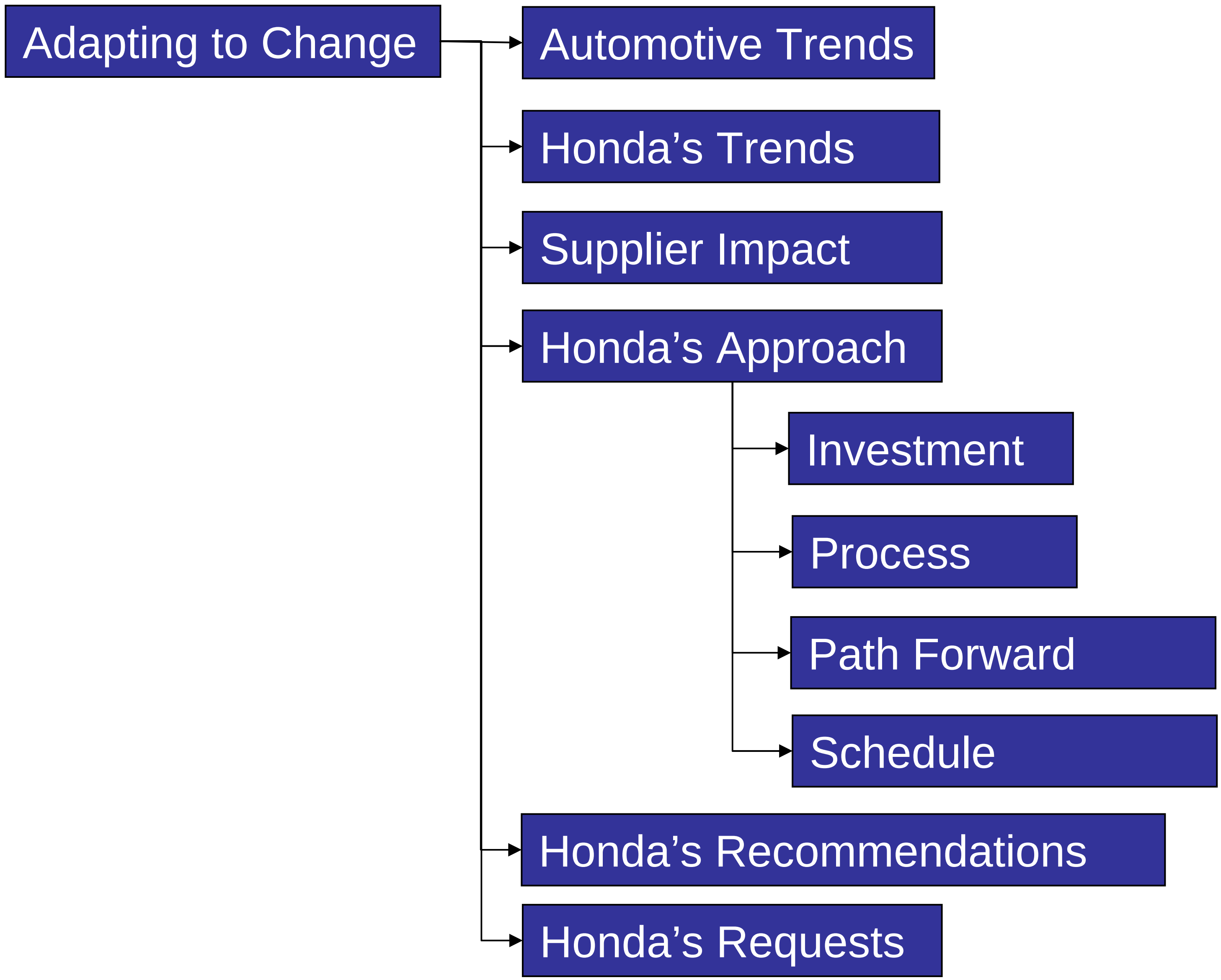
Adapting to the New Automotive World



Supplier Impact

Honda N.A. Production Increase

- Suppliers adding capacity
- Increased capital investment

Honda's Model Mix Increase

- Lower Volumes for Niche vehicles
- Increased changeovers

Continuing Challenge: How to further improve our competitiveness and grow market share ?

Improve Throughput Efficiency

Best Tooling Layout

Process Efficiencies

Aluminum Alloy Molds

Background Direction

- January 2005 – Request from Larry Jutte and Koki Hirashima to evaluate low volume tooling
- Tooling for these programs has greater unit impact and can adversely affect program viability
- Investigate best method to control cost while maintaining Honda quality standards
- Timing coincides with design events for ZQ (Acura RDX) and WQ (07 CRV) programs

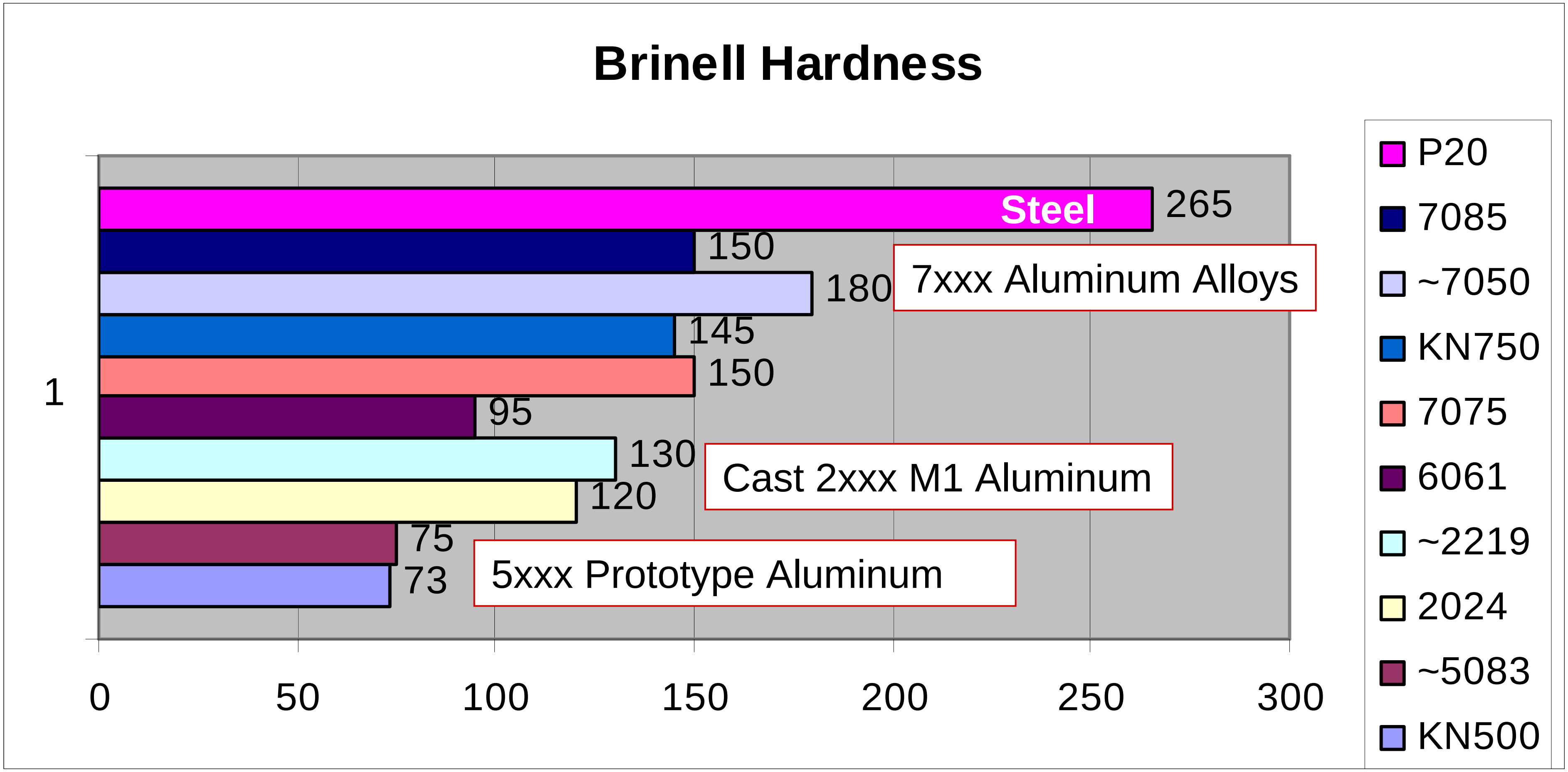
Why Aluminum Alloy?

- High strength alloys originally developed for aircraft are suitable for most mold applications
- Toolmakers: Faster machining and shorter lead times
- Molders: Shorter processing times, less part distortion due to better heat dissipation (3x faster than steel)
- Honda: Parts which meet quality expectations while achieving lower investment $.

Approach for Aluminum Alloy

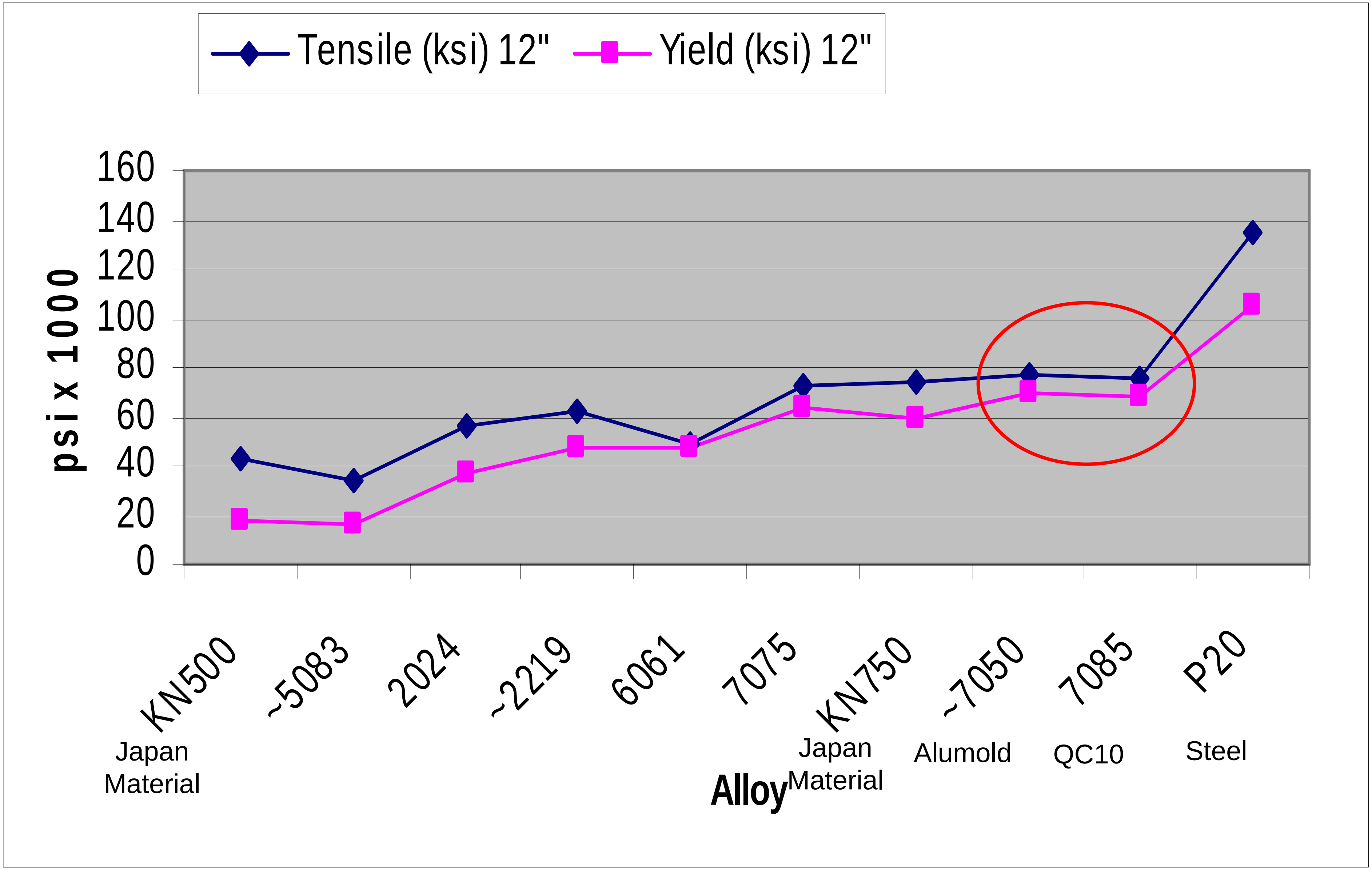
- Met with key Aluminum Alloy Material Suppliers
- Concluded that Honda should begin working with its suppliers to build Aluminum Alloy Tools. (ZQ/WQ)
- Honda decided to build 2 sets of Tools and pay for the backup Steel Tool
  - Purpose: Evaluate Tool build efficiencies and Process Cycle time improvement while protecting our Suppliers and Honda plants from downtime concerns.
- Monitor Tool Maintenance and durability concerns
- Honda paid for 3rd Party Testing to validate Material composition, Mechanical properties, abrasion resistance and compression strength.
- Honda paid for Texture plaque development to further understand Aluminum Alloy texture capabilities as well as repair methods.
- Based on Low Volume Results, began focusing on High Volume applications to validate AL Alloy durability.

