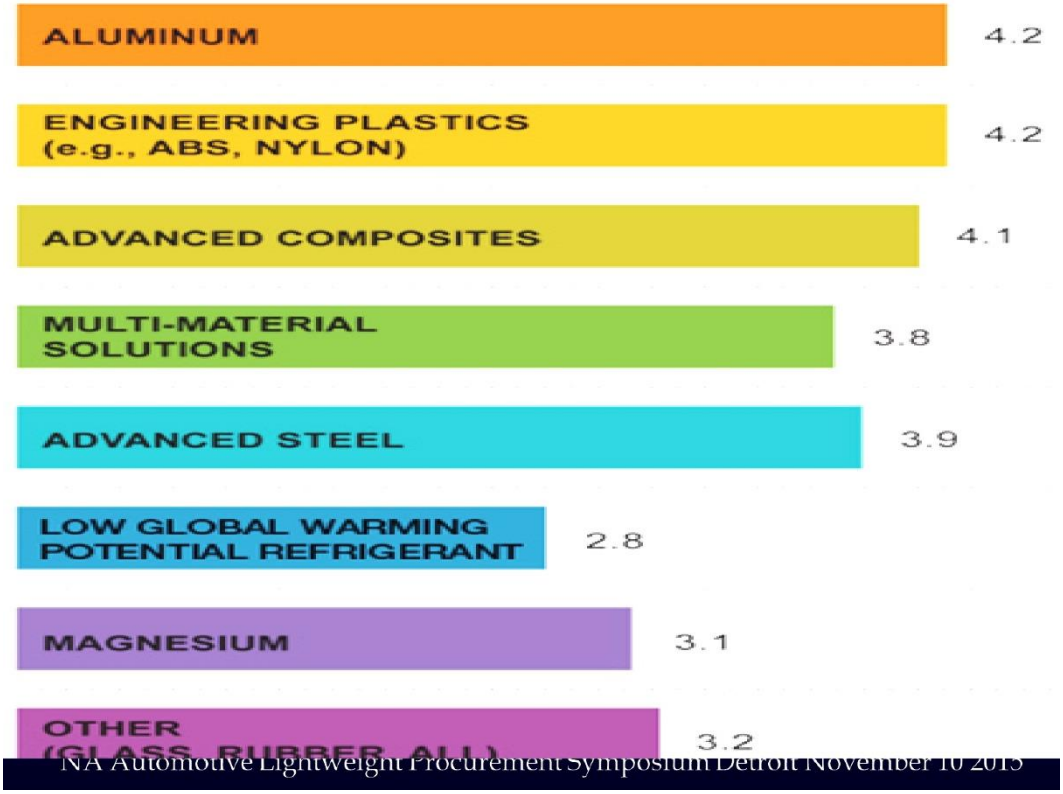

Ford Advanced Prototype Fusion

- 19-inch CFRP wheels, Δ 42%
- Composite coil springs, Δ 57%
- SS-coated Al rotors Δ39 % vs CI
- CFRP seats
- Chemically toughened laminate windows, Δ35%
- 40% MR engine block

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BMW M3

CFRP strut brace, driveshaft, roof panel (-40% vs steel)
Al control arms, wheel hubs, subframes, hood, front panels
Engine: Twin wire arc-coated cylinder walls vs CI liner,
Mg Sump …(-10 kg),

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Joining and Assembly of Hybrid Structures

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- Assembling hybrid structures requires unique joining, bonding & corrosion-inhibiting techniques ….requiring novel structural adhesives
- But there are concerns……
  - Crash modeling
  - Manufacturing models, SPC

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- Surface preparation (primers)
- Adhesion properties of epoxies, hot melts, phenolics, acrylics
- Chemical reactions
- Cure time affected by environment (RH, temperature),
- Joint mechanical durability affected by fatigue & corrosion
- no good FMEA failure models

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Ford (+Magna) LightWeight Concept (Multi-material) Mixed Materials

D. Wagner, M. Zalucek (Ford)
J. Conklin, T. Skszelk (Magna Intl)

SAE 2015
ASM Advanced Materials & Processes, March

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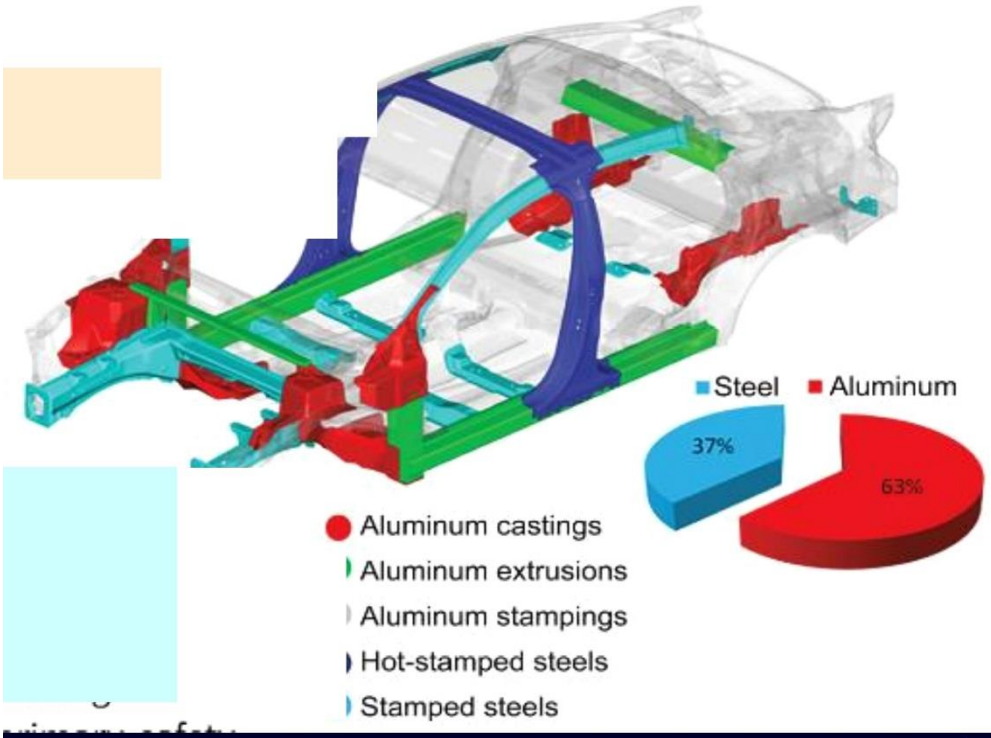

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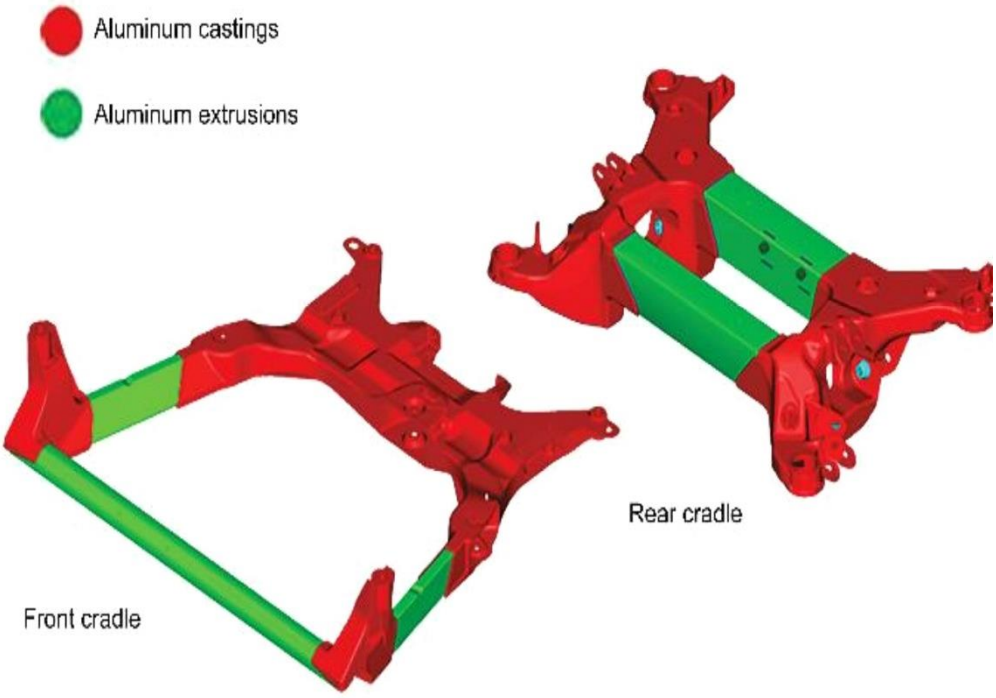

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Weight Reduction of Vehicle Subsystem

Vehicle systems and subsystems	2013 Ford Fusion weight, kg	MMLV weight, kg	MMLV curb weight, %	MMLV weight reduction, kg	MMLV weight reduction, %
1. Body	525.0	400.4	33.5%	-124.6	-23.7%
2. Interior	260.4	202.7	17.0%	-57.7	-22.2%
3. Chassis	355.0	260.0	21.8%	-95.0	-26.8%
4. Powertrain	337.0	263.1	22.0%	-73.9	-21.9%
5. Electrical	57.0	49.5	4.1%	-7.5	-13.1%
A. Assembly	25.0	19.5	1.6%	-5.5	-22.0%
Total vehicle	**1559.4**	**1195.2**	**100%**	**-364.2**	**-23.4%**

Material	2013 Fusion	MM LV
AHSS	418	67
Conventional	414	290
Cast Iron	50	20
DC Al	146	148
Stamped Al	13	144
Extruded Al	16	67
Forged Al	0	10
Magnesium	2	16
Plastic	235	177
TOTAL	1560	1195 kg

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Governments are pushing emissions reduction and fuel economy
They fund lightweighting RTD as a way to achieve their goals
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NIST- New National Center for Automotive Lightweighting
Investigate how new vehicle materials hold up in collision, which is strongly influenced by material, part shape and stresses from body forming.
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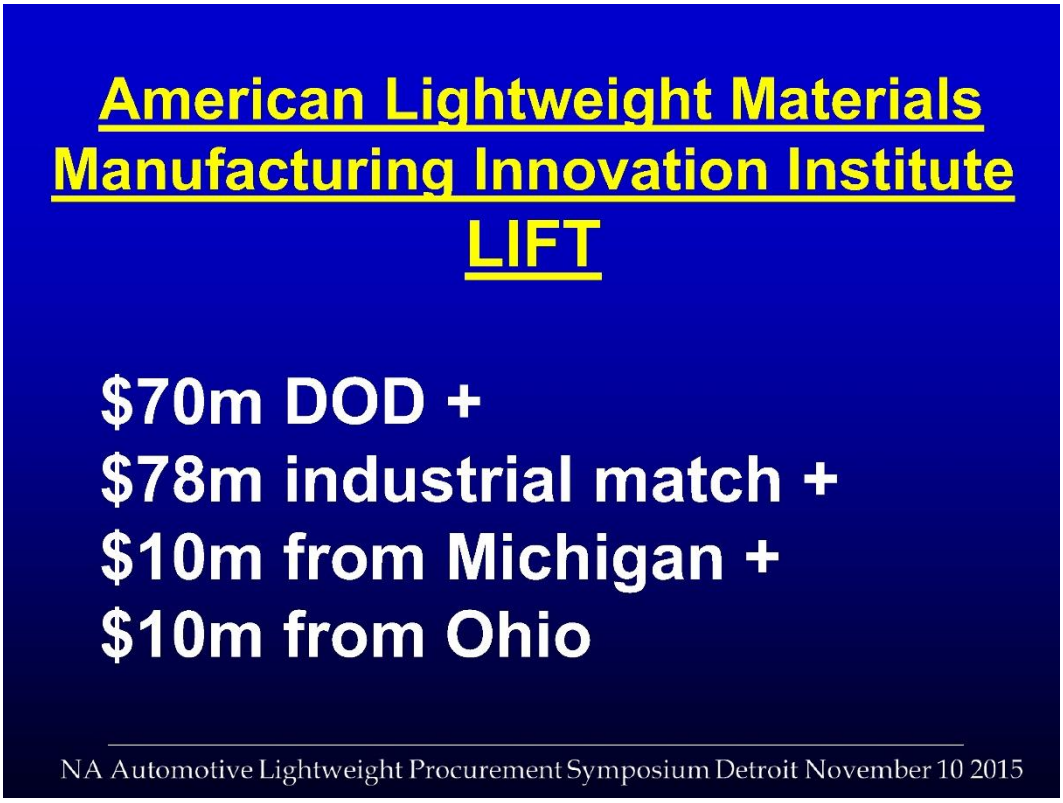
American Lightweight Materials Manufacturing Innovation Institute LIFT
$70m DOD +
$78m industrial match +
$10m from Michigan +
$10m from Ohio
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Establish regional manufacturing ecosystem to move cutting edge light metals out of lab & into commercial/ military: cars, trucks, planes & ships.
Help educate next generation manufacturing technical workforce.
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MFERD

Magnesium Intensive Front End R&D Project

(100 engineers and scientists from the 3 countries)

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Goal

- Demonstrate casting, extrusion, sheet & joining techniques of Mg in auto body structures.
- Predict & validate performance of Mg: crashworthiness, corrosion, fatigue & durability
- Part is 38 kg lighter than typical front-end steel structure.

