

Great Designs in

STEEL



Die Steel Improvements for AHSS Applications

Thomas Bell

HITACHI METALS LTD

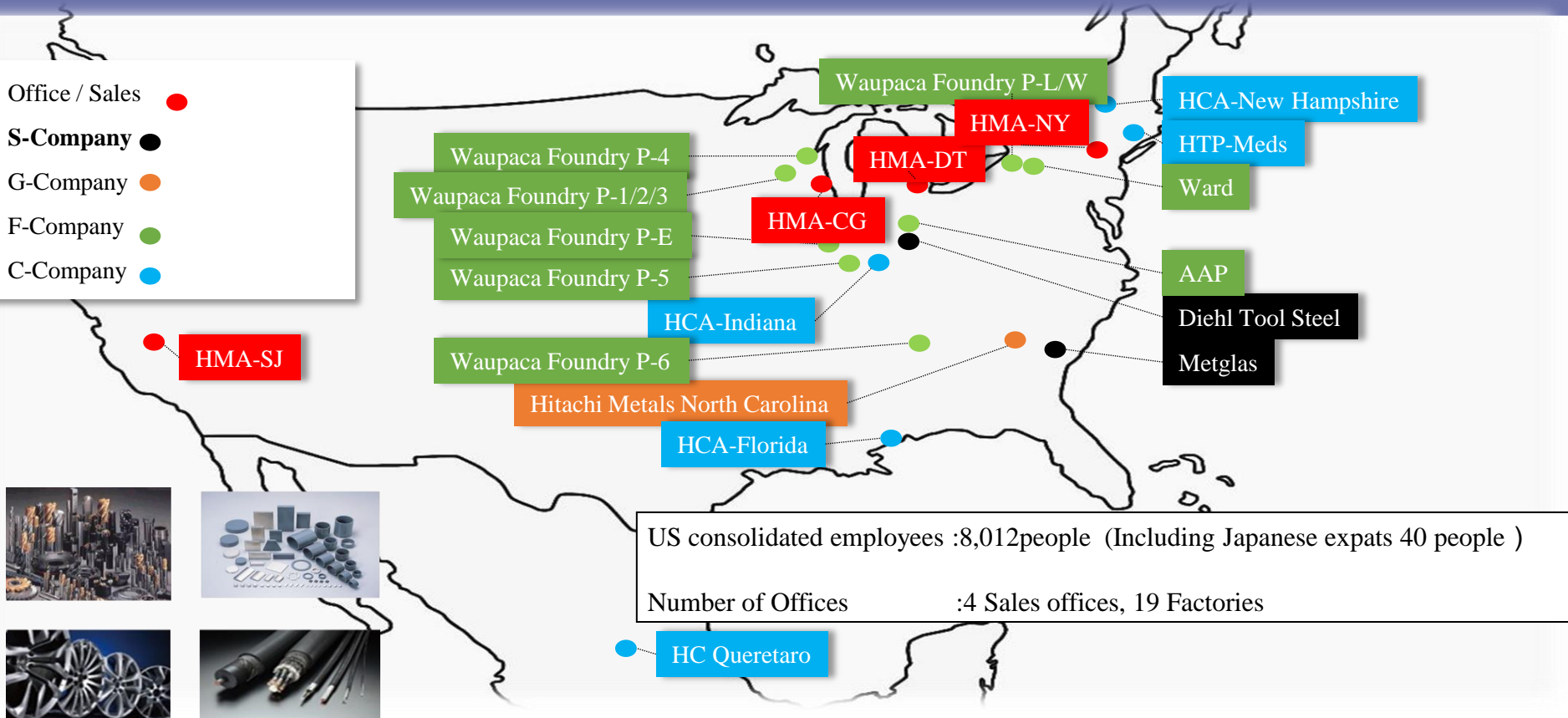
Arlington Hts, IL

AGENDA

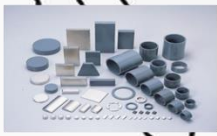
- HITACHI Intro
- Steel Production Methods for Die & Tooling Steels
- Typical Failure modes of Die Steels for AHSS
- Solutions to improve Tooling Performances
 - Steel Types, Coatings
- Hot Stamping Die Steels
- Pre Hardened Die Steels
- Grain Oriented Die Steel Study