How does surface hardness compare to steel?



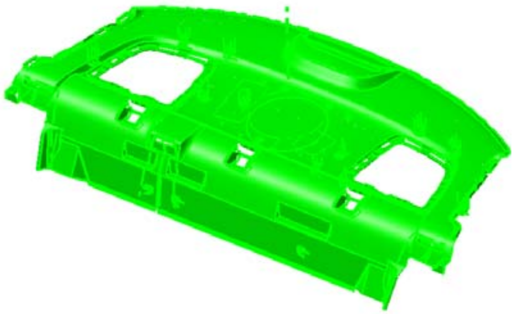
- **Surfaces can be hard anodized or plated to increase wear characteristics if required**

Tensile and Yield Strength Data



Can the mold be crushed by too much pressure?

*Compressive strength for 2PX RR tray mold



- **Unit stress = load/area**
- **Projection area of mold = 46 x 74 = 3404 in2**
- **Projection area of part = 955 in2**
- **Contact area = 3404 - 955 = 2449 in2**
- **Stress (2500 ton press) = 5,000,000 / 2449 = 2,041.65 psi**
- **Tensile strength of 7050 alloy**

Clamping Stress is only 2.6 % of the AL Alloy Tensile Strength

Will Aluminum Alloy handle high Injection Pressure without failure?

- Compressive strength of alloy – 77,600 psi
- Maximum injection pressure at the front of the screw (regardless of machine size) – 33,000 psi
- Percentage –

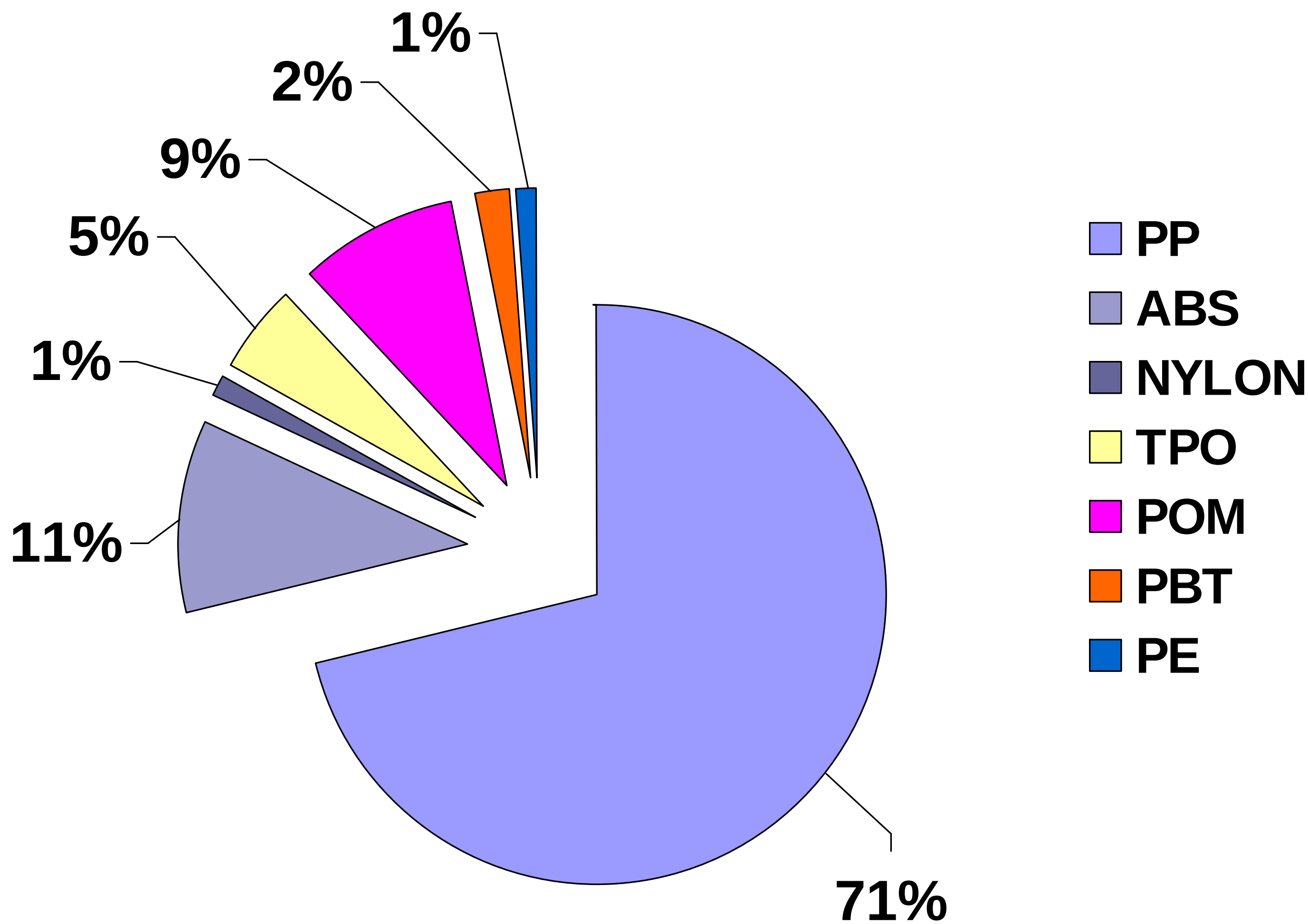
  33,000 / 77,600 = 42.5% of maximum at highest possible pressure

Low Volume Trials
ZQ & WQ Models

Honda purchased backup Steel tools to protect Suppliers and Honda Production

ZQ Mold Distribution Percentages

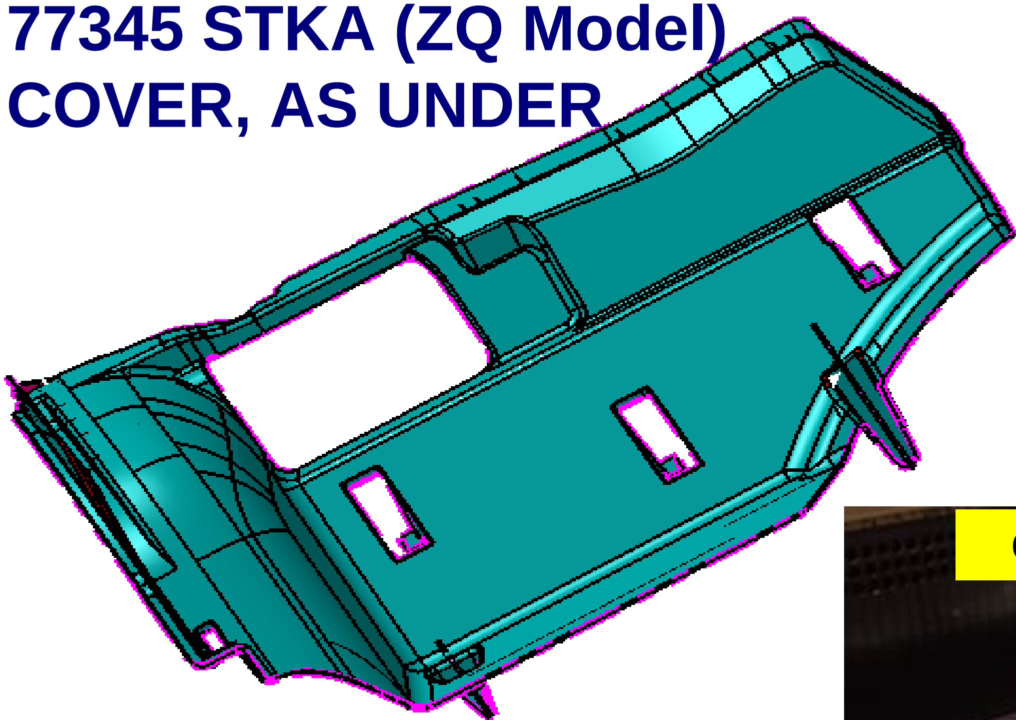
By Number of Molds



Initial Focus is PP based on the Largest Percentage of the Total Application, however other part materials will be considered for future application.