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Cost of Mass Reduction

"How much will OEM's pay to meet CAFÉ requirements".

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Mass Reduction Costs

- Ducker report (2011):
  - 10% MR costs $500/vehicle
- C.A.R. study (2013):
  - 15 % MR costs $1,160/vehicle
- MIT study (2008) Cost of Δ1% FE:
  - $130 Diesel,
  - $110-220 Hybrid PT,
  - $80-$180 Mass Reduction
- Ford (2015) $3.18 per lb in suspension

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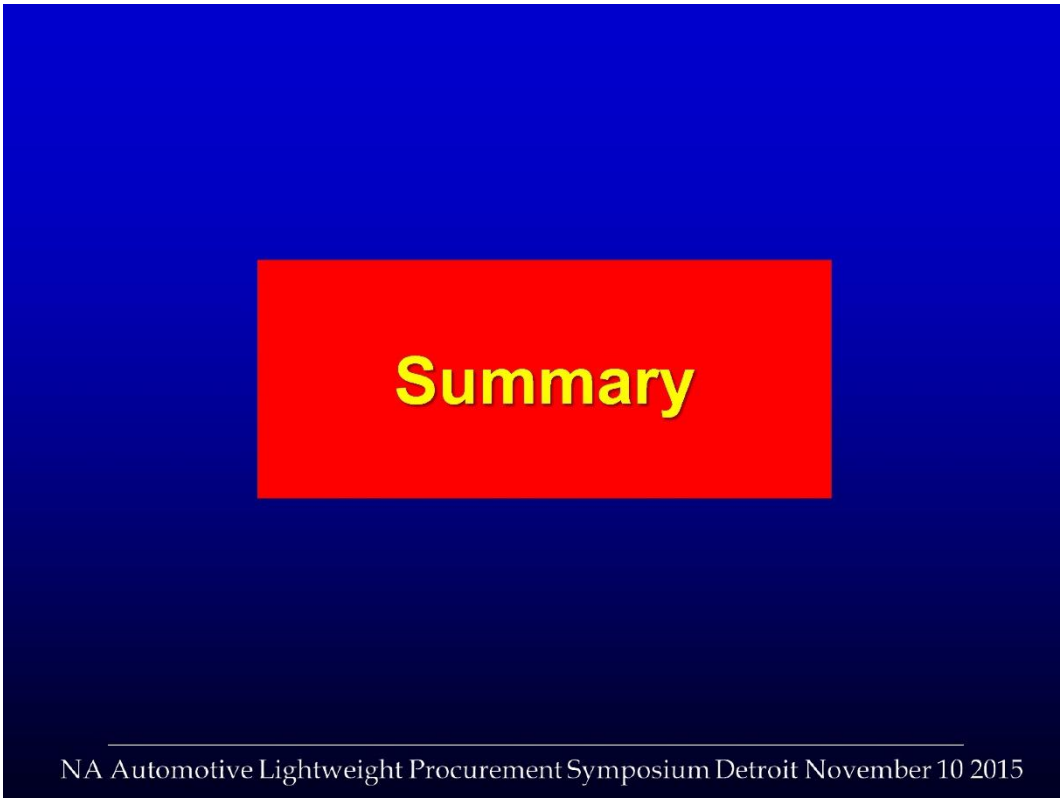
Summary
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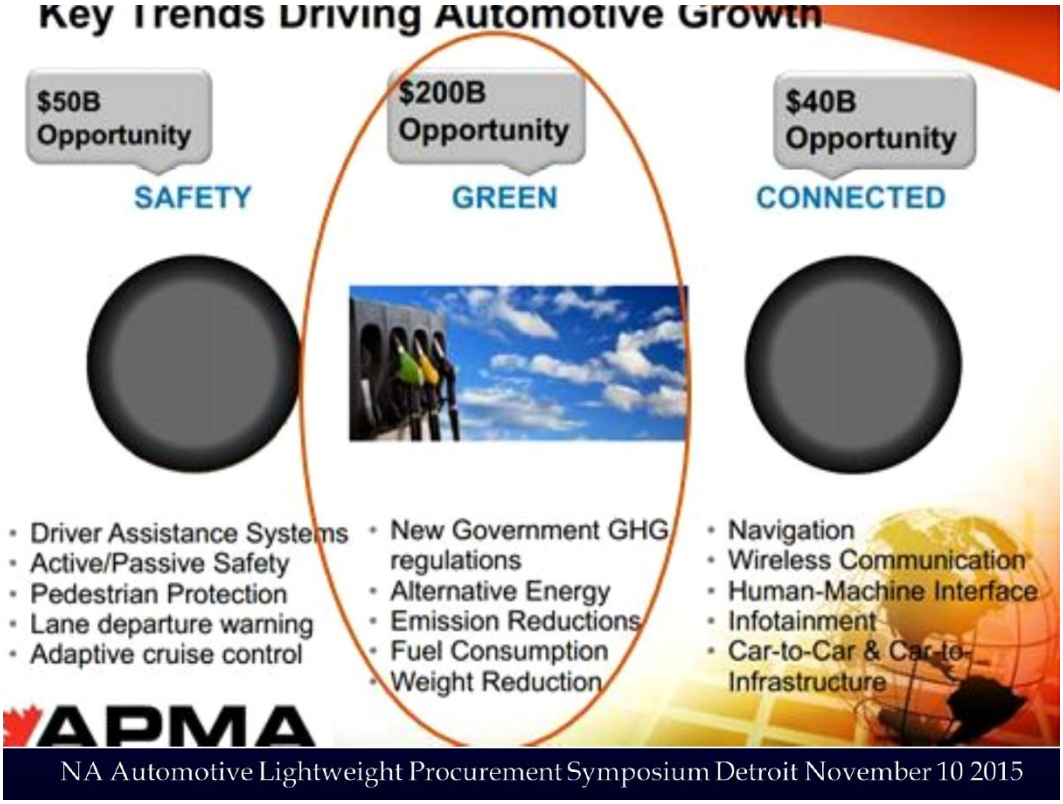
Key Trends Driving Automotive Growth
$50B Opportunity
SAFETY
$200B Opportunity
GREEN
$40B Opportunity
CONNECTED
• Driver Assistance Systems
• Active/Passive Safety
• Pedestrian Protection
• Lane departure warning
• Adaptive cruise control
• New Government GHG regulations
• Alternative Energy
• Emission Reductions
• Fuel Consumption
• Weight Reduction
• Navigation
• Wireless Communication
• Human-Machine Interface
• Infotainment
• Car-to-Car & Car-to-Infrastructure
APMA
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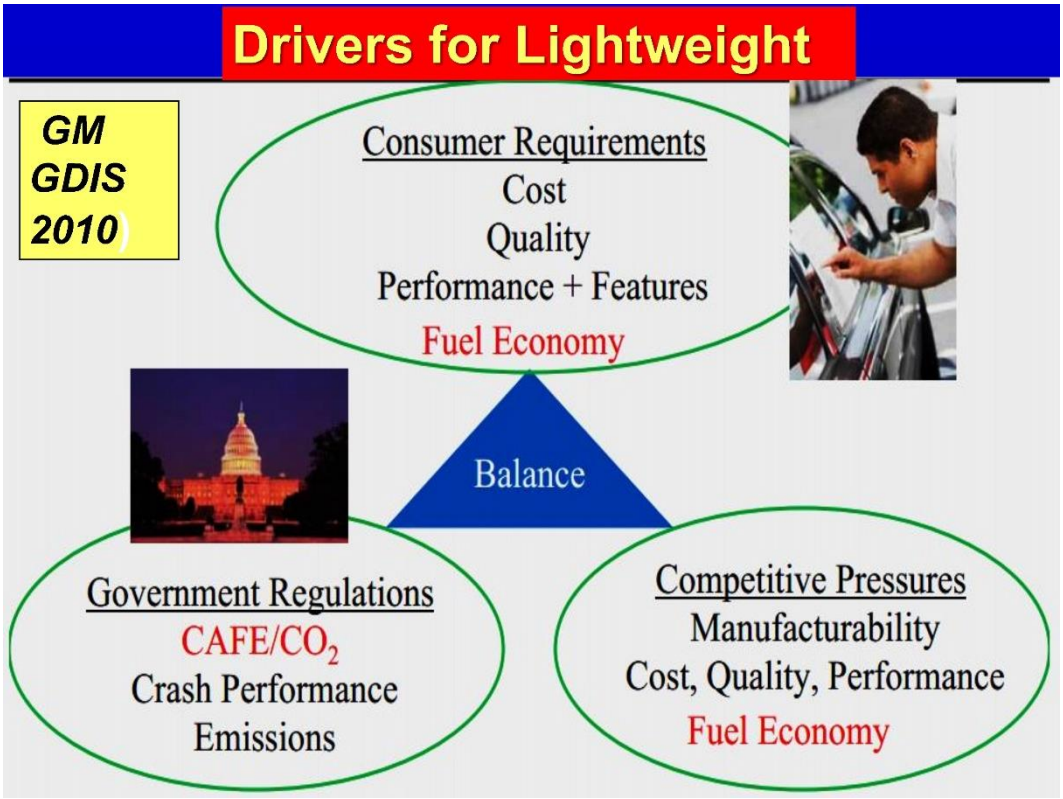
Drivers for Lightweight
GM
GDIS
2010)
Consumer Requirements
Cost
Quality
Performance + Features
Fuel Economy
Balance
Government Regulations
CAFE/CO_2
Crash Performance
Emissions
Competitive Pressures
Manufacturability
Cost, Quality, Performance
Fuel Economy


Material Challenges
(ASM 4/13/2015)
Automotive lightweighting is the key to achieve the challenging goals of vehicle:
➢Weight reduction,
➢Fuel efficiency and
➢Performance improvement
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- Weight reduction requires new materials to have a higher specific strength and stiffness.
- Multi material solutions are the key to successfully develop affordable safe & fuel efficient vehicles: robust & efficient joining technology is crucial

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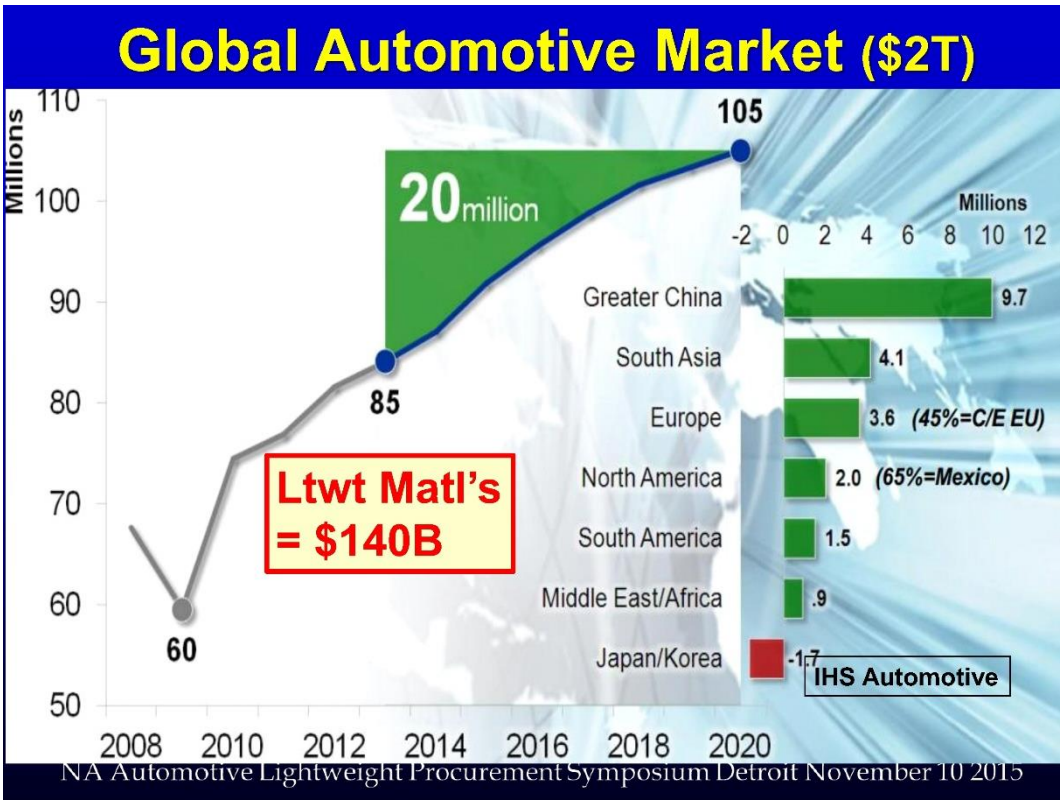