HMA NA Group Location

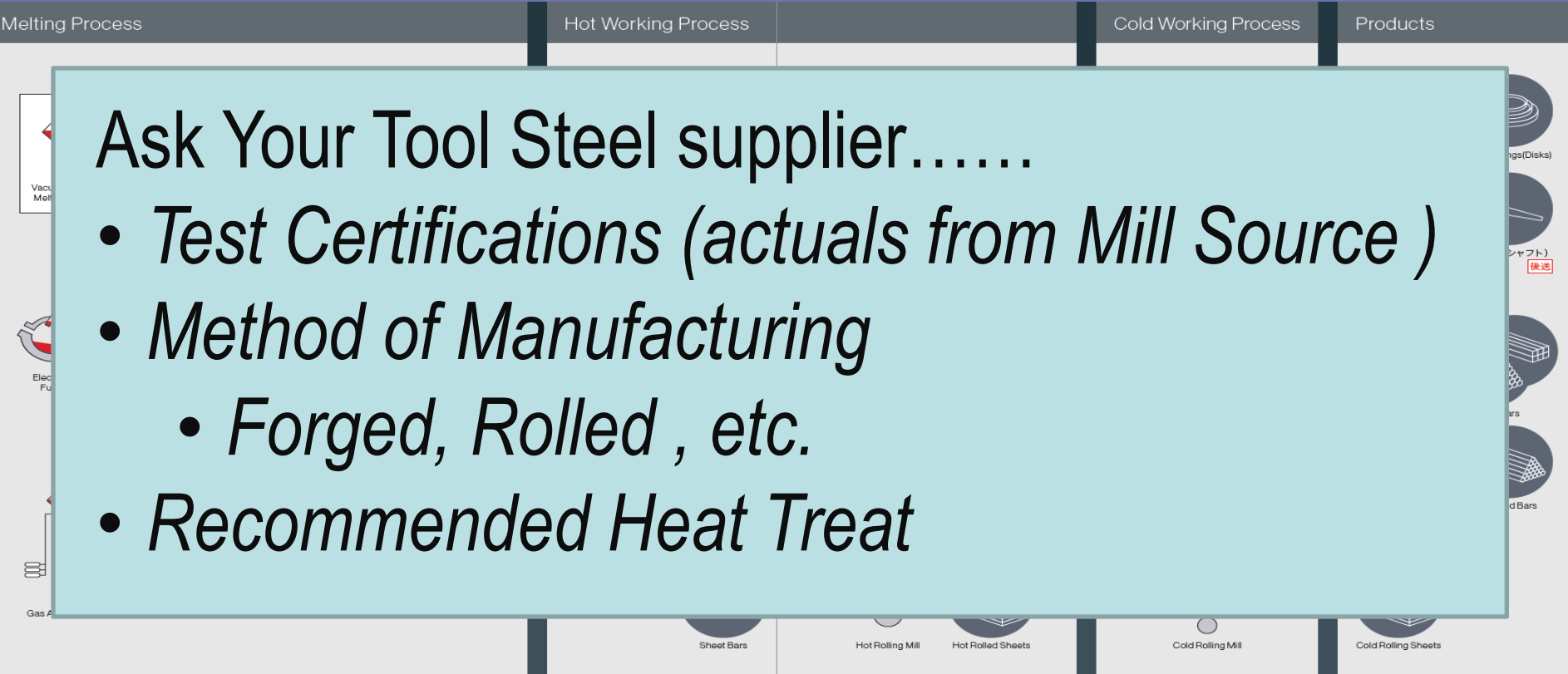
- Office / Sales ●
- S-Company ●
- G-Company ●
- F-Company ●
- C-Company ●



US consolidated employees :8,012people (Including Japanese expats 40 people)
 Number of Offices :4 Sales offices, 19 Factories