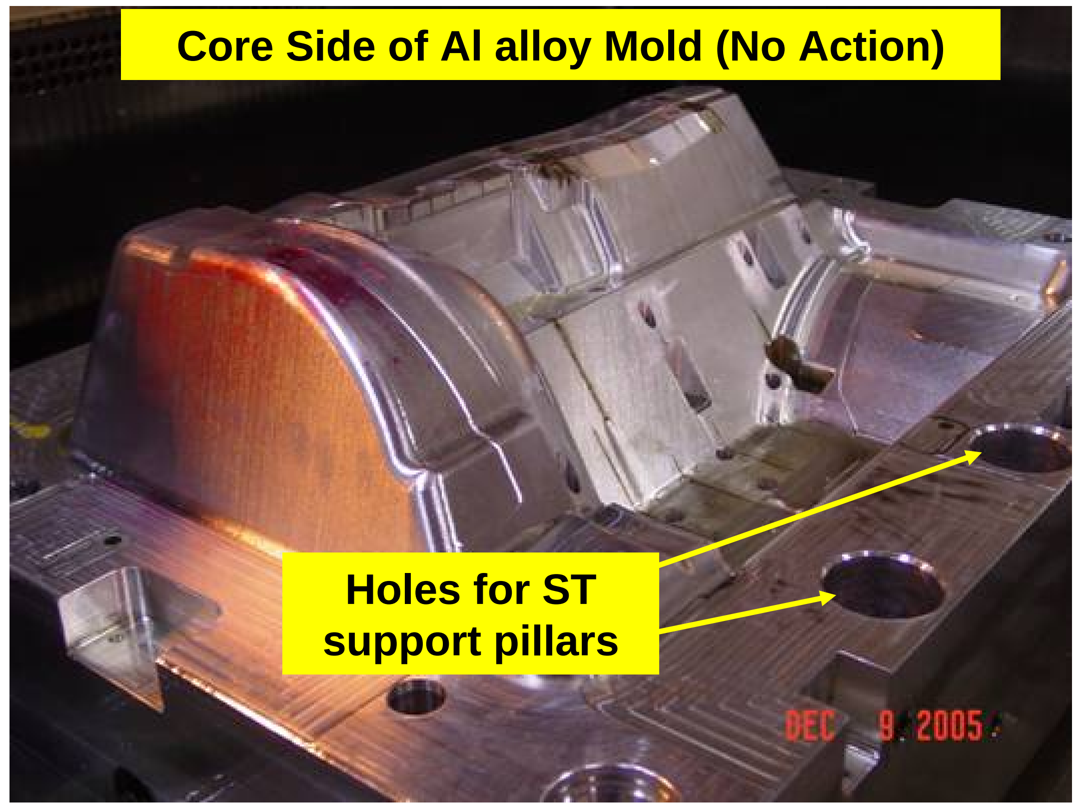
77345 STKA (ZQ Model)
COVER, AS UNDER

Toolmaker
Rapid Die



Part Characteristics

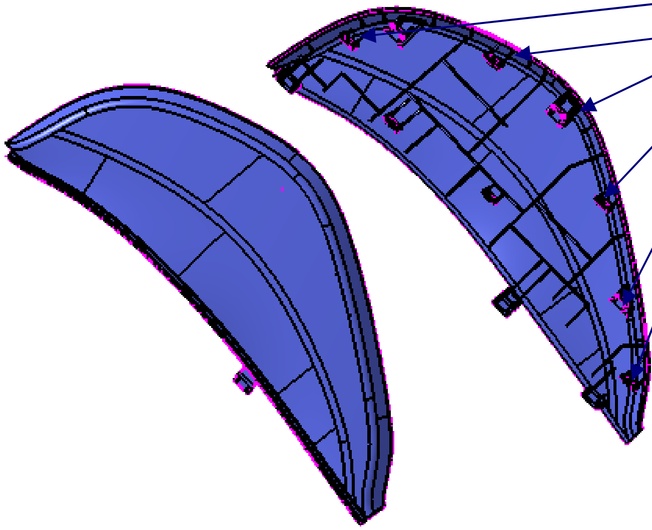
- **Polypropylene Part**
- **IP Underside**
- **Light Texture**
- **No Slides or Lifters**
  - **3 lifters removed at D1-1**

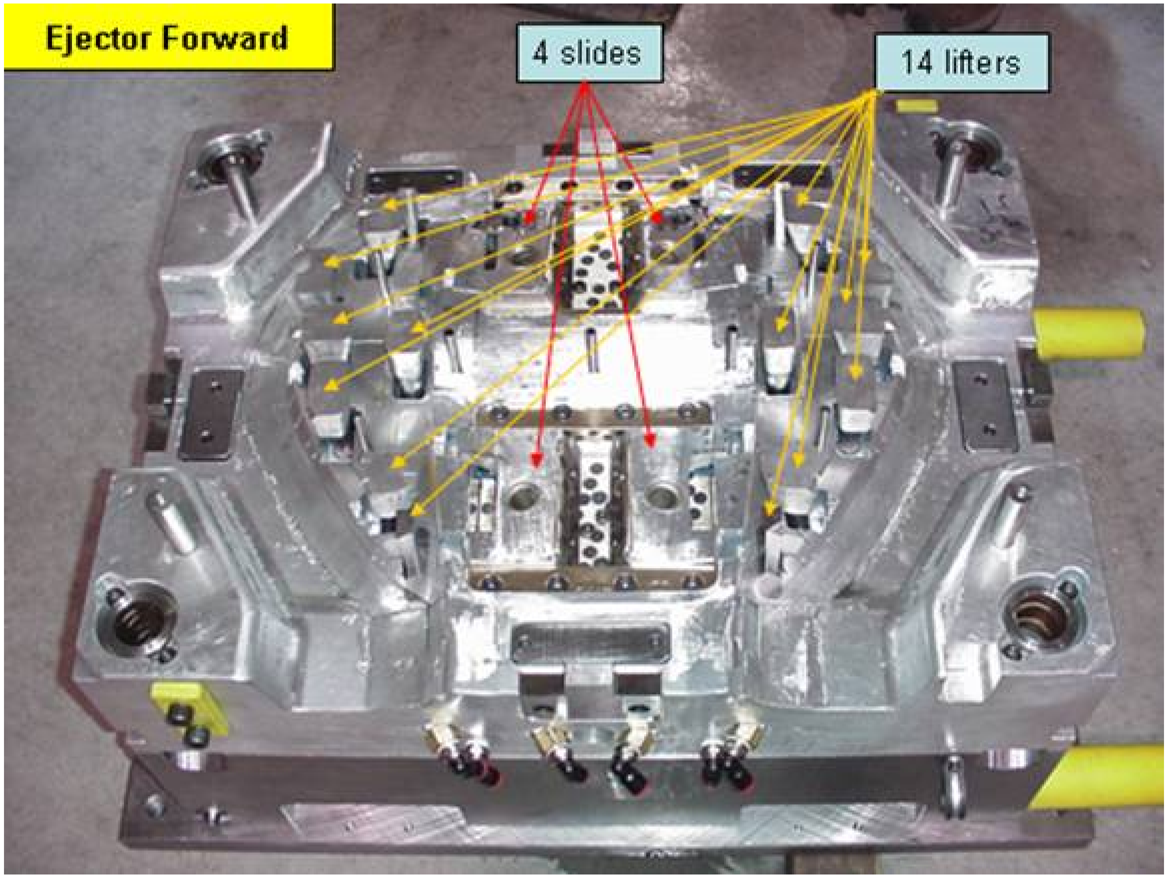


77210/15 SWAA (WQ Model)
LID, INST R/L SIDE

Toolmaker
Unique

Multiple Actions added at Tool Go timing





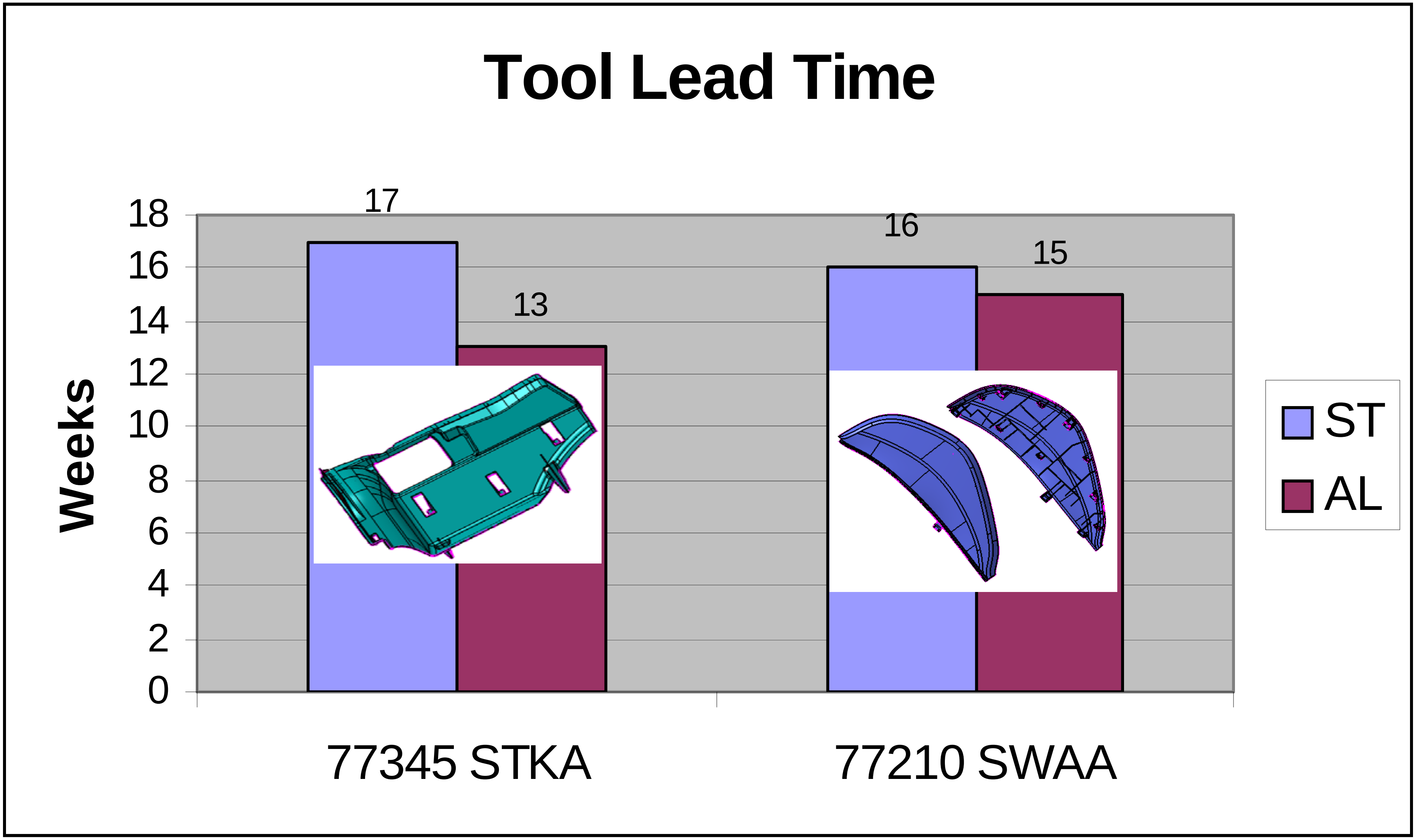
Part Characteristics

- Polypropylene Part
- IP Side Covers
- Leather Texture
- Has Action (Lifters)
  - 6 lifters to 14 at Tool Go