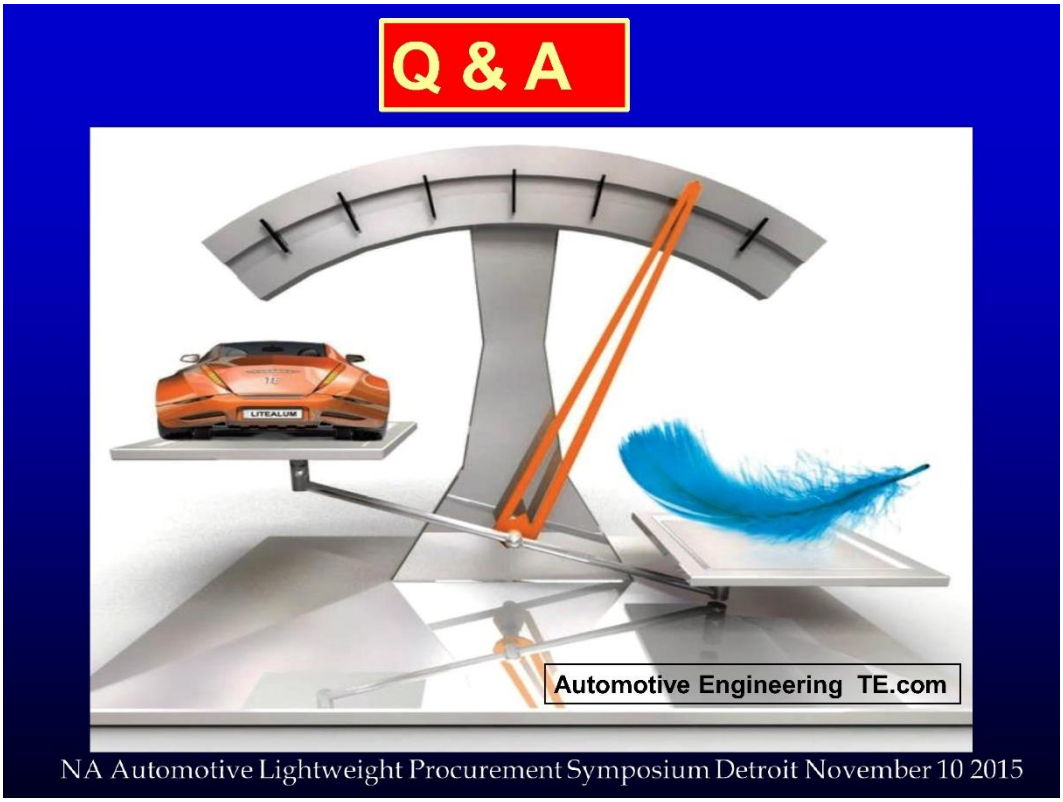
Q & A
LITEALUM
Automotive Engineering TE.com
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EJOT Fastening Systems LP USA

Mr. Laurence CLAUS
President Of NMI Training & Consulting & Technical Consultant

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Tel.: +1 262 612 3550
www.ejot-usa.com

TITLE

EJOT Fastening Solutions Enable Lightweight Body-in-white Assembly

ABSTRACT

The 2015 all-aluminum Ford F150 marked a game changing milestone in US automobile design and assembly. Ford's pioneering efforts proved that lightweighting on a large scale could be a practical reality and ushered in a new day where lightweight body structures will be the norm. As with any pioneering innovation, though, other enabling technologies must come alongside. In this case, Ford's challenge was to find new fastening and joining technologies since the traditional methods of joining simply would not work. One of the key Ford engineers in the development of the new F150 even noted that, "we had to completely reinvent the way we put cars together."
One of the ways the new Ford F150 became a reality was with the enabling technology of the EJOT® FDS® Screw. The FDS® is a self-piercing, flow-drilling, thread forming screw which enables the connection of aluminum to aluminum and aluminum to mild steel. This screw is especially advantageous over other connection methods because it can fasten more than two sheets, into thick aluminum cross sections (such as castings and extruded elements), and without tool support from the back side (i.e. one-sided access.)
Additionally exciting, new this year is the release of the EJOT® EJOWELD® friction element welding system. This is the only technology of its kind that can fasten aluminum sheets to ultra-high strength steel sheets with rated strengths of up to 2000MPa. This unique friction welded element is currently enabling the joining of aluminum top sheets to reduced thickness ultra-high strength steel structural components. These connections open doors to high strength body-in-white structures at a fraction of the weight of traditional ones. This technology is currently employed by Audi and under consideration of many other OEMs.
These are but two EJOT® fastening technologies enabling automotive body-in-white and assembly engineers to realize their lightweighting goals, solve challenging joining problems, and provide cost effective assembly.

EJOT Fastening Systems LP USA

EJOT

EJOT

Fastening Technology Enabling Light weighting

AluMag® North America 2015
Presented By:
Laurence Claus- EJOT® Fastening Systems LP, USA

EJOT

How do you choose joining technology for lightweight automotive body structures that:

- Overcome the engineering challenges?
- Provide efficient, scalable serial production assembly methods?
- Are cost effective?

"You don't get to change the way you build vehicles very often." Amanda Freis- Ford Mechanical Joining Research Engineer

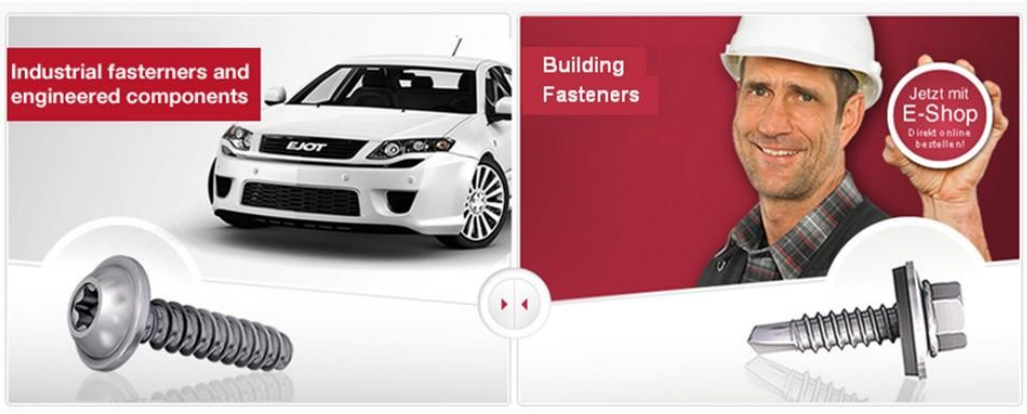
2015 Aluminum Body Ford F150

EJOT Fastening Systems LP USA

Who is EJOT

EJOT is:

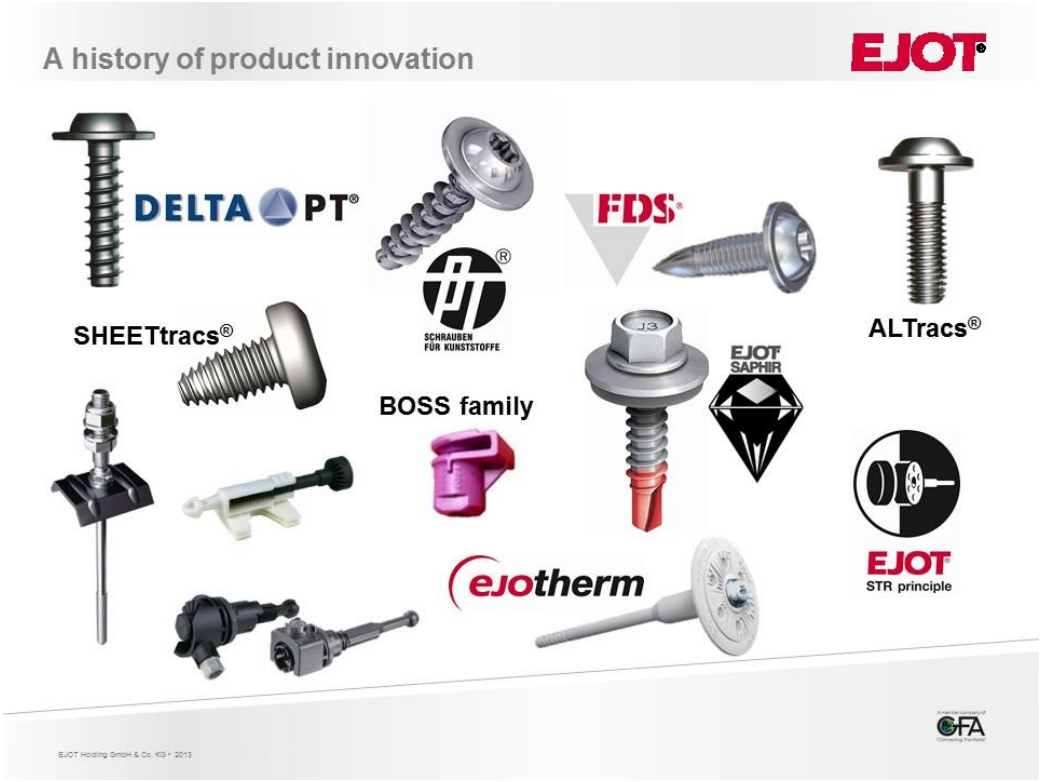
- 91 Year Old Family Business
- Leading innovator of automotive and construction fastening technology
- Globally located, Headquartered in North Rhine-Westphalia, Germany
- Global Brand Names include:
  - FDS®
  - EJOWELD®
  - SHEETtracs®
  - Delta PT®
  - PT®
  - Altracs Plus®

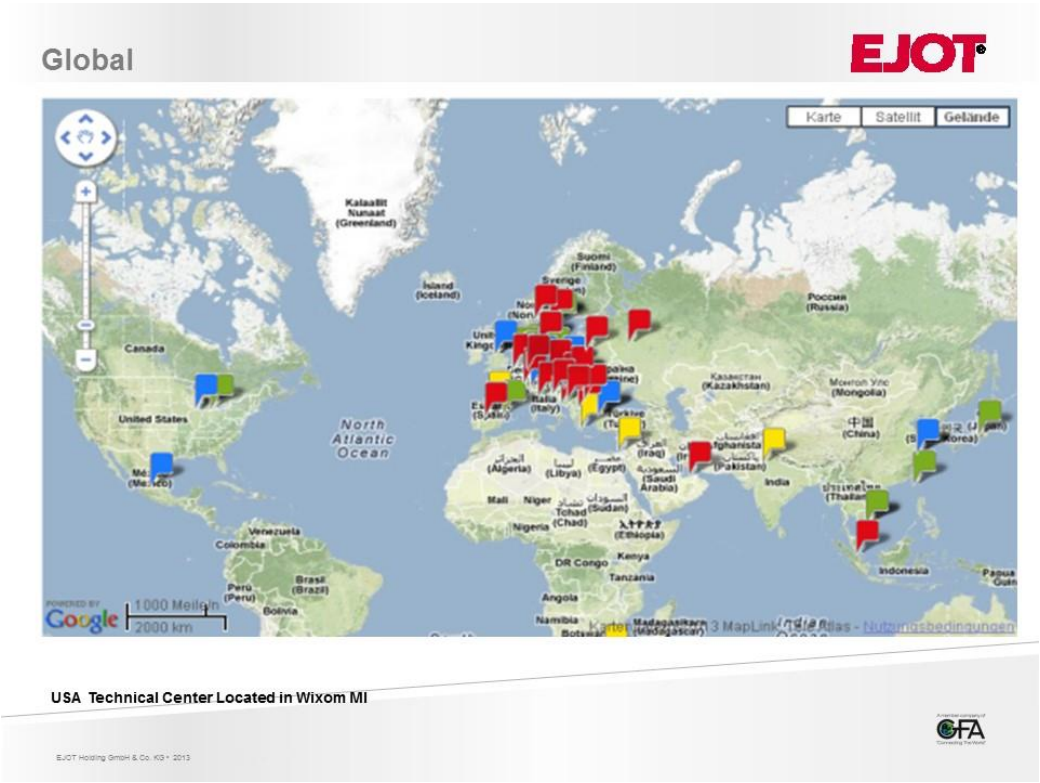


Automotive and Industrial ~50%

Building Fasteners ~50%

EJOT Fastening Systems LP USA



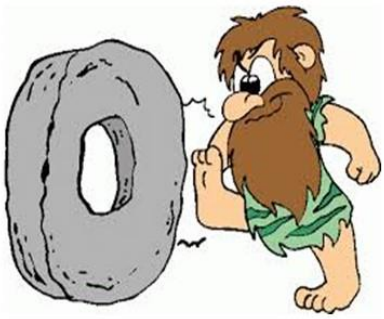


Traditional View on Costs- Missing the Big Box

- Our Traditional Purchasing systems:
  - Incentivize savings at the component level
  - Often miss the opportunities of getting the "substantial savings" of the Big Box
- Cost of a Fastened Joint
  - Components
  - Preparation (Ex. Holes or tapping)
  - Assembly (Time and system costs)
  - Inefficiencies (Downtime, scrap, rework)
  - Opportunity Cost (What is lost if you choose the wrong method?)
  - Working Capital
  - Administrative

Impact of New Technology

- New Technology Impacts:
  - Opportunity Costs
    - Makes possible a joint combination not previously feasible
    - May allow downsizing or reduction in the number of required joints
    - Provides better method of fastening a joint
  - Assembly
    - Better, faster, simpler
  - Changes/eliminates need for preparation
  - Changes the component costs



Traditional Body-in-White Joining Methods

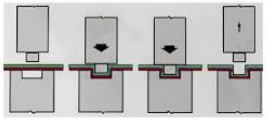
- Welding
  - Resistance Spot Weld
  - Laser Welding
  - Shielded Arc Welding

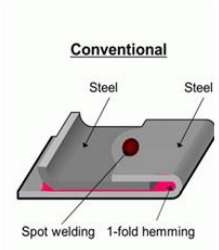
- Brazing

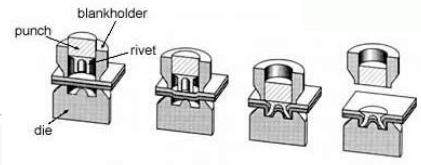
Traditional Body-in-White Joining Methods

- Adhesive Bonding

- Mechanical Fastening
  - Clinch Joining
  - Rivets
  - Screws
  - Hemming
  - Bolt and Nut

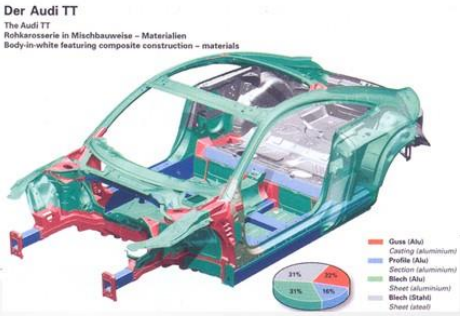






Lightweighting Trends in Body-in-White

- Mixing Materials
  - Aluminum (Weight Savings)
  - Magnesium (Weight Savings)
  - Mild Steel (Strength)
  - Ultra-High Strength Steel (Weight savings and strength)



Challenges Joining with "New" Mixed Material Body-in-white Structures

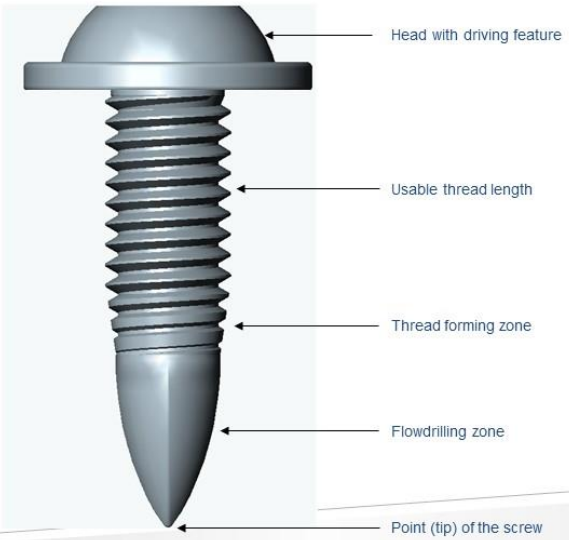
- Challenges:
  - Mixed structures are difficult or impossible to weld
  - Adhesive bonding alone does not supply enough strength or needs to be fixed to allow time to cure in-place
  - Space, Location, or design does not allow access to both sides
  - Material is too strong to be feasible for joining method
  - Method that can be scaled to production volumes
  - Short assembly cycle time
  - Ability to pierce top sheet without the need for a pilot hole
  - Ability to address multiple sheet stack-ups
  - Galvanic corrosion risk of pairing dissimilar materials
  - Cost effectiveness

EJOT® Solutions

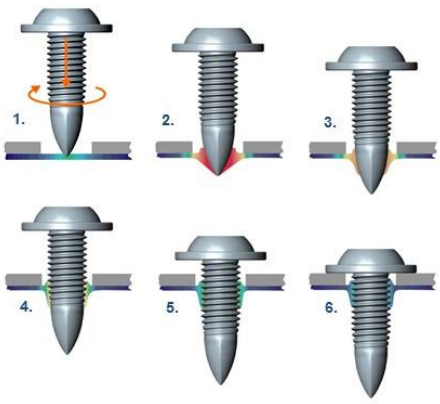
- FDS®
  - Aluminum to Aluminum
  - Aluminum to Mild Steel
- EJOWELD®
  - Aluminum to High-strength and Ultra-High Strength Steel

FDS®

Anatomy of the FDS® Screw



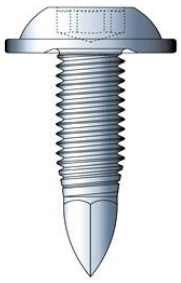
Stages of the FDS® Assembly (With Clearance Hole)



1. Warming up the sheet metal by axial end load and high speed
2. Penetration into the material
3. Forming of the extrusion
4. Chipless forming of a female machine thread
5. Installation
6. Tightening with the pre-set torque

Types of FDS® screws

Standard (sharp point)



- Fastening without clearance holes
- Material thickness limits:
  Assembly by hand:
  - Steel plate 0.3 – 0.8 mm
  - Aluminum plate 0.3 - 1.2 mm
  - Magnesium plate 1.0 – 1.2 mm
- Automatic assembly:
  - Steel plate 0.5 – 1.75 mm
  - Aluminum plate 0.8 – 3.5 mm
  - Magnesium plate 1.0 – 3.5 mm
- Eliminates problems with overlapping hole line-up
- Realizes an extrusion height of up to 3 times the initial sheet thickness

Types of FDS® Screws

PKS (radius point)

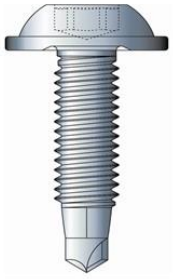
dn= nominal screw diameter

- Pilot hole diameter about 0.6 x dn
- Material thickness limits:
  Assembly by hand:
  - Steel plate 0.3 – 0.8 mm
  - Aluminum plate 0.3 – 1.2 mm
  - Magnesium plate 1.0 – 1.2 mm

  Automatic assembly:
  - Steel plate 0.5 – 1.75 mm
  - Aluminum plate 0.8 – 2.0 mm
  - Magnesium plate 1.0 – 2.0 mm
- Realizes an extrusion height of about 2 times the initial sheet thickness

Types of FDS® Screws

BS (drill point)



- Fastening without clearance holes
- Material thickness limits:

Assembly by hand:

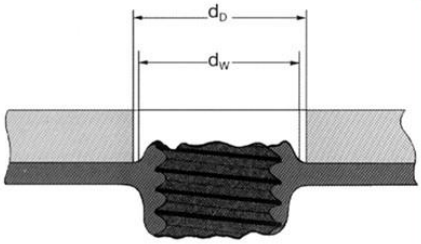
- Steel plate	0.4 – 0.8 mm
- Aluminum plate	0.4 – 1.2 mm
- Magnesium plate	1.0 – 1.2 mm

Automatic assembly:

- Steel plate	0.5 - 1,75 mm
- Aluminum plate	0.8 – 2.0 mm
- Magnesium plate	1.0 – 2.0 mm

- Realizes an extrusion height of about 2 times the initial sheet thickness

Flowdrilling Behavior



d_W → bulge diameter
d_D → clearance hole

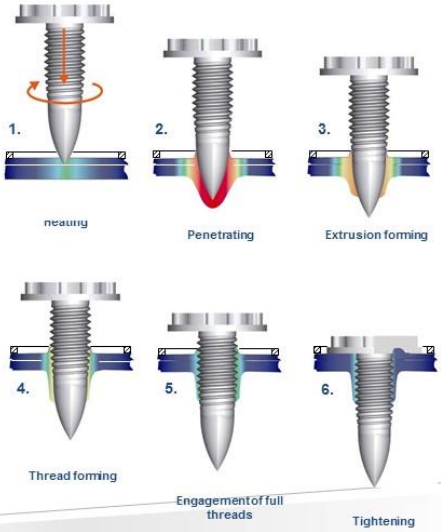
•By flowdrilling, a small portion of the formed part is flowing opposite to the fastening direction and creating a bulge that has to be accommodated by the upper part´s clearance-hole or when piercing the top layer, an undercut in the fastener head.

•When piercing the top layer it is important that the material combination is:

- „Thin“ on „Thick“
- „Weak“ on „Hard“

Process steps of FDS® Assembly Without a Clearance Hole, i.e. Piercing Top Sheet

= Hold Down Clamp



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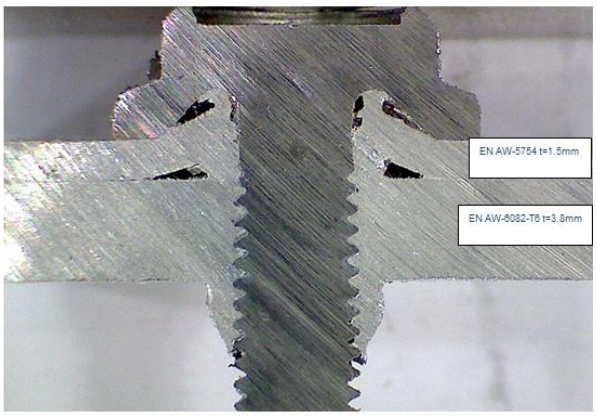
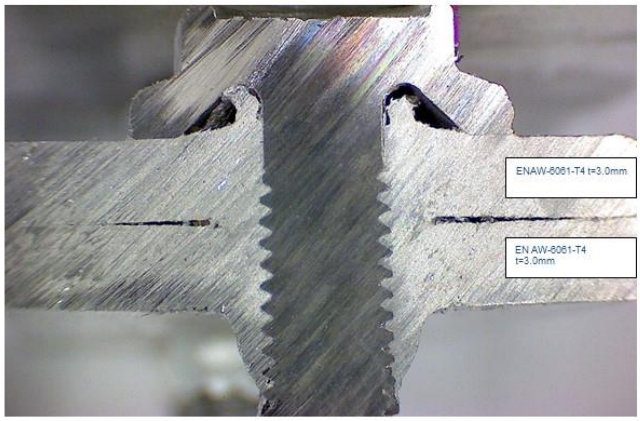
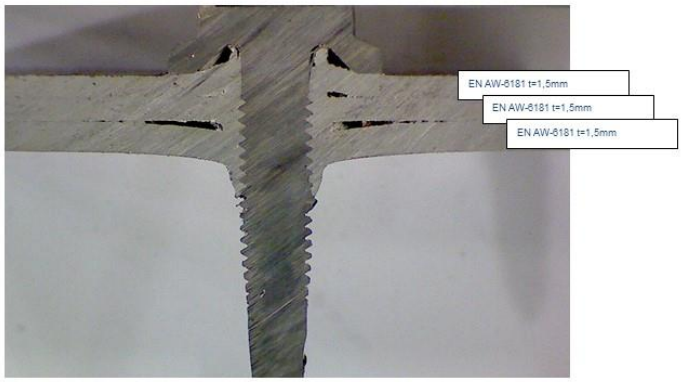
FDS® 2 Sheet Aluminum to Aluminum Joint