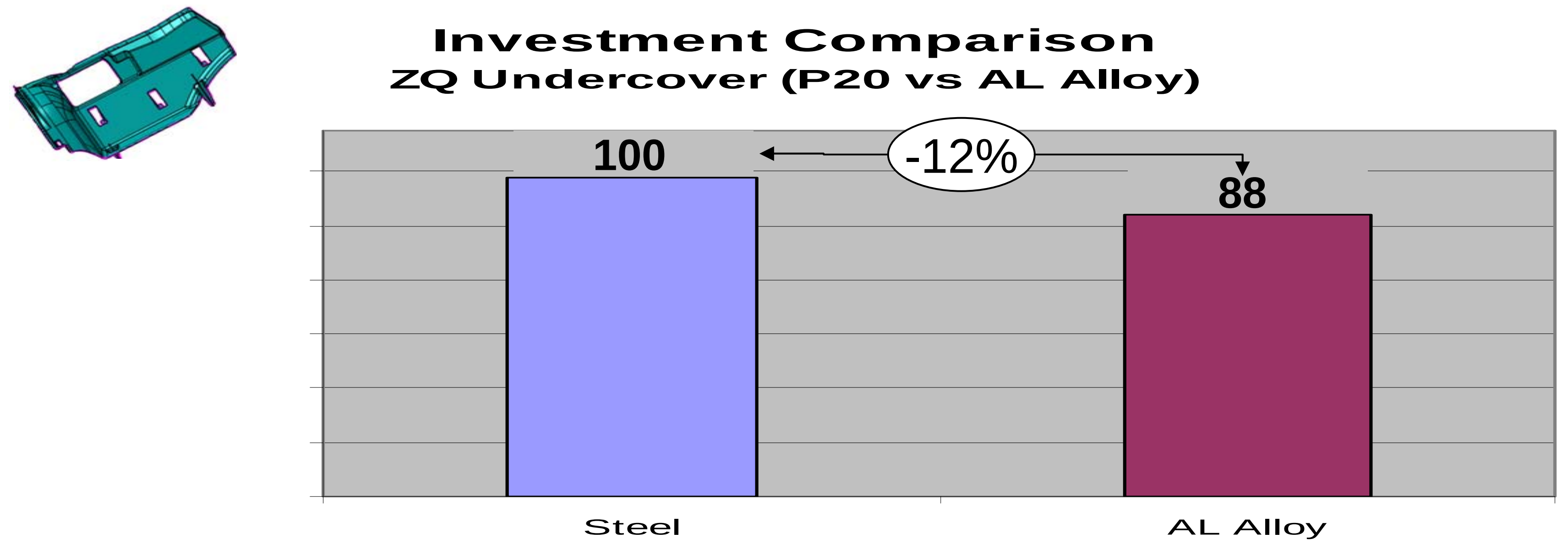
Low Volume Trial Results

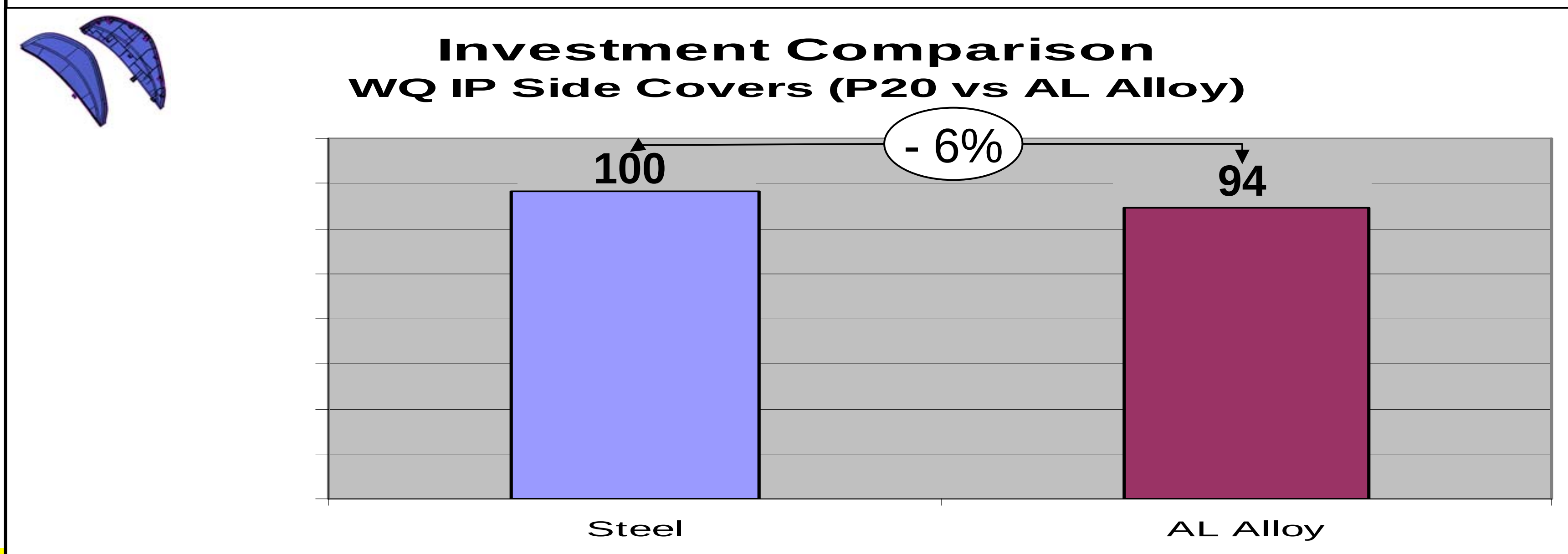
Tool L/T Comparison of Mold Builds

P20 Steel vs Aluminum Alloy



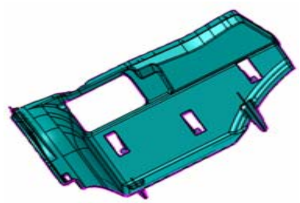
Investment Result for ZQ / WQ Tools





Investment Savings when comparing Steel Mold –vs- Aluminum Alloy Mold

Process Cycle Time Comparison

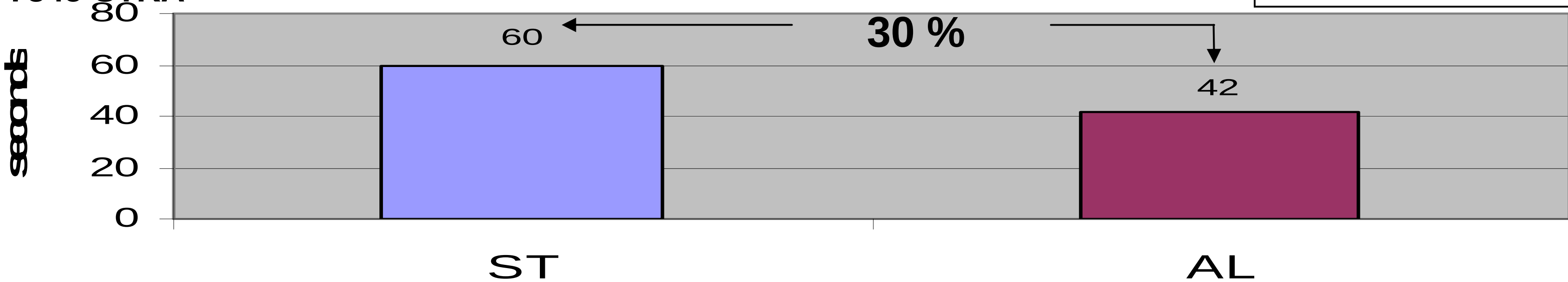


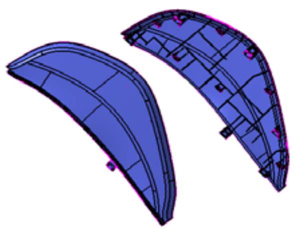
77345-STKA

Cycle Time Comparison of Mold Builds

P20 Steel vs Aluminum Alloy

Part Temp in deg F
ST – 110 vs AL - 87



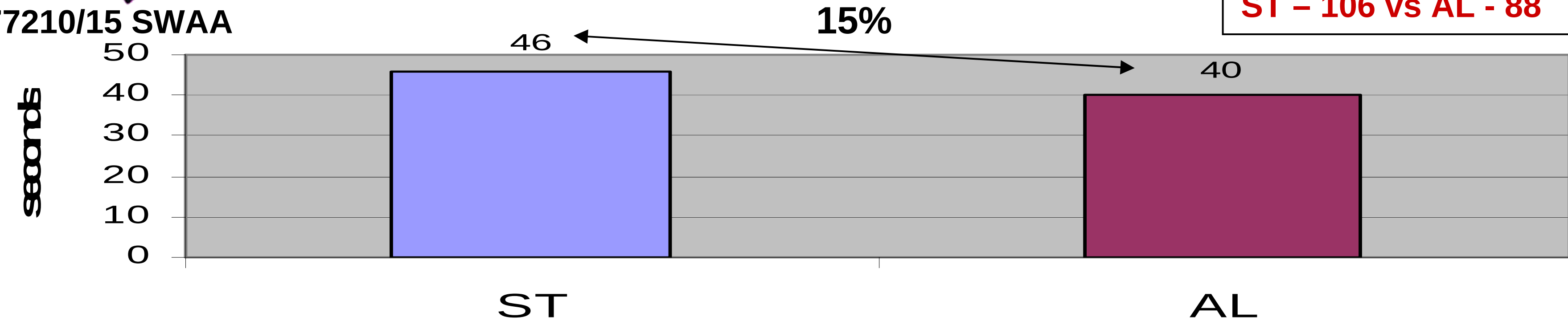


77210/15 SWAA

Cycle Time Comparison of Mold Builds

P20 Steel vs Aluminum Alloy

Part Temp in deg F
ST – 106 vs AL - 88



Cycle Time Savings when comparing Steel Mold –vs- Aluminum Alloy Mold

3rd Party Testing

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METALLURGICAL AND MECHANICAL EVALUATION OF MOLD METALS

1.0 INTRODUCTION

A set of five materials were evaluated through various tests in an effort to identify differences in metallurgical and mechanical characteristics. The evaluation incorporated the following tests:

- Chemical analysis (Employing Glow Discharge Optical Emission Spectrometry)
- Mechanical Testing (ASTM E8)
- Rockwell Hardness Measurements (ASTM E18)
- Brinell Hardness Measurements (ASTM E10)
- Abrasion Resistance (Employing linear abrasion methodology)
- Cyclic Compression Testing (Employing surface to surface contact at 5000psi through 10,000 cycles)
- Surface roughness and scanning electron microscopy of compression specimens before and after testing.

Sample material identification was an follows:
-Alumold
-Aluminum
-P-20
-Hokotol
-QC-10

2.0 Summary of Observations

Evaluation of the five alloys revealed that the "P-20" alloy was by far the hardest, strongest and most abrasion resistant material, as would be expected considering it to be a steel alloy, while the other materials were aluminum alloys. With respect to the aluminum alloys, it would appear the "Hokotol" and "Alumold" exhibited the best overall physical characteristics, while the "QC-10" was a close runner-up. The "Aluminum" material was significantly softer and less resistant to abrasion when compared with than any of the other alloys represented in this report.

The cyclic compression testing stress of 5000 psi over 10,000 cycles did not appear to significantly alter the surface texture of any of the alloy samples, suggesting that any of these materials could withstand loading of this nature. However, if loading or the number of cycles was increased significantly, it would be expected that the life expectancy of these alloys would best be represented by their mechanical properties.

The following is a presentation of our observations.

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3.0 TEST METHODOLOGY AND RESULTS

3.1 Chemical Analysis / Glow Discharge Spectrometry

The GDS-850A Atomic Emission Spectrometer can simultaneously analyze forty-one different wavelengths with the support of special features including:

- A Grimm-type 4 mm glow discharge source.
- A 0.75 m direct-reading spectrometer with a 1800 & 3600 groove holographic gratings and Wavelength range of 119-800 nm with the dual spectrometer option installed.
- Window - driven software interfaced with a LECO 486 base computer.

The GDS-850A provides accurate elemental compositions from depths of tens of nanometers to one hundred micrometers. It performs rapid, routine surface analyses on conductive materials. Results are presented in Table 1.

Table 1. Chemical Analysis (%wt)

	Aluminum	Alumold	Hokotol	QC-10	P-20
C					0.36
Cr	0.05	0.01	0.01	<0.01	1.89
Cu	2.79	2.13	1.71	1.78	
Fe	1.03	0.04	0.04	0.04	
Mg	1.06	2.16	2.18	1.6	
Mn	0.06	0.01	0.01	<0.01	1.45
Mo					0.22
Ni					1.02
P					0.010
S					0.008
Si	0.18	0.06	0.03	0.03	0.27
Ti	0.03	0.04	0.04	0.01	
Zn	0.05	6.20	6.18	8.47	

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3.2 Mechanical Testing

Tensile testing was conducted on each sample using the Instron 4208 Universal Testing Machine. Samples were extracted from the long axis of each material test block and prepared in accordance with "ASTM E8, Figure 9, Specimen Type #4" (See Appendix 1). Results are summarized in Table 2 and stress vs strain curves are illustrated in Figure 1.