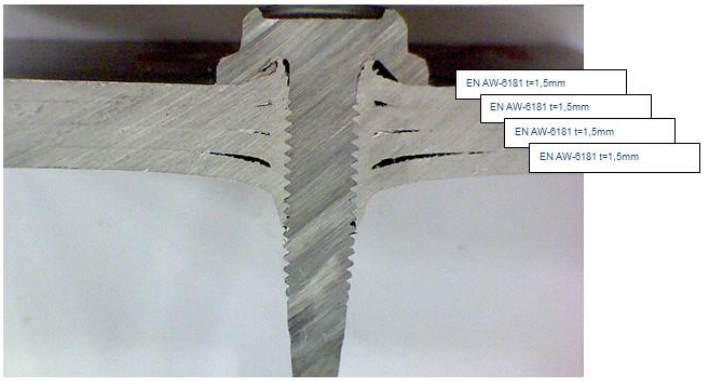
FDS® 2 Sheet Aluminum to Aluminum Joint



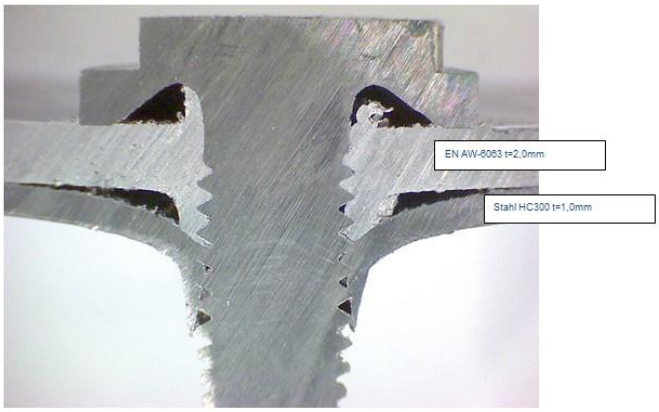
FDS® 3 Sheet Aluminum to Aluminum Joint



FDS® 4 Sheet Aluminum to Aluminum Joint



FDS® 2 Sheet Aluminum to Steel Joint



FDS® 3 Sheet 2 Aluminum to Steel Joint

System for Fully Automated FDS® Robot-Assembly

EJOT Fastening Systems LP USA

EJOT

EJOWELD®

EJOT

EJOWELD®

EJOWELD® CFF

Composite Friction Fastener

EJOWELD® CFP

Composite Friction Pin

EJOWELD®

Equipment Production, Control Systems, and Service

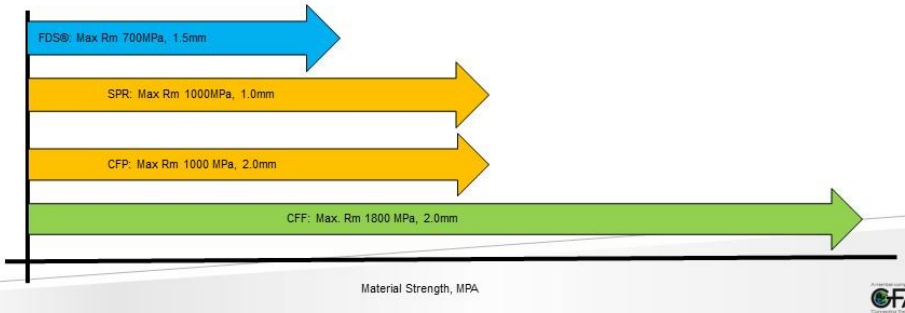
EJOWELD®

Feeding Systems

Sheet Strength Limits

No **Clearance** Hole
One Sided Access

No Clearance **Hole**
Two Sided Access



Composite Friction Pin (CFP)

Top Plate Materials:

- Steel Plates Rm < 300 MPa
  0.8 – 1.2 mm
- Aluminum (Diecast, Profiles, Sheets)
  0.5 – 1.8 mm
- Synthetic (Composite) Material With Clearance Hole

Lower Sheet Materials:

- Steel Plates Rm < 600 MPa
  0.7 – 3.0mm
- High-strength Steel Plates Rm < 1000 MPa
  0.7 – 2.0 mm

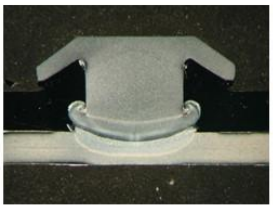
CFP Automated Installation Head

Fastening Element (CFP)

Features:

- Developed for one-sided access
- Robot application capable
- Total weight 80kg
- Slim configuration (max. width 120mm)
- Real time process control

Composite Friction Fastener (CFF)



Top Sheet Materials:

- Aluminum up to 3 mm
- Synthetic (Composite) Material With Clearance Hole

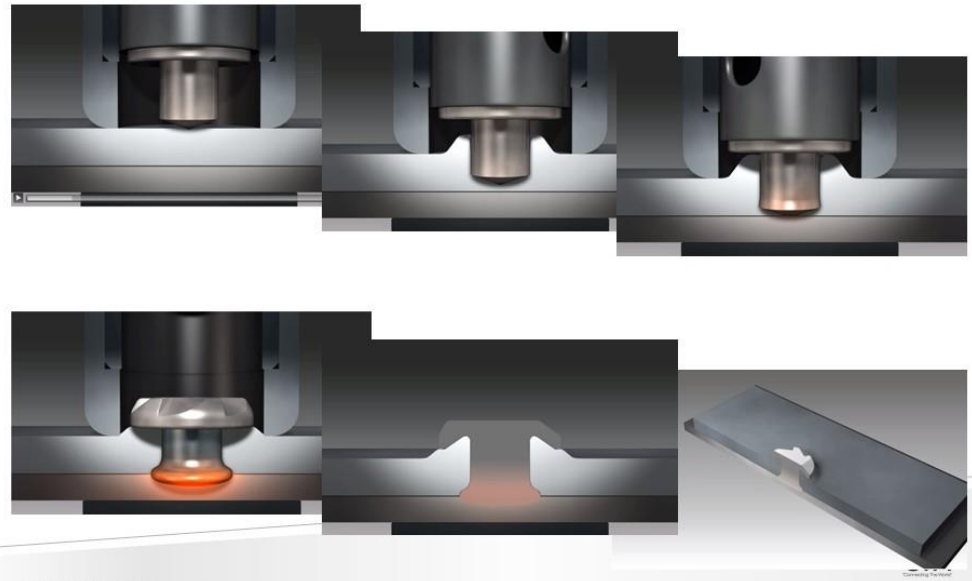
Lower Sheet Materials:

- High-strength and Ultra-High Strength Steel

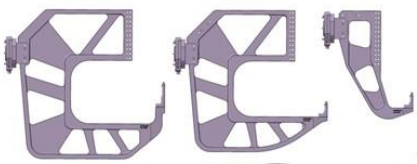
Features:

- Can be used in combination with adhesives
- No pilot hole required
- Steel on steel possible with clearance hole in top sheet

CFF Joining Process



CFF Automated Installation Head



Sample C-Frame Variations

Fastening Element (CFF)

Features:

- Developed for two-sided access
- Robot application capable
- Total weight 100 to 150kg
- Slim configuration (max. width 120mm)
- Real time process control

Wrap-up

- EJOT® FDS® and EJOWELD® provide enabling solutions for lightweighting body structures
- Provide joining solutions for bottom sheets that range from ~300MPa to ~2000MPa
- Within limits, provide one-sided access assembly options- opening the door to enabling attachment to aluminum extrusions and hydroformed members
- Production tested- already on multiple production platforms
- FDS capable of fastening together a variety of mixed joints, including aluminum, magnesium, and mild steel
- Can be used in combination with adhesives
- Cost effective

Thank you for your attention!

To learn more or arrange a visit to our Wixom, MI Technical Center

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TITLE

UACJ's Global Strategy And Approach To The Automotive Aluminum Market

ABSTRACT

Abstract:
– Outline of UACJ
– UACJ's global strategy
– Approach to Automotive Aluminum Market

UACJ's Global Strategy and Approach to the Automotive Aluminum Market

November 11, 2015

North America Automotive Lightweight Procurement Symposium 2015

AluMag®
Europe ■ India ■ Americas ■ Asia
THE MARKET DEVELOPER

Akio NIIKURA, Ph.D.
General Manager
R&D Division
UACJ Corporation

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Contents

1. Outline

Introduction

Started on October 1st, 2013

Furukawa-Sky Aluminum Corp.

Sumitomo Light Metal Industries, Ltd

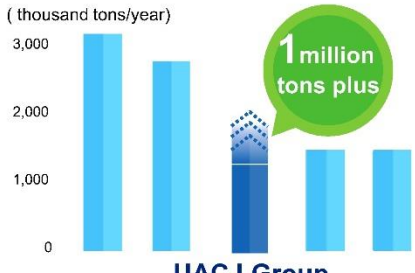
History

integrated business to form UACJ Corporation

Business Outline

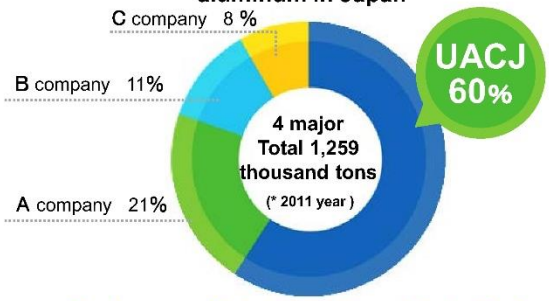
Establish	October 1, 2013
Capital	45 billion yen
Total Companies	77 (160 bases)
Employee	8,556
Consolidated Net Sales	572.5 billion yen (Fiscal 2015)

Production capacity of Flat rolled aluminum



UACJ Group
3rd Group Company of the World

Production ratio of wrought aluminum in Japan

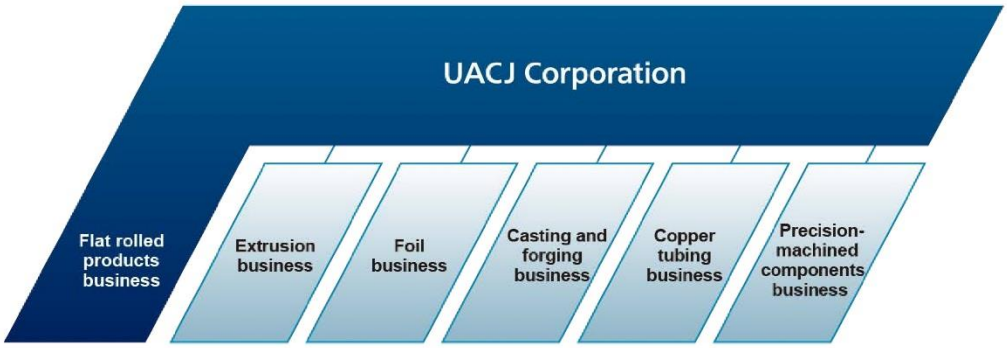


The Japanese Market Share Overwhelming Top!

※ Estimated on the basis of the data of Japan Aluminium Association

Business Fields

Business areas of UACJ group dealing with a wide range of fields



The UACJ Group is structured along business unit lines.

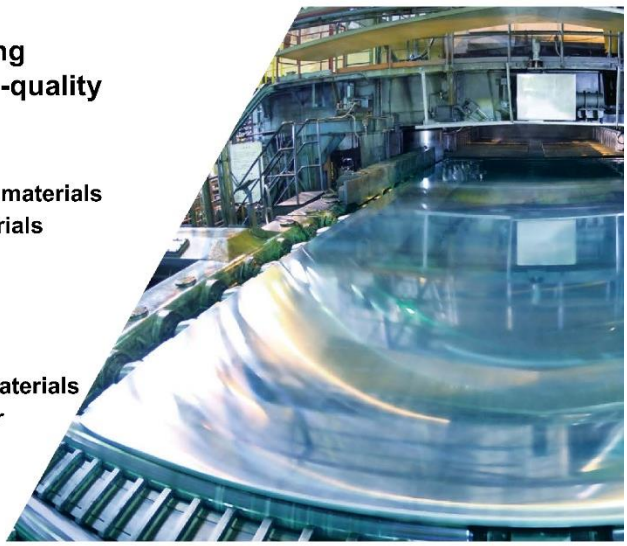
UACJ Corporation provides oversight for each units and UACJ is also responsible for manufacturing and sales in our flat rolled products business.

Business Fields

Flat Rolled Products Business

World-leading Manufacturing Capabilities to Deliver High-quality Flat Rolled Products

- Aluminum can stock and closure materials
- Automotive heat exchanger materials
- BiW (Body-in-White) panels
- LNG tank materials
- Aviation and aerospace materials
- IT materials
- Air-conditioner compressor fin materials
- Liquid crystal and semiconductor equipment thick plates
- Litho sheet materials
- Construction plates



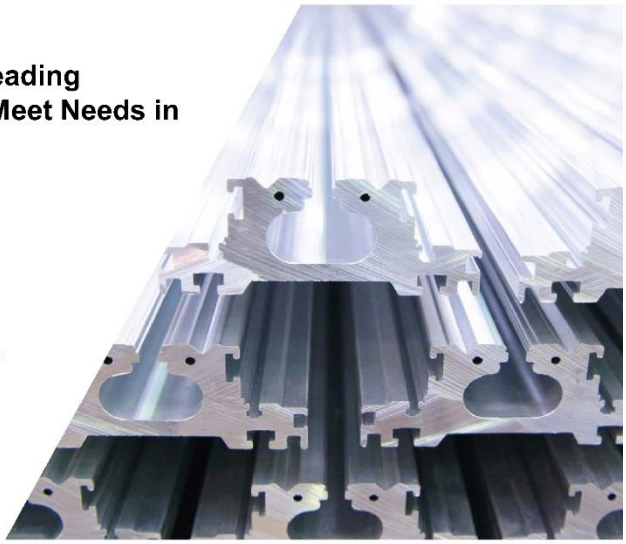
Business Fields

Extrusion Business

UACJ

Comprehensive, Industry-leading Technological Prowess to Meet Needs in a Wide Variety of Fields

- Automobile heat exchanger and tube materials
- Motorcycle frame materials
- Photocopier photoconductive drum materials
- Machine parts materials