Table 2. Mechanical Test Results

		Aluminum	Alumold	Hokotol	QC-10	P-20
Mechanical Properties						
Tensile (psi)		38700	80900	82900	73300	136500
Yield (psi)		21300	75800	77000	66700	118700
Elongation (%)		6	12.5	10.5	9	17

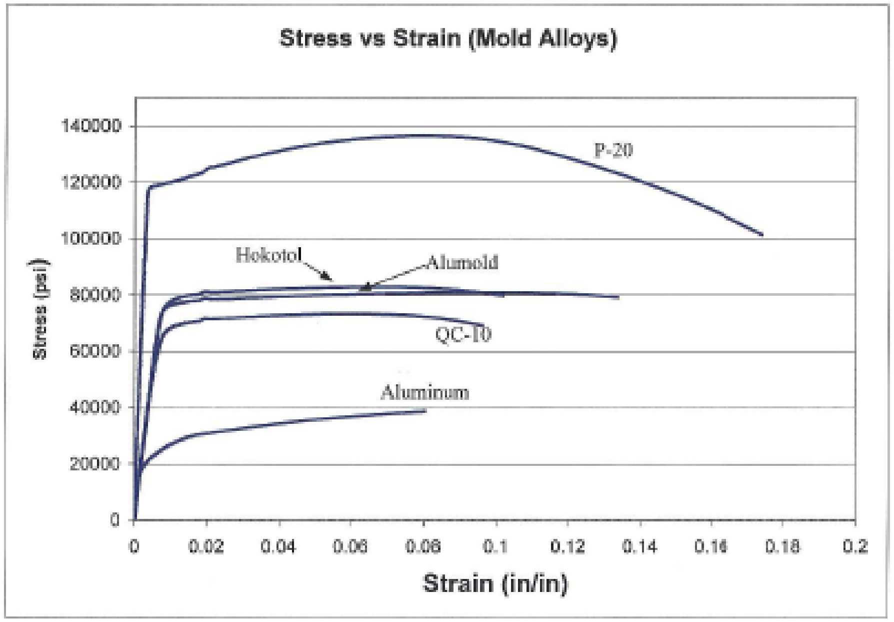

Figure 1. Compiled stress strain curves for the five alloys.

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3.3 Hardness Measurements

Rockwell Hardness
Hardness measurements were taken from each sample employing Rockwell measurement techniques (ASTM E18) and Brinell techniques (ASTM E10). The Rockwell "B" technique employs a standard load of 100 kgf to a 1/16th inch diameter ball and records the extent of indentation into the test specimen, which in turn may be correlated to the strength and wear resistance of that material. This measurement technique is sensitive to variation in metallurgical composition, and is best suited to wrought / homogeneous alloys. Measurements were recoded from each material, with the average presented in Table 3.

Brinell Hardness
The Brinell hardness technique employs the standard ASTM E10, in which a 500kgf load is directly applied to the test sample through a 10mm diameter tungsten carbide ball. Hardness measurements are based on the resultant impression. This technique provides reliable hardness characteristics covering the bulk metallurgical properties, thus, is less sensitive to hardness variations associated with microstructural constituents. Measurements are presented in Table 3.

Table 3. Hardness Results

	Aluminum	Alumold	Hokotol	QC-10	P-20
Brinell Hardness (HB)	76	165	164	140	289
Rockwell Hardness	39.1 HRB	91.1 HRB	89.4 HRB	81.8 HRB	24.7 HRC

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3.4 Abrasion Resistance

An abrasion resistance testing technique was specifically developed for Unique Tool and Gauge in an effort to qualify material loss characteristics associated with rubbing contact.

Each sample was machined to a 5" x 1.5" x 0.35" platen, weighed then placed longitudinally on the test platform. A hardened steel abrasion block with a contact width of 0.25" x 0.10" was placed in contact with the test platen and load vertically to 250gf. The test platen was then cycled longitudinally through a length of 3.5 inched at a rate of 30 cycles per minute for a total of 5000 cycles. After cycle completion, the final weight was measured and weight loss determined. The surface topography was then evaluated using the scanning electron microscope. The five platens are illustrated in Figure 2, and the surface characteristics associated with the abrasion are illustrated in Figures 3 through to 7. Results are presented in Table 4.

Table 4. Abrasion Resistance Material Loss (g)

	Initial Wt	Final Wt	Wt Loss / 5000 cycles
Aluminum	65.174	65.148	**0.026**
Alumold	70.840	70.826	**0.014**
Hokotol	71.325	71.321	**0.004**
QC-10	71.950	71.928	**0.022**
P-20	185.234	185.234	**0.000**

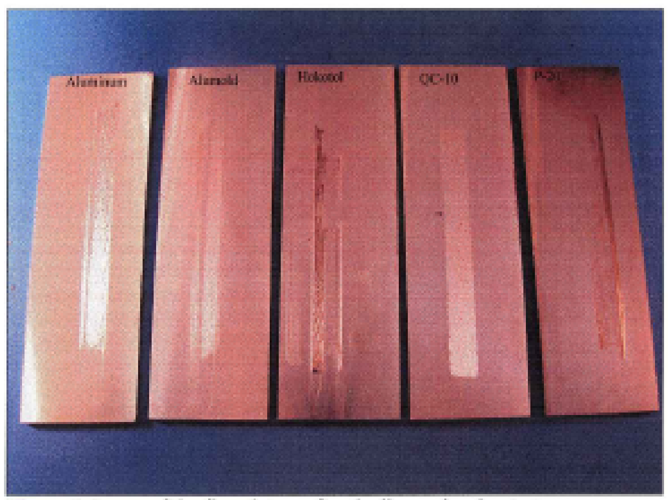

Figure 2. Image of the five platens after the linear abrasion test.

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3.5 Cyclic Compression Testing

Cyclic compression testing was conducted on cylindrical specimens prepared from each alloy in an effort to simulate the nature of contact damage which may be associated with real-life mold closure. Matching cylindrical specimens of 1.0" diameter were prepared from each alloy and surface finished with a 250 grit emery paper. The surfaces were measured for roughness (Ra) using the Mitutoyo Surftest 201 surface roughness tester. Surface texture was also recorded with the JEOL JSM-5600 scanning electron microscope.

The compression test incorporated a servo-hydraulic test frame and a holding jig specifically developed and tested for this cyclic compression test procedure (Figure 8). The test involved the compression of the matching specimens to a stress of 5000psi at a closure rate of 1" per minute, then held at closure for a period of 10 seconds for a total 10000 cycles. Upon completion of testing each sample was then re-measured for surface roughness and examined with the scanning electron microscope. Surface roughness data, test specimens and surface images are presented in Table 5 and Figures 8 to 14 respectively.

Table 5. Compression Sample Surface Roughness

	Surface Roughness (Ra µin)				
	Aluminum	**Alumold**	**Hokotol**	**QC-10**	**P-20**
Face "A" Before Test	10.7	8.0	6.0	7.0	15.0
Face "A" After Test	10.3	6.6	6.6	6.7	19.0
Face "B" Before Test	9.3	11.6	5.3	6.0	13.7
Face "B" After Test	10.3	7.0	5.7	9.3	15.3

Figure 8. Compression frame and test jig fixture employed in the test of the five alloys. The arrows highlight the location of the test specimens.

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Lab Ref. No 608885 - 89
30 October, 2006

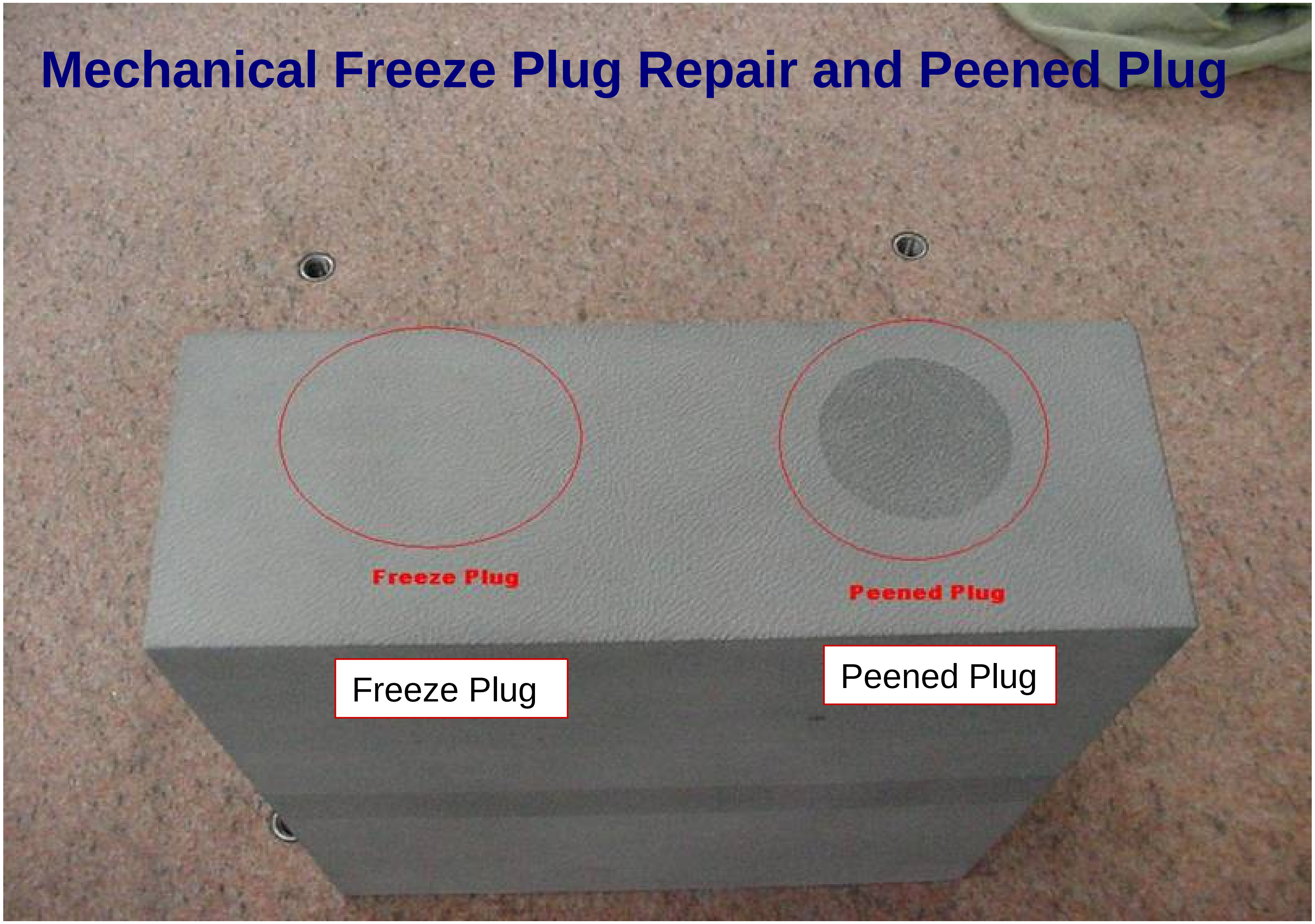
Figure 9. Image of the five alloy sets. This image was taken after the completion of the cyclic compression tests.

In Conclusion from 3rd Party Testing

- P20 was the hardest, strongest and most abrasion resistance considering it was Steel as compared to the other 4 AL Alloys.
- All AL Alloys exhibited increased hardness, strength and abrasion resistance, which confirmed the data provided by the AL Alloy suppliers.
- Cyclic Compression testing showed that all materials could withstand loading of this nature. Higher cycling would provide further understanding of full life expectancy.