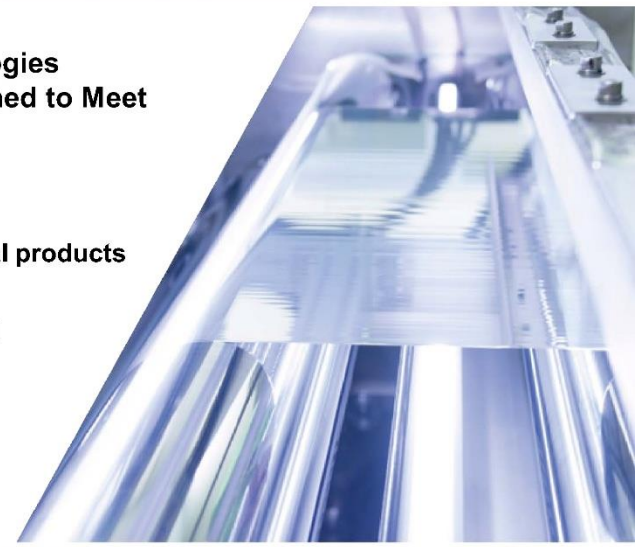
Business Fields

Foil Business

UACJ

Unparalleled Foil Technologies to Supply Products Designed to Meet the Latest Needs

- Capacitor foil
- Medical industry and chemical products packaging foil
- Foodstuffs and packaging foil
- Lithium-ion battery current collector foil
- Construction foil
- Daily-use foil



Business Fields

Casting and Forging Business

Delivering Highly Competitive Products Utilizing Advanced Technologies and Production Network

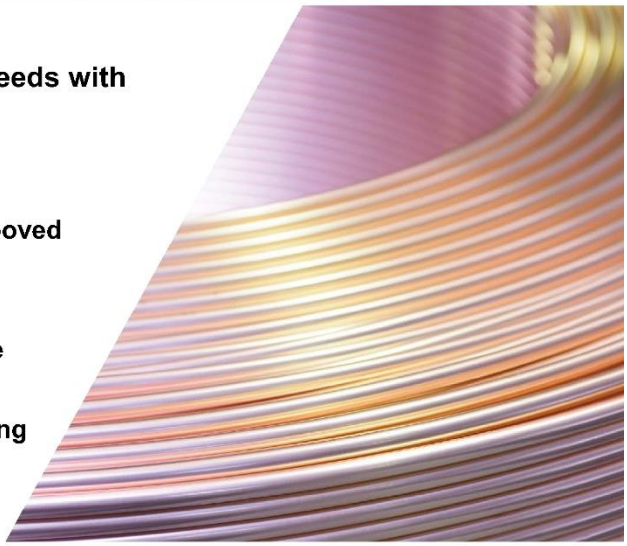
- Turbocharger compressor wheels
- Forged products for aviation and aerospace materials
- Forged products for railcars
- Forged products for liquid-crystal production facilities

Business Fields

Copper Tubing Business

Meeting a Wide Range of Needs with the Superior Materials Characteristics of Copper

- Air-conditioner internally grooved copper tubing
- Hot-water heater pipe
- Construction/refrigerant pipe
- Heat exchanger tubing
- Copper alloy condenser tubing
- Titanium condenser tubing

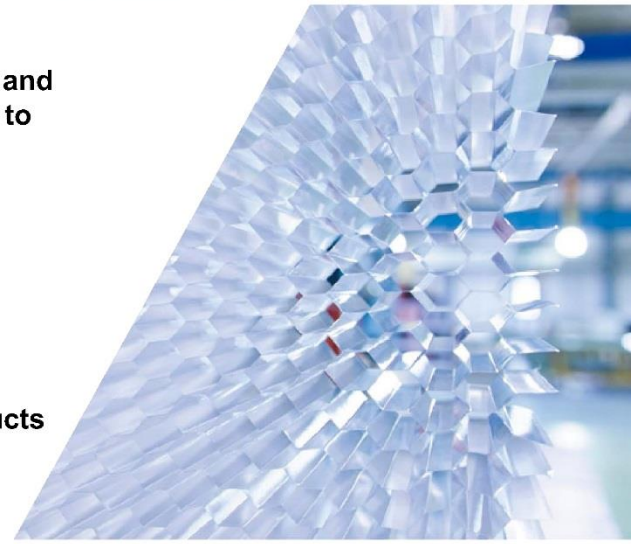


Business Fields

Precision-machined Components Business

A Vast Array of Equipment and Technologies in Response to Various Processing Needs

- Structural products
- Welded products
- Heat dissipation /cooling products
- Functional material products



Research & Development

Applying Advanced Aluminum Expertise to Create New Innovations

UACJ is continuously developing next-generation products and technologies as we explore the potential of aluminum and create new value in metals. These R&D initiatives are spearheaded by the UACJ Technical Research and Development Center.

Fukaya Center

Nagoya Center

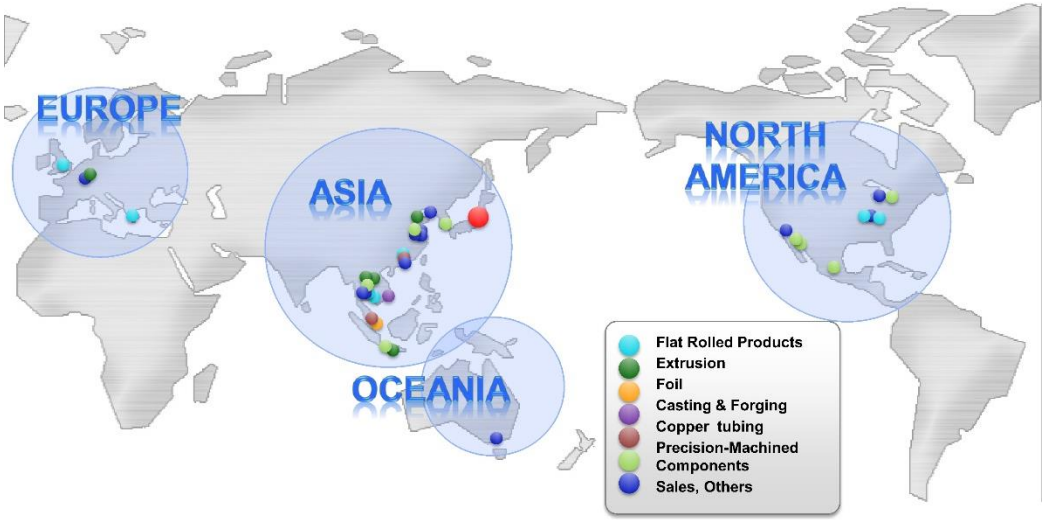
Pursuing New Possibilities for Aluminum

Technology Development Headquarters for the UACJ Group

2. Global Network

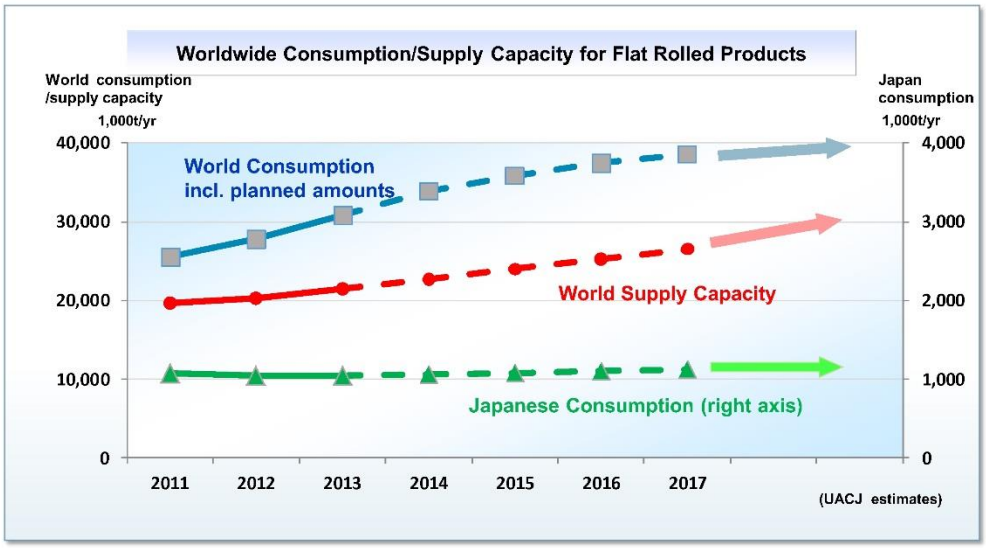
Global Network of UACJ group

Global Supply Network to Deliver Products to Regions Worldwide



World wide Supply and Demand for Flat Rolled Products

World demand for flat rolled products is expected to grow steadily



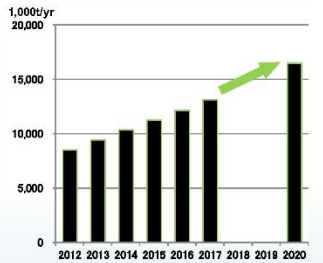
Demand for Flat Rolled Products in Growth Regions and Fields

Growth Regions Demand is increasing in all fields, such as can and foil stock, with the remarkable economic growth in Asia and the Middle East.

Growth Regions Demand is growing in transportation fields such as the automotive industry and aerospace, especially in Europe and America, due to the need to reduce weight and other factors.

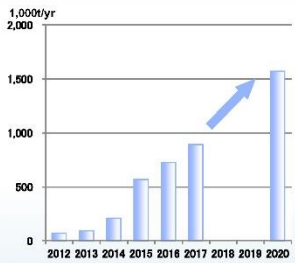
Growth Regions

Total Demand in Asia/Middle East

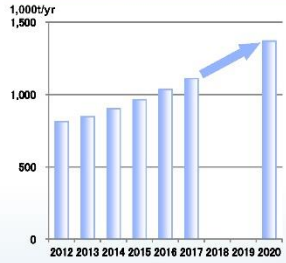


Growth Fields

Demand for BiW in North America



Demand in European Transportation Sector



(UACJ estimates)

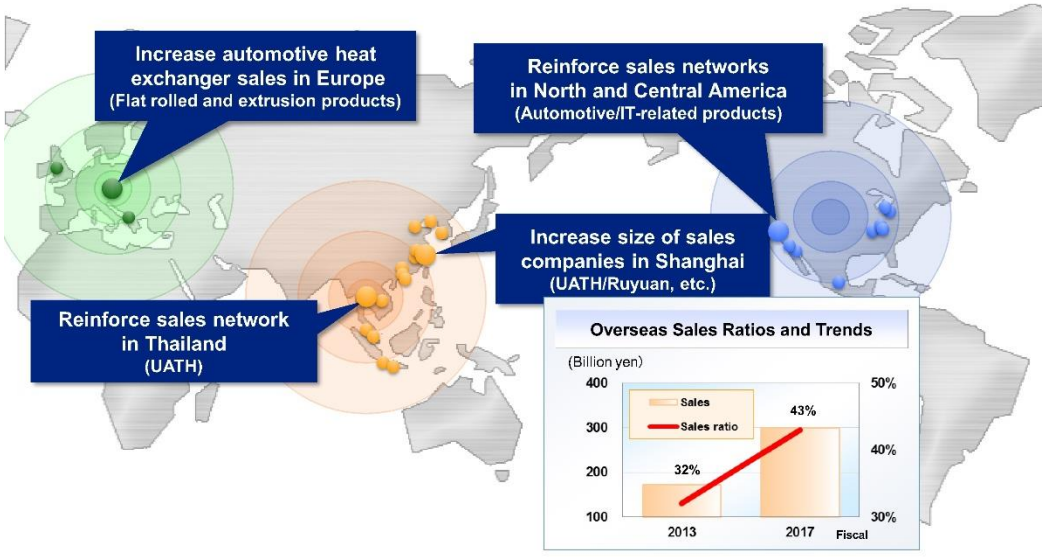
Optimize Global Supply Network

Main products \ Region	Japan	North America	Europe	China/ South Korea	Southeast Asia	India	Middle East/ Africa
Can Stock	Fukui	TAA	–	Fukui UATH	UATH	UATH	UATH
Automotive heat exchanger materials	Nagoya (Nikko)	UATH AFSEL	AFSEL	Ruyuan UATH	UATH	UATH	UATH
BiW	Nagoya (Fukaya)	Joint venture with Constellium	Under investigation				
Litho sheet	Nagoya	BAL	BAL	Nagoya	Nagoya	BAL	BAL
Thick plate (LNG tanker etc.)	Fukui Fukaya	–	–	Fukui Fukaya UPIA	Fukaya	–	–

TAA : Tri-Arrows Aluminum Inc. (USA),
AFSEL: AFSEL S.A.(Joint venture with ELVAL, Greece) BAL: Bridgnorth Aluminum Inc.(UK)
Ruyuan: Ruyuan Dong Yang Guang Fine Foil Co., Ltd.,(China)

Strengthening the Global Sales Network

Enhance marketing capabilities utilizing the global network

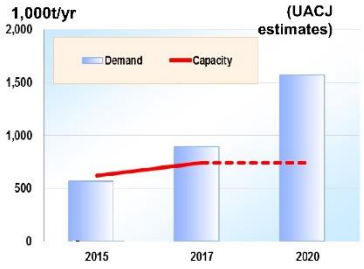


Global Network: North America

North American BiW Business

Joint venture with Constellium N.V.