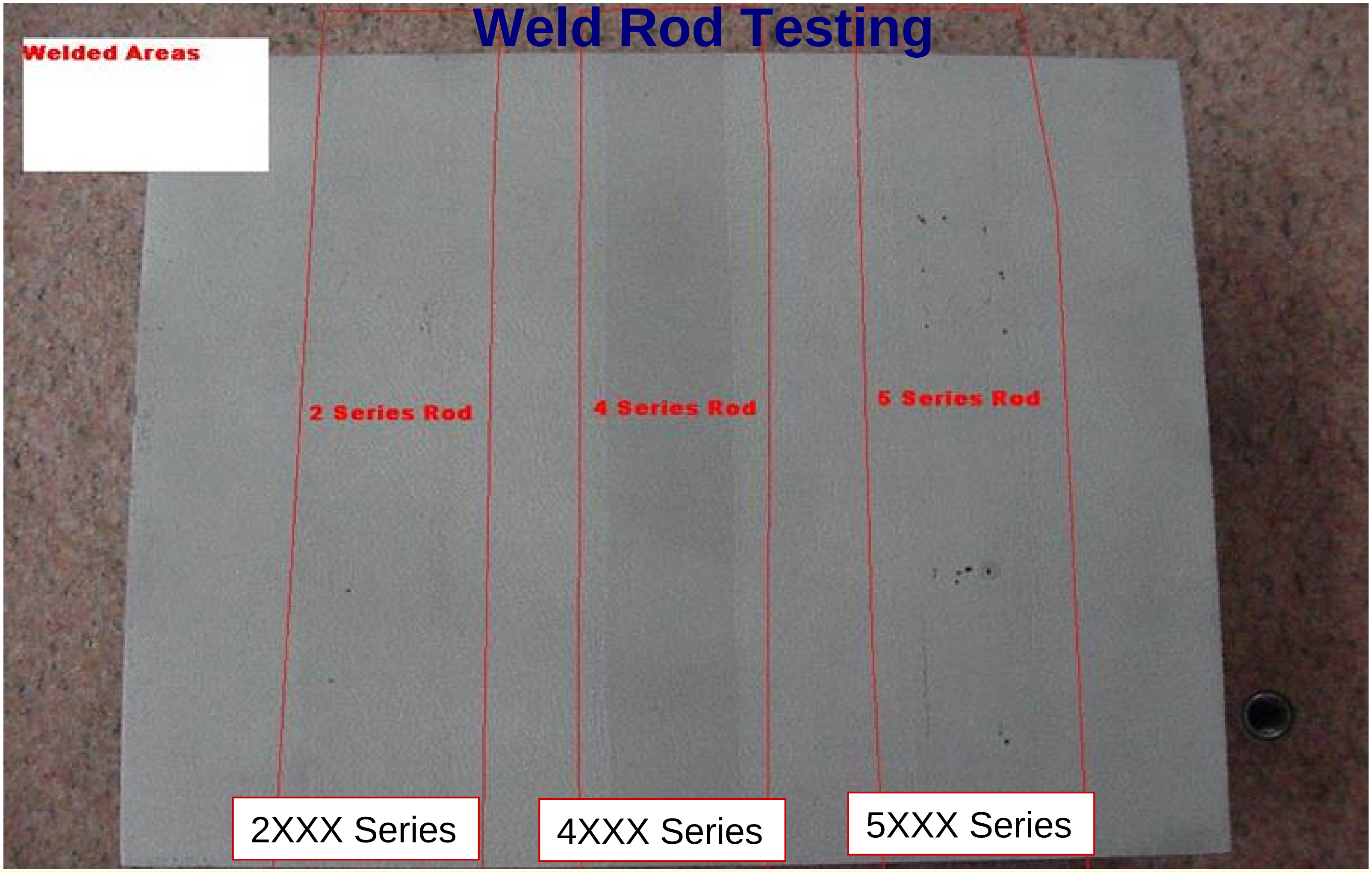
Aluminum Alloy Repair & Texturing

Tool Shop and Honda Verified



Mechanical Freeze Plug performed best

Tool Shop and Honda Verified



Porosity on 5000 series rod was worse than 2000 series and 4000 series performing the best

Texture Plaque Tools for H390 & H402 Grains

Honda R&D activity for Texture Evaluation and Repair Methods

Texturing Result of Aluminum Alloys (Honda 390 Grain)

Texturing Result was successful for each AL Alloy. Repair Results varied by each Alloy. (See Samples)

Texturing Result of Aluminum Alloys (Honda 402 Grain)

Texturing Result was successful for each AL Alloy. Repair Results varied by each Alloy. (See Samples)

Texturing and Repair Results

	Evaluation Item	2XXX Series	7XXX Series	
		Cast M1	Alumold	QC10
	Texturing	Good	Good	Good
	Repairability (As compared to Steel)	Good	Needs Improvement	Needs Improvement
H402 Grain	Welding Repair	Good	Needs Improvement	Needs Improvement
H402 Grain	Freeze Plug	Good	Good	Good
H390 Grain	Welding Repair	Good	Needs Improvement	Needs Improvement
H390 Grain	Freeze Plug	Good	Good	Good
Non - Grain	Welding	Good	Good	Good

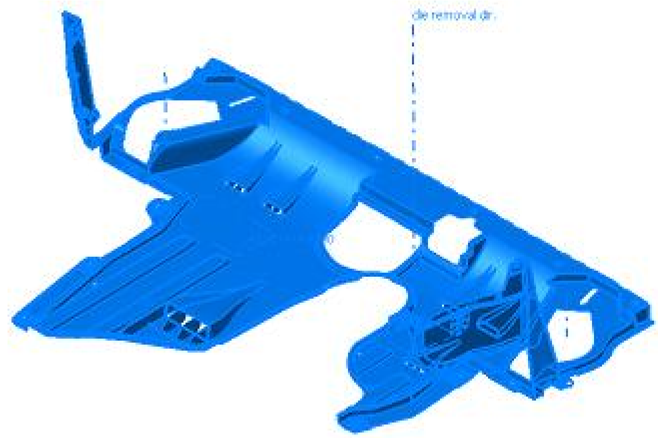
- ● Good
- ▲ Needs Improvement
- X Poor

Working with Material Vendors to improve Weldability for 7XXX series Alloy

High Volume Trial & Results

08 Accord Tools for AL Alloy Application

Rear Tray

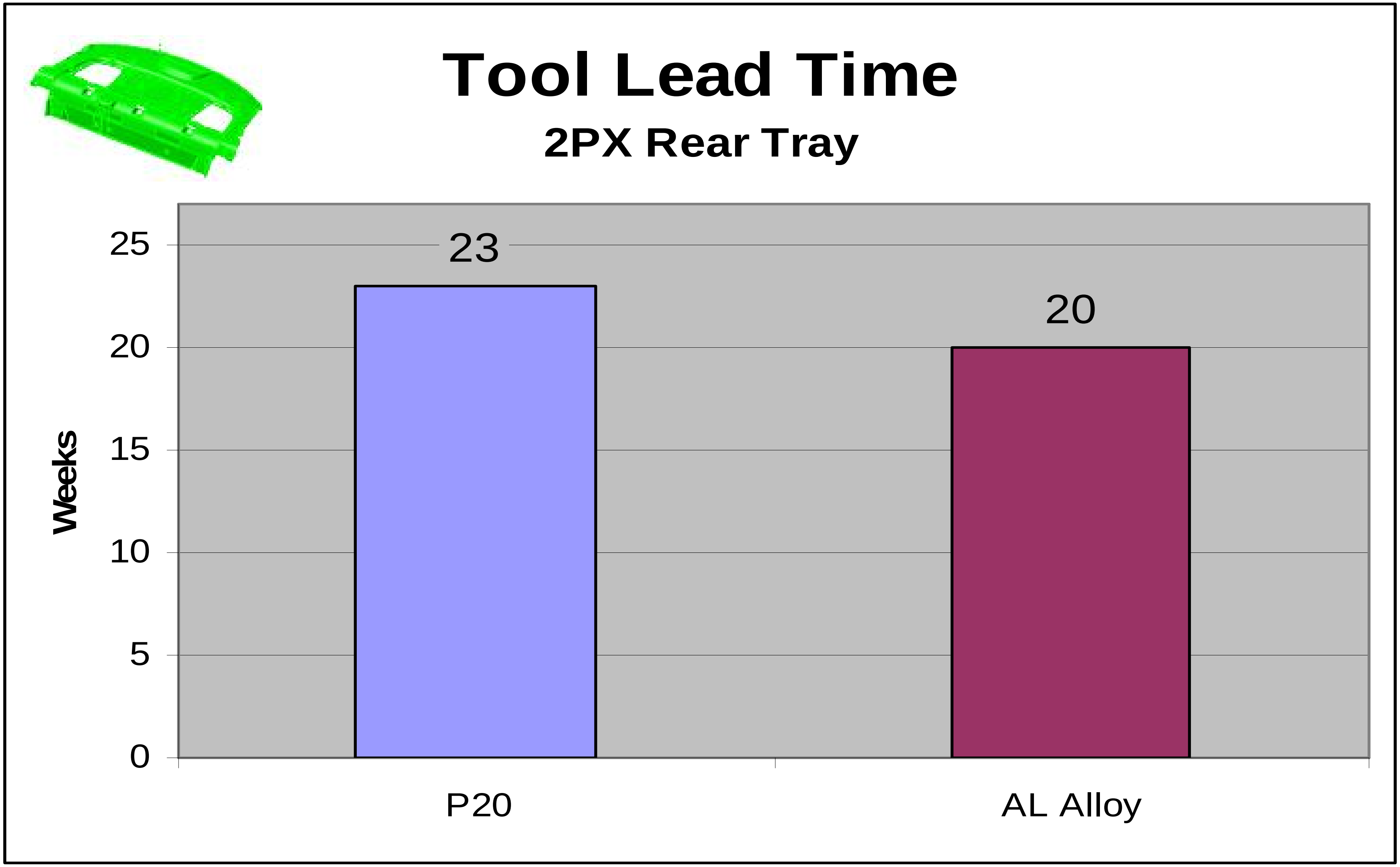


Engine Under Cover

Cowl Side Assy

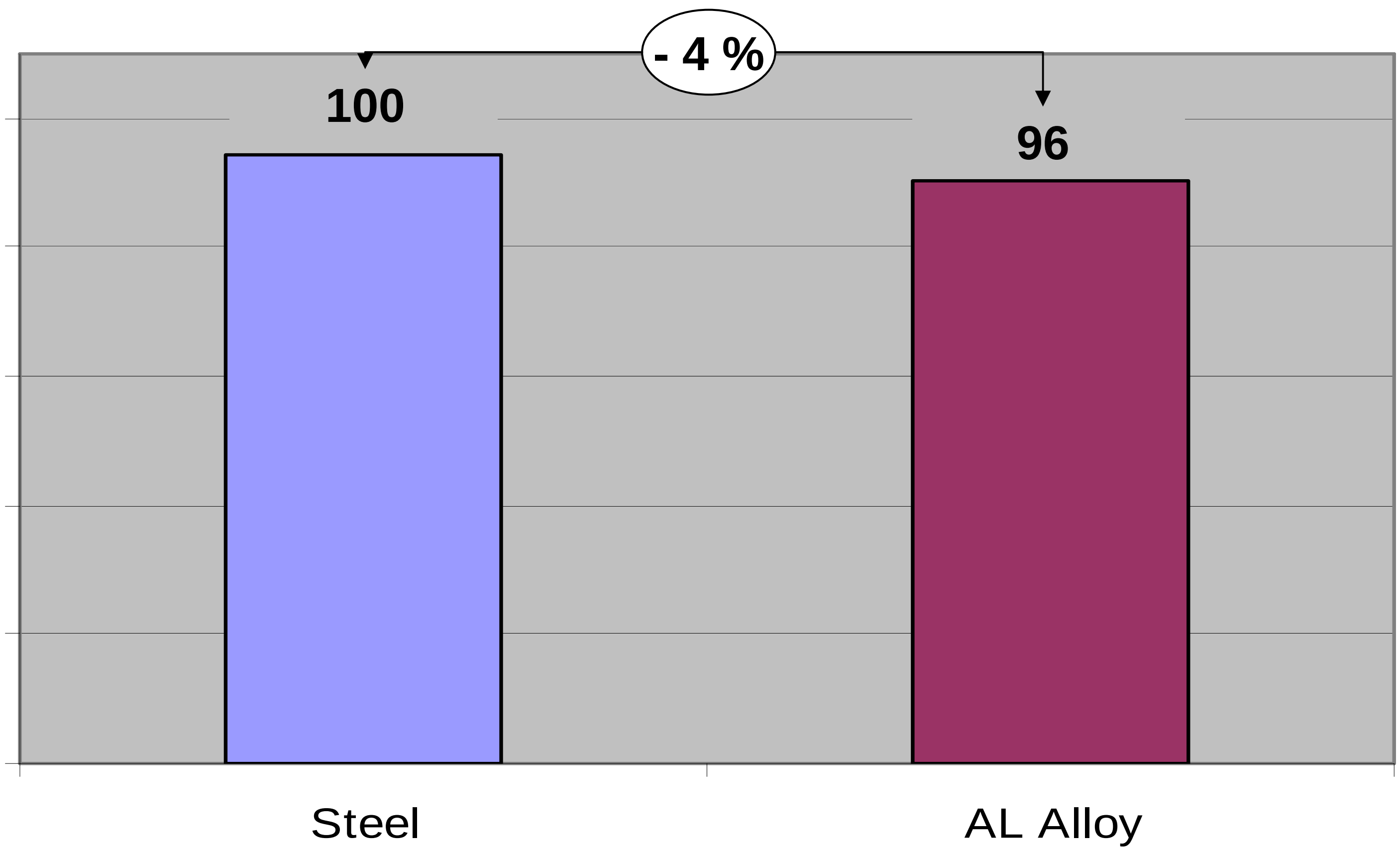
Toolmaker	Part Name	PPA
Unique	Rear Tray	Capacity Plus, JS Parts
Rapid	Engine Under Cover	Capacity Plus
Unique	Cowl Side Assy	Capacity Plus

Tool L/T Comparison of Mold Build



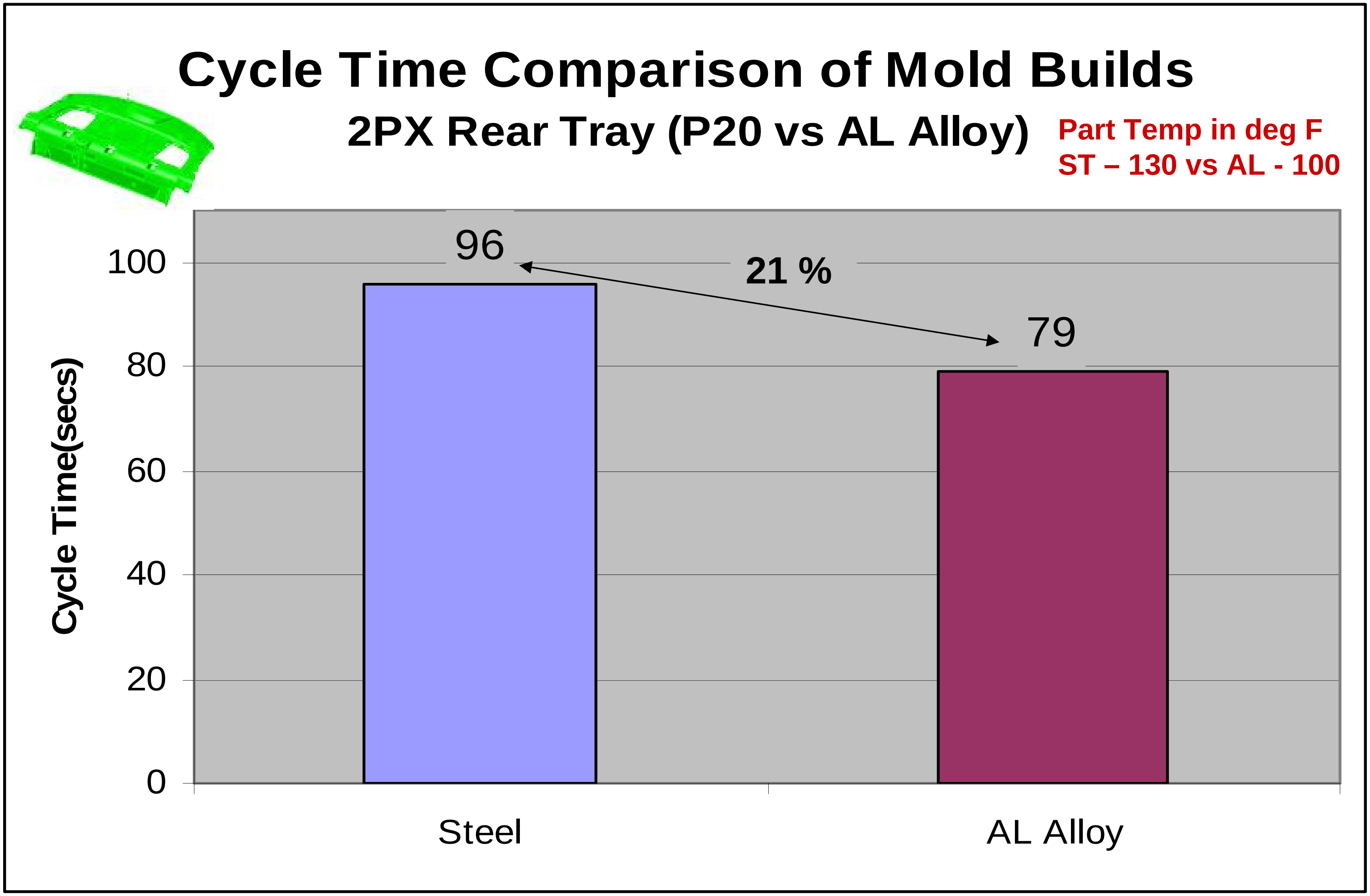
Leadtime Savings when comparing Steel Mold –vs- Aluminum Alloy Mold

Investment Result for 2PX Rear Tray

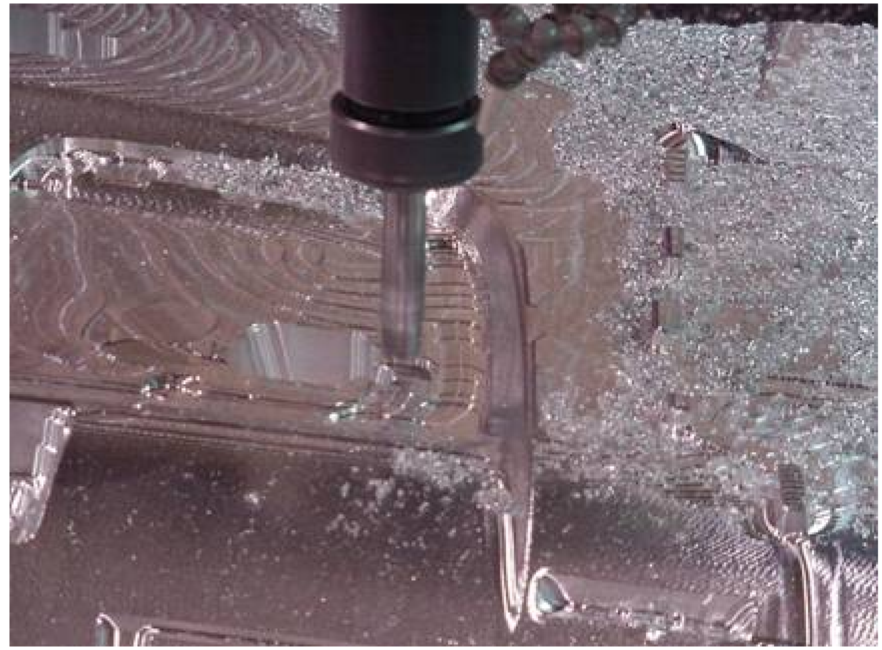


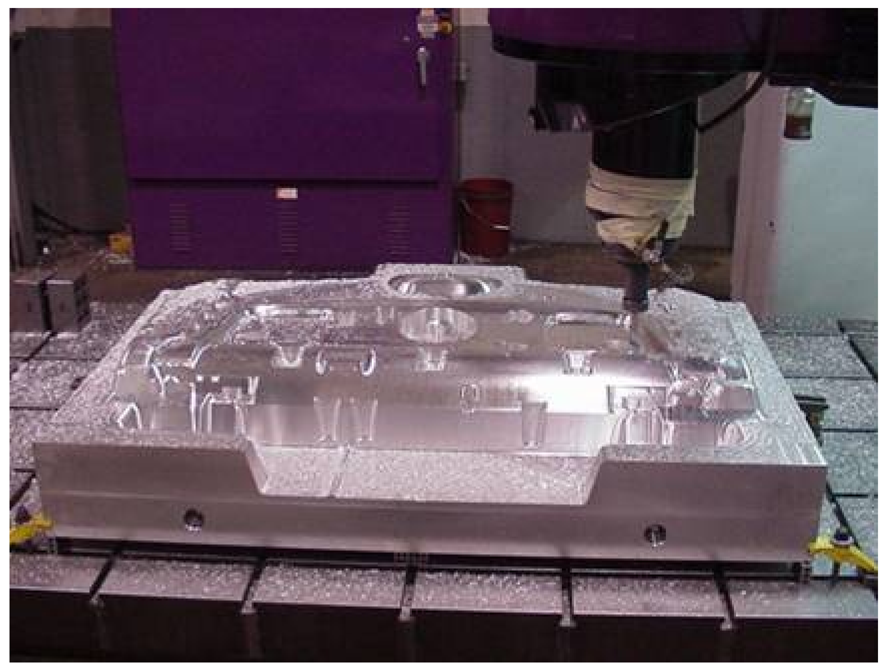
Investment Savings when comparing Steel Mold –vs- Aluminum Alloy Mold

Process Cycle Time Comparison



Cycle Time Savings when comparing Steel Mold –vs- Aluminum Alloy Mold



Benefits of Aluminum Alloy

- Investment Savings through machining efficiency
- Process Cost Savings due to improved Thermal conductivity (Reduced Cycle Time)
- Reduce number of molds **and** injection machines required to mold parts
- Different grades of Aluminum can be applied based on Program Volume
- Lower Injection and Clamp Pressure as compared to a Steel Tool