BiW Market in North America



Provide high-quality products by combining the technologies of UACJ and Constellium N.V.

Invest in plant and equipment and prepare supply network

- Shorten period for first phase of investment

➡ Establish 100,000 t/yr capacity from 2016

Realize fully-integrated manufacturing in North America

- New UACJ-Constellium CALP plant in Bowling Green, KY
- Procure cold-rolled coil mainly from TAA/Logan mill

North American BiW Business
(joint venture with Constellium N.V.)

New UACJ-Constellium plant in Bowling Green, KY

Continuous Annealing Line with Pre-Treatment

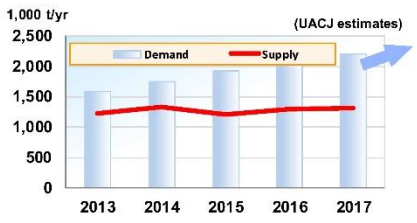
UACJ (Thailand) Co., Ltd.
Rayong Works

Establish fully-integrated manufacturing network

Differentiate by improving competitiveness

Function as first-class aluminum works in Asia

Outlook for Demand in Southeast Asia and Other Nearby Regions (excl. China, S. Korea and Japan)



UATH Production Volume

UACJ (Thailand) Co., Ltd.
Rayong Works

Bird's-eye View of the Rayong Works

Mass Production

Melting Furnace

Production of Slabs

Hot Rolling Mill

Four-stand Finishing Mill

3. Approach to the automotive Aluminum Market

Automotive Lightweight & High-performance

Al

BIW/Structure	Automotive body panels
	Superplastic aluminum alloy (ALNOVI)
	Aluminum alloy extruded shapes
	Joining Technology, FSW, FSSW
Heat Exchanger	Tailored blanking
	Clad material (Heat exchanger for automotive)
	Heat-sink
EV/HEV/Diesel	Aluminum cast product
	LiB module for automotive
	Foil for LiB
Engineering, R&D	SMART sheet
	CAE Technology

Aluminum alloys for automotive body panels

Point of material design

Controling tems:

1) Chemical composition

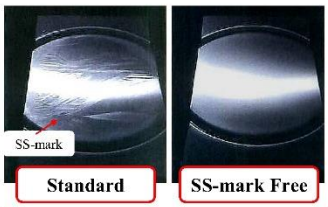
2) Microstructure
- Intermetallic compound
- Grain structure
- Precipitation and solid solution
- Crystal orientation

Through the production process

High-quality surface properties

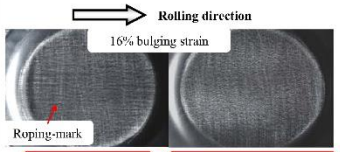
5xxx series alloy

★ High SS-mark resistance ★

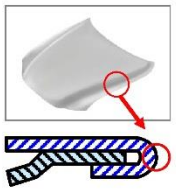


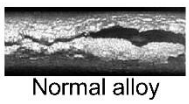
6xxx series alloy

★ High Roping-mark resistance ★



Good bendability

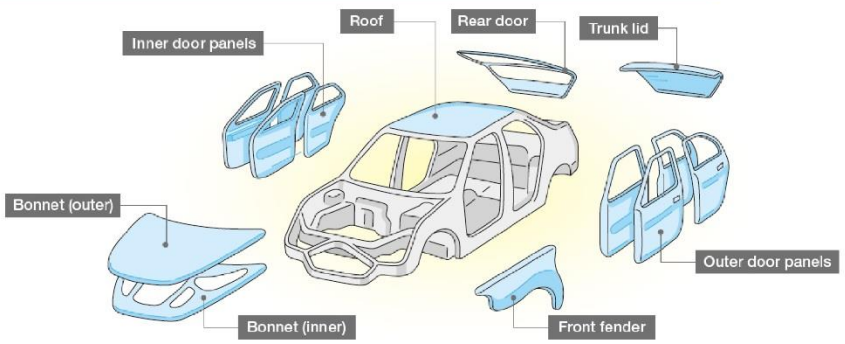




Normal alloy

Developed alloy

Aluminum alloys for automotive body panels



Aluminum alloys for automotive body panels

6000 series

Higher strength

High formability →

High formability →

Mechanical properties

Types and mechanical properties (Sheet thickness: 1mm)

Material properties	AA*1	Tensile strength (N/mm²)	Proof stress (N/mm²)	Stretch (%)	Proof stress (after baking)*2 (N/mm²)
SG112-T4	(6016)	230	120	27	195
SG212-T4	(6016)	240	130	28	205
SG212-T4 High formability type	(6016)	245	135	30	170
SG312-T4	(6111)	245	120	30	200
TM30-T4	(6005)	210	110	27	200
TM66-T4	(6111)	240	115	29	210
TM67-T4	(6111)	255	120	29	215
TM67-T4 High formability type	(6111)	285	145	29	175

5000 series

Higher strength

Mechanical properties

Types and mechanical properties (Sheet thickness: 1mm)

Material properties	AA*1	Tensile strength (N/mm²)	Proof stress (N/mm²)	Stretch(%)	n value*2
GC45-O	5022	280	140	32	0.31
GC55-O	5023	285	130	34	0.35
GM145-O	5182	270	120	28	0.33
52S-O	5052	205	105	28	0.26

*1 AA: The Aluminum Association (U.S.A.)
*2 Average value from 2% to the maximum load

Superplastic forming Material

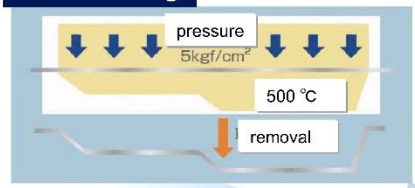
Superplastic 5000 Series Aluminum Alloy "ALNOVI"

Superplastic deformation

Aluminum alloys with fine grains show high elongation, 300%- at high temperature,400～500℃

Manufacturing technology

Blow forming



Superplastic blow forming and ALNOVI enable flexible forming as if plastic.

Products

Automotive

Aircraft

Miniature model

Aluminum alloy extruded shapes, tubes

Material development

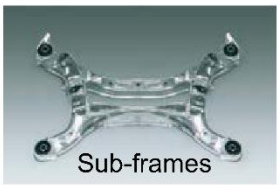
- ZK80: Alloy with strength and fracture toughness further enhanced than the 7204
- Creating and Optimum cross-sectional configuration

- 254S(A5154): non-heat-treatable 5000 series alloy

- Aluminum materials can be applied to structural and rotational axis materials.

Manufacturing technology

Bumper



Sub-frames

Products

Mazda MX-5

Front Bumper system
⊿weight = -2.4 Kg

Higher strength 7000 series Extrusion

UACJ

Material development

Ordinary extruded shapes **UACJ High strength 7000series**

6061-T6	
TS	: 315 MPa
YS	: 275 MPa
EL	: 17 %

ZK170-T5		40%up	ZG62-T76		90%up
TS	: 440 MPa		TS	: 600 MPa	
YS	: 400 MPa		YS	: 560 MPa	
E	: 14 %		E	: 12 %	

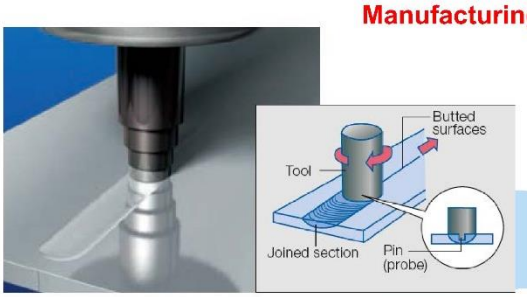
Products

ZG62(A7050) : The world's top share as the front fork outer material for motorbikes

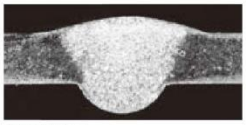
FSW (Friction Stir Welding)

UACJ

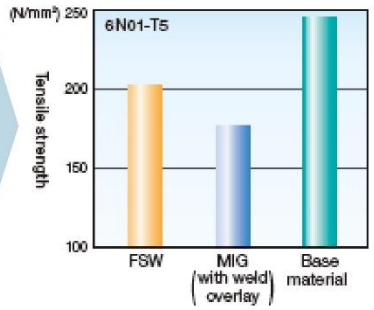
Manufacturing technology



FSW



Arc welding



Strength at joined section

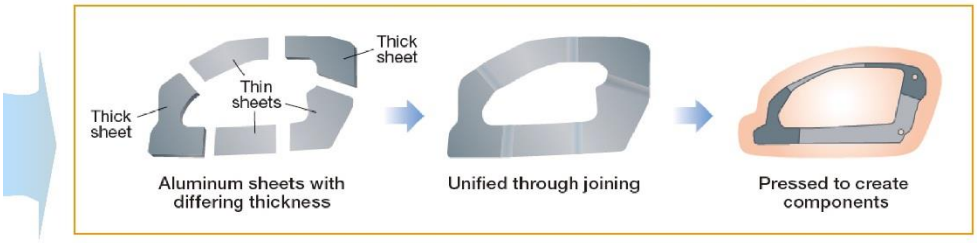
- The strength reduction at the thermally affected area is very small.
- High joint strength
- As strain is small, Residual stress can be suppressed.

Tailored blanking

UACJ

Manufacturing technology

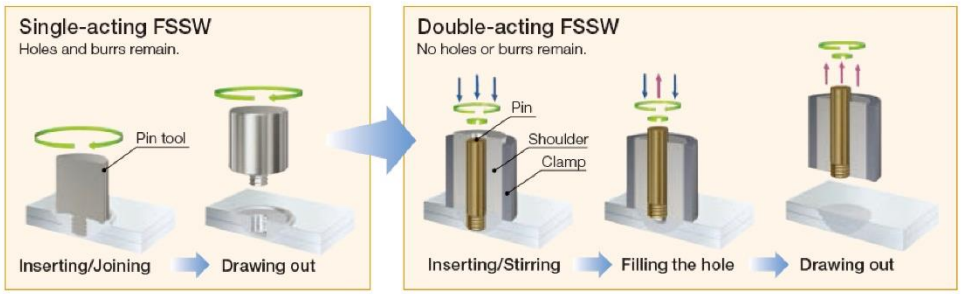
The thickness of materials can be arranged in an optimal manner, which effectively reduces the weight of parts.



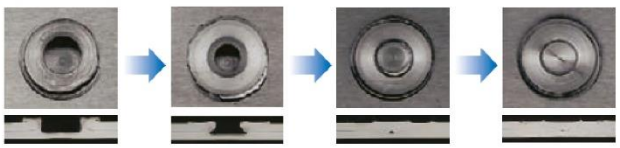
FSSW (Friction Stir Spot Welding)

UACJ

Manufacturing technology



Double-acting FSSW process



less energy than resistance spot welding
Improves the work environment: no sputtering

Aluminum materials for automotive heat exchanger

UACJ

Material development

Durability (Strength)

Core Alloy Design
Use of Age-hardening

Corrosion resistance

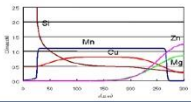
Sacrificial and Core Alloy Design
Coating Material Development
Corrosion Life Prediction

Brazeability

Filler and Core Alloy Design
Metallic Structure Control
Flux Free Brazing

Use of Simulation

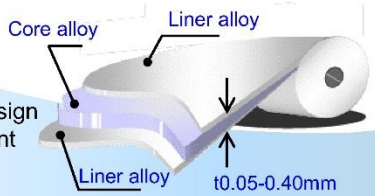
Elemental Diffusion



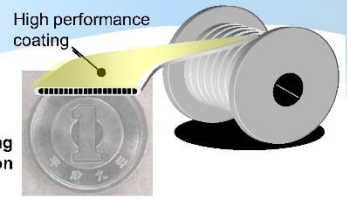
Elemental Distribution during Filler Solidification

Manufacturing technology

Cladding technology

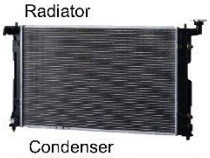


Extrusion and Coating technology



Products

Radiator



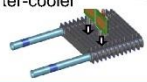
Condenser

Evaporator

Heater-core

Charge-air-cooler (Inter-cooler)

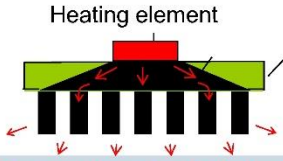
Inverter-cooler



Heat sink

UACJ

Heatsink for electronic device

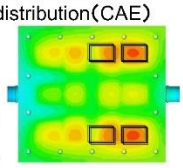


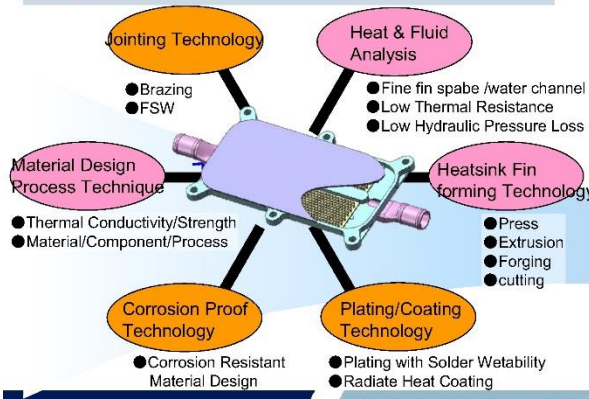
Products

◎ Automobile (EV、HEV、FCV)
◎ Railway car
◎ Industrial machine controller

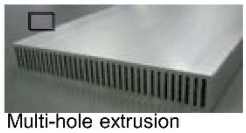
Thermal conductivity (material) & construction design : CAE

Surface temp. distribution(CAE)

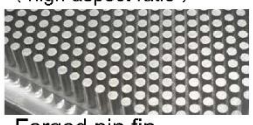




Corrugate(off-set type)



Multi-hole extrusion
(high aspect ratio)

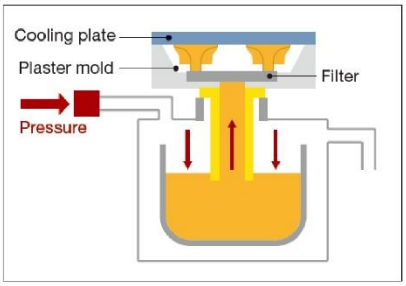


Forged pin fin

Aluminum cast products

Manufacturing technology

Low-pressure casting



The molten aluminum is cast into the mold by applying low-pressure gas. Aluminum castings with excellent strength, durability and dimension accuracy are produced.