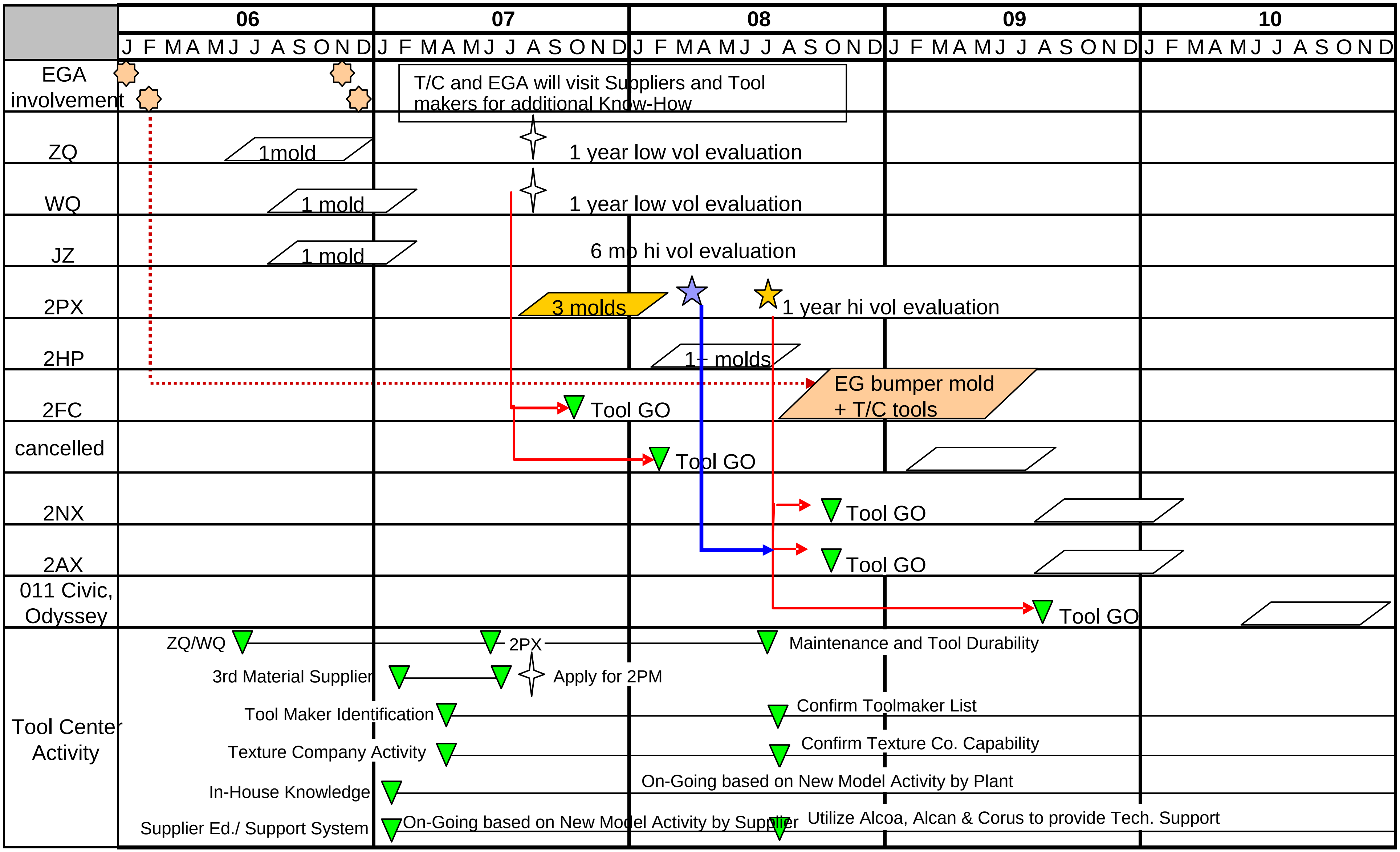
Path Forward and Challenges

- Maintenance & tool life monitoring
- Introduce 2xxx series for low volume programs
- Combine 2xxx (cavity) & 7xxx (core) alloys for low to medium volume models
- Continue improving toolmakers skill sets (Cutting Tool Technology)
- Companies with Al alloy texture and repair capabilities
- Purchasing agreements/contracts with Al alloy suppliers & distributors
- Strengthen In-house & supplier knowledge

Total AL Alloy Activity to date (14 tools total)

program	part #	model	description	comments	# shots
06 Acura RDX	77345	STKA	AS Undercover	pilot program, P20 backup	44,728 - 21 Dec 07
06 CR-V	77210/15	SWAA	Instr side cover R/L	pilot program, P20 backup	76,730 - 08 Jan 08
06 MDX	71502	STXA	RR Bpr Skid Garnish-China	variation model	?
08 Accord	84500	TA0A	RR Tray	Al alloy primary tool, P20 capacity tool	90,966 - 02 Jan 08
08 Accord	74111	TA0A	Engine Undercover	Al alloy primary tool, P20 capacity tool	Jan 08 M/P
08 Accord	83111/61	TA0A	Cowl side lining R/L	Al alloy primary tool, P20 capacity tool	Jan 08 M/P
06 Civic capacity up	17252	RNAA	Tube Assy air intake	volume increase	360,000/yr
06 Civic capacity up	17253	RNAA	Tube Comp C air intake	volume increase	360,000/yr
08.5 Pilot	71502	SZAA	RR Bpr Skid Garn-Russia	variation model	?
08.5 Pilot	53320	SZAA	Cover, steering joint	single tool, higher volume model	140,000/yr
09 Acura TL	71105/09	TK4A	Housing, lwr intake	single tool, higher volume model	90,000/yr
09 Acura TL	74112	TK4A	Plate, air guide	single tool, higher volume model	90,000/yr
09 Acura TL	74225	TK4A	A/C umbrella	single tool, higher volume model	90,000/yr
Personal watercraft	77350	HW5A	RR Grip	low volume power sport product	15,000/yr

Schedule



06
07
08
09
10
J F M A M J J A S O N D
EGA involvement
T/C and EGA will visit Suppliers and Tool makers for additional Know-How
ZQ
1mold
1 year low vol evaluation
WQ
1 mold
1 year low vol evaluation
JZ
1 mold
6 mo hi vol evaluation
2PX
3 molds
1 year hi vol evaluation
2HP
1+ molds
2FC
Tool GO
EG bumper mold + T/C tools
cancelled
Tool GO
2NX
Tool GO
2AX
Tool GO
011 Civic, Odyssey
Tool GO
Tool Center Activity
ZQ/WQ
2PX
Maintenance and Tool Durability
3rd Material Supplier
Apply for 2PM
Tool Maker Identification
Confirm Toolmaker List
Texture Company Activity
Confirm Texture Co. Capability
In-House Knowledge
On-Going based on New Model Activity by Plant
Supplier Ed./ Support System
On-Going based on New Model Activity by Supplier
Utilize Alcoa, Alcan & Corus to provide Tech. Support

Adapting to the New Automotive World

- Adapting to Change
  - Automotive Trends
  - Honda's Trends
  - Supplier Impact
  - Honda's Approach
    - Investment
    - Process
    - Path Forward
    - Schedule
  - Honda's Recommendations
  - Honda's Requests

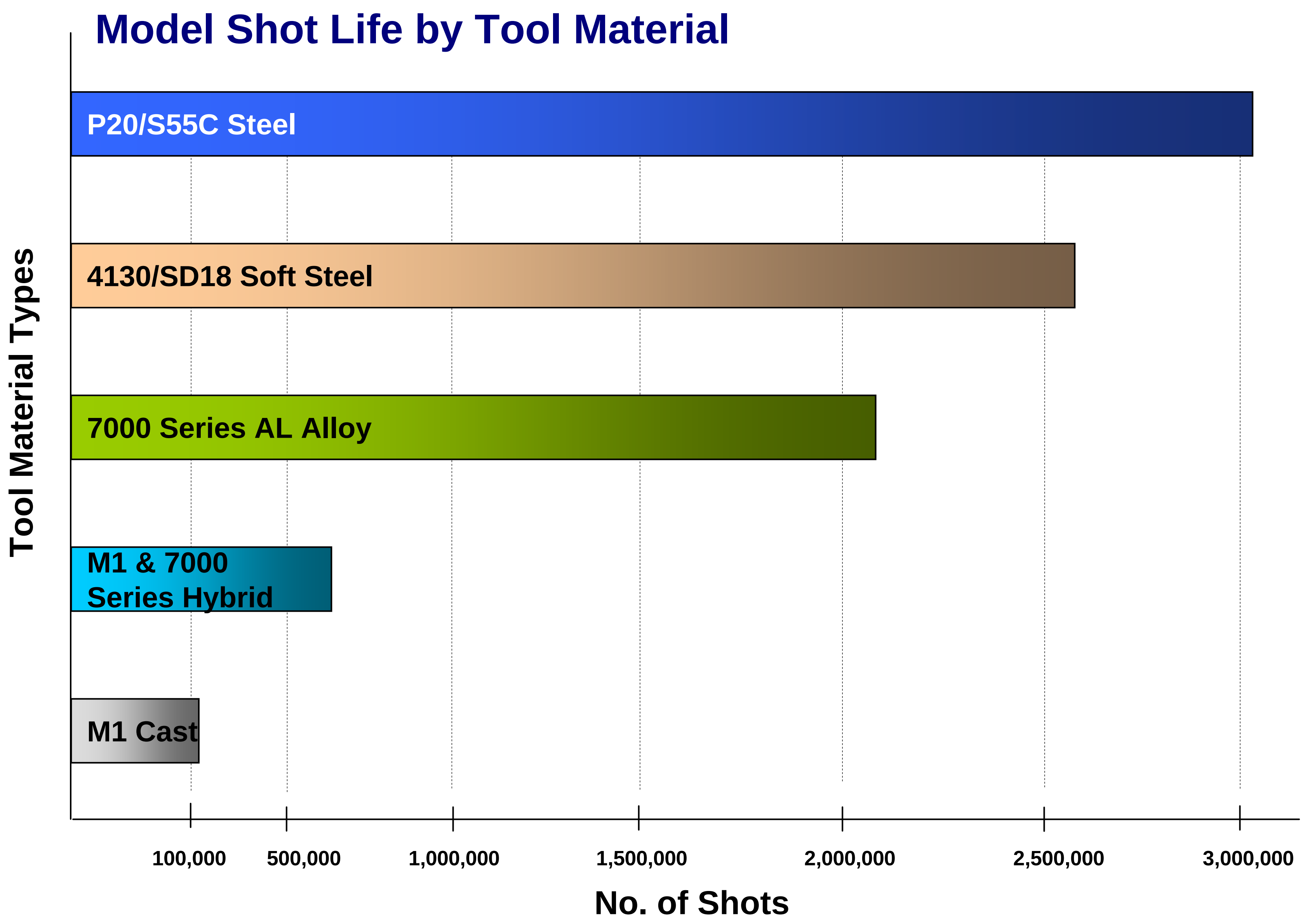
Honda Recommendations

Investment & Process Cost Savings Matrix

Material	Current Tools		Multi-Cavity Tools		Family Tools	
	Invest.	Process	Invest.	Process	Invest.	Process
H13/S7	115	100	155	50	170	50
P20/S55C	100	100	140	50	150	50
4130/SD18	92	100	132	50	142	50
AL Alloy	90	80	130	40	140	40
Alpase M1	85	80	125	40	135	40
Comments	Example: 1 Single Cavity Tool		Example: 1 Cavity to 2 Cavity		Example: 2 Tools 1 Cavity to 1 tool 2 cavity family	

Increasing the use of AL Alloy, Multi-Cavity and Family Tools improves the overall Throughput efficiency

Honda Recommendations



Honda Requests

New Model Schedule & Targets

	Model	Target tools	Actual Tools	Toolmaker	Part Name	Part Characteristics	Risk	Comment
Current	ZQ	1	1	Rapid	Passenger Under Cover	Low visibility, light texture, No Action	L	Backup Steel Tool
	WQ	1	1	Unique	IP Side Covers	Med visibility, leather texture, multiple action	L	Backup Steel Tool
	2PX	6	3	Unique	Rear Tray	Med visibility, Multiple texture, multiple action	M	Capacity Plus Tool: 2nd Tool needs to run around 20 % to meet capacity. If trouble, then Japan Supply.
				Rapid	Engine Under Cover	Low visibility, No texture, Functional, Some action	L	Capacity Plus Tool, however upon investigation with supplier 1 tool could make production
				Rapid	Cowl Side Assy	Low visibility, Light texture, Some action	L	Capacity Plus Tool, however upon investigation with supplier 1 tool could make production
Future	2HP	3	1	Rapid	Strg Joint Cover	low visibility, functional	M/H	First Al only, no ST backup
	2FC	5	3	Co-Mgmt	Hood Strike Garn Udr Cvr Flr Assy	interior/exterior, low visibility, no texture	M	EGA bumper fascia for Low Volume model (China Export)
	cancelled	5				interior/exterior, low visibility, no texture	L	low volume M/P
	2AX	50%				interior/exterior, low/med/hi visibilty	M/H	low volume M/P
	2NX	25%				interior/exterior, low/med/hi visibility	M/H	medium volume M/P
	011 Civic, Odyssey	30% of unit				interior/exterior, med / hi visibility, textured	M/H	two years of M/P data minimizes risk

Honda Requests

<u>New Model Planning</u>

- Best Tool Material for Production Volume
- Best Tool Layout
- Best Process Cost

Develop a Comprehensive Tool Strategy to include alternative materials and sourcing locations.

In Conclusion – A little food for thought ....

- “Every injection molder who intends to stay in business must continually ask himself, ’What must I do to run as fast and efficiently as possible and still meet the customer’s quality requirements?’”

\- *Moldmaking Technology* Magazine, quoting an article published in 1988