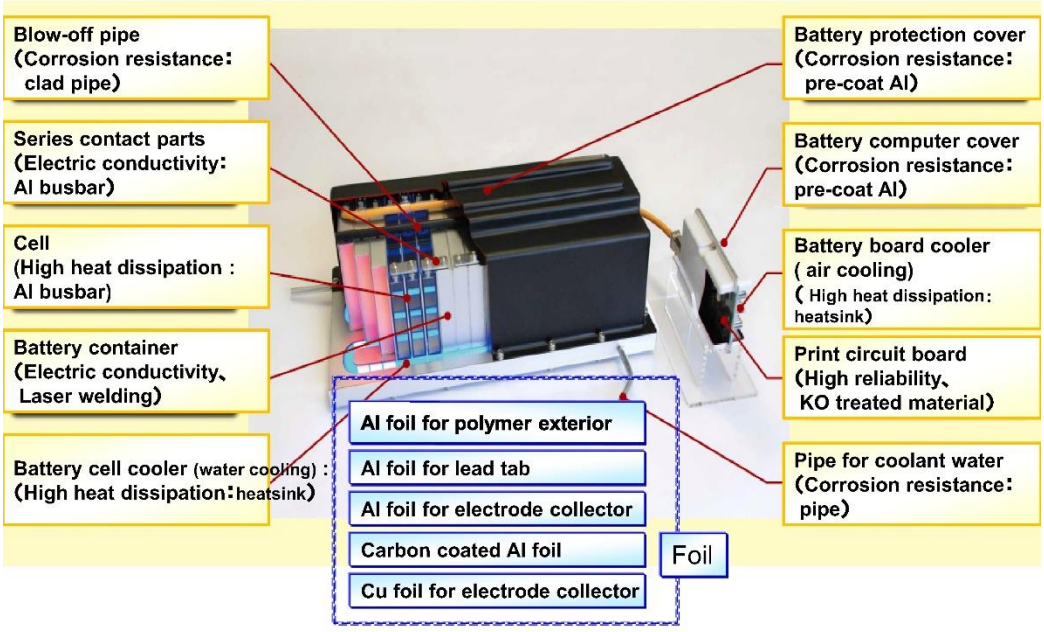
Products

Compressor wheels for automobile Turbocharger

Over 10million pieces/year

No.1 Share In the World

LiB module for automotive



Foil for LiB

Material development

- Strength
- Electric conductivity
- Formability

Product design

Electrode Collector

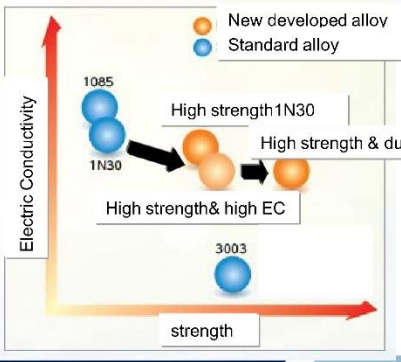
- **Surface profile better for active materials**
- **Better adhesion properties**
- **Lower internal resistance**

Products

Electrolytic capacitor

High strength Al foil

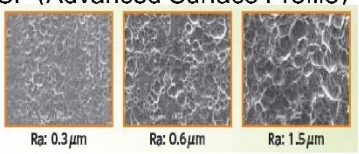
Realize the downgaugeness of foil



LiB
Electric double-layer capacitor

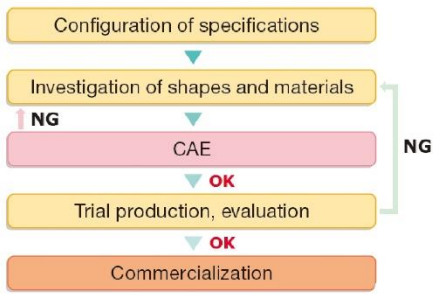
Al foil with advanced surface profile

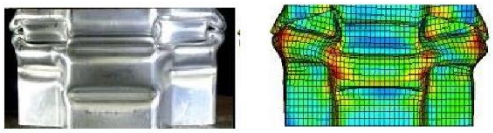
ASP (Advanced Surface Profile)



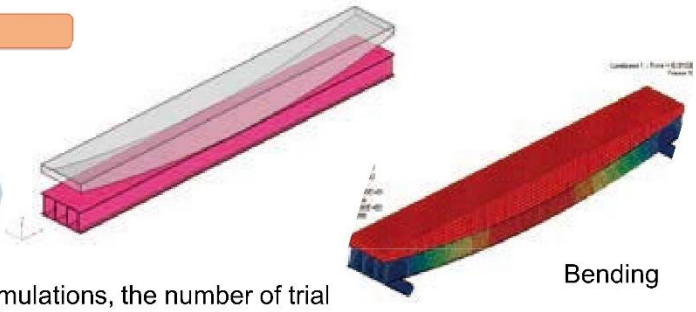
CAE Computer-Assisted Engineering

■ Development procedures





Compression test on energy-absorbing components



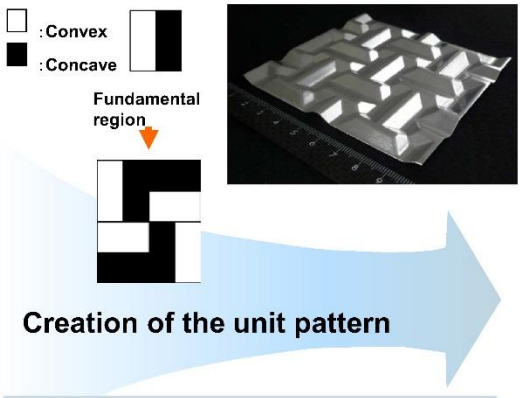
Bending

By using various CAE simulations, the number of trial productions and evaluation tests can be reduced.

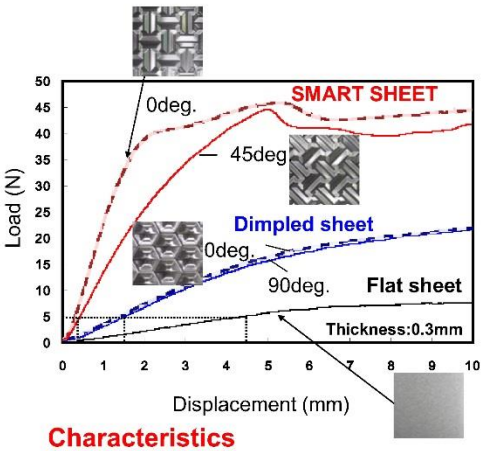
SMART sheet

Super Multipurpose Aluminum Reinforced and Textured SHEET

Design concept



Having high second moment of area at any arbitrary cross sections of the unit pattern



Characteristics

- Isotropic high bending stiffness
- High energy absorption performance

Summary

1. Outline

UACJ corporation was started on October 1st 2013. The annual capacity for flat rolled products exceeded 1 million tons, making them the largest such manufacturer in Japan and the third largest in the world.

2. Global Network

UACJ focuses in all fields such as can and foil stock in Asia and the Middle East, and transportation fields such as the automotive industry and aerospace, especially in Europe and America. UACJ has an extensive global network system to supply products worldwide.

3. Approach to the Automotive Aluminum Market

Automotive weight reduction technology is indispensable for improving efficiency. UACJ is actively involved in R&D of aluminum material as well as the technological development required for promoting their utilization.

Thank you for your attention!

Please visit UACJ booth #1204
at the "Aluminum USA 2015 " Exhibition.

LIGHTWEIGHT INNOVATIONS FOR TOMORROW

Mr. Lawrence E. BROWN
Executive Director

Lightweight Innovations for Tomorrow
USA, 48216 Detroit

Tel.: +1 313 3099003
www.lift.technology

TITLE

Lightweight Innovations For Tomorrow!!!!

ABSTRACT

Lightweight Innovations for Tomorrow

Aluminum Blanking Company

Ms. Laura ANDERSON
President & CEO

Aluminum Blanking Company
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TITLE

The Story Behind Aluminum's Sourcing Evolution: A North America Perspective

ABSTRACT

Aluminum sourcing emerged in response to the highly recognized CAFE requirements. OEMs and suppliers increasingly turn to lightweight materials to meet 2025 standards. According to analysts, the amount of aluminum sourced is expected to more than triple today's levels. Key players recognize new risks are emerging and additional investment is required to prepare for the bright future that lies ahead. Aluminum Blanking Company is pleased to provide its perspective of how far the industry has evolved as one of the first pioneers of aluminum processing in North America and share some of the challenges presented over the years.

ALUMINUM BLANKING
COMPANY, INC.

THE STORY BEHIND ALUMINUM'S SOURCING EVOLUTION:

A NORTH AMERICAN PERSPECTIVE

AluMag Procurement Symposium - November 11,2015

Foundation

- Post War Automotive Boom in North America; Steel is King
- Automotive Metals Processing Industry; a Hole Family Legacy

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Beginnings

- The Historical Influence on Motor City Direction and ABCo's Opportunity:
  - The Energy Crisis; America's Crisis of Conscience

New Direction

- North America adjusts course – CAFE and competition drive innovation and alternatives

- Aluminum shows promise
- Paving the path to ABCo

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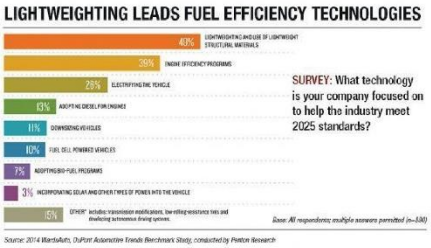
Change Takes Many Forms



- One Directive
- Many Initiatives Suit Multiple Objectives

Change Takes Many Forms

- ABCO is Founded
- Aluminum Gains Notice in the Auto Industry; A Compelling Option but not Yet a Priority

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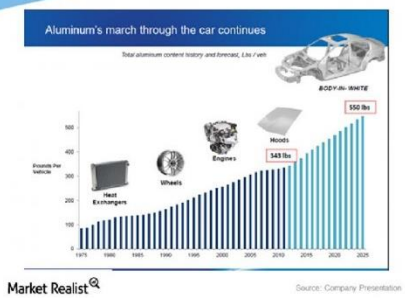
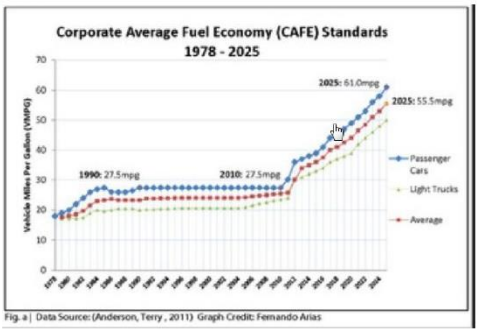
Automotive Aluminum "Niche"



- Modest fuel economy through rest of 80s and 90s
  - Aluminum usage in automotive reflects this; still the "new kid on the block"
  - Steel and lack of familiarity are the competition and challenges

Becoming a Critical Path



- The Clean Air Act - Aluminum Becomes the Direction

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The Road Ahead

- Preparing the North American Supply Chain
- Emerging Supplier Requirements in 2015 and Beyond

Thank You

- Please visit us at:

http://www.albl.com/

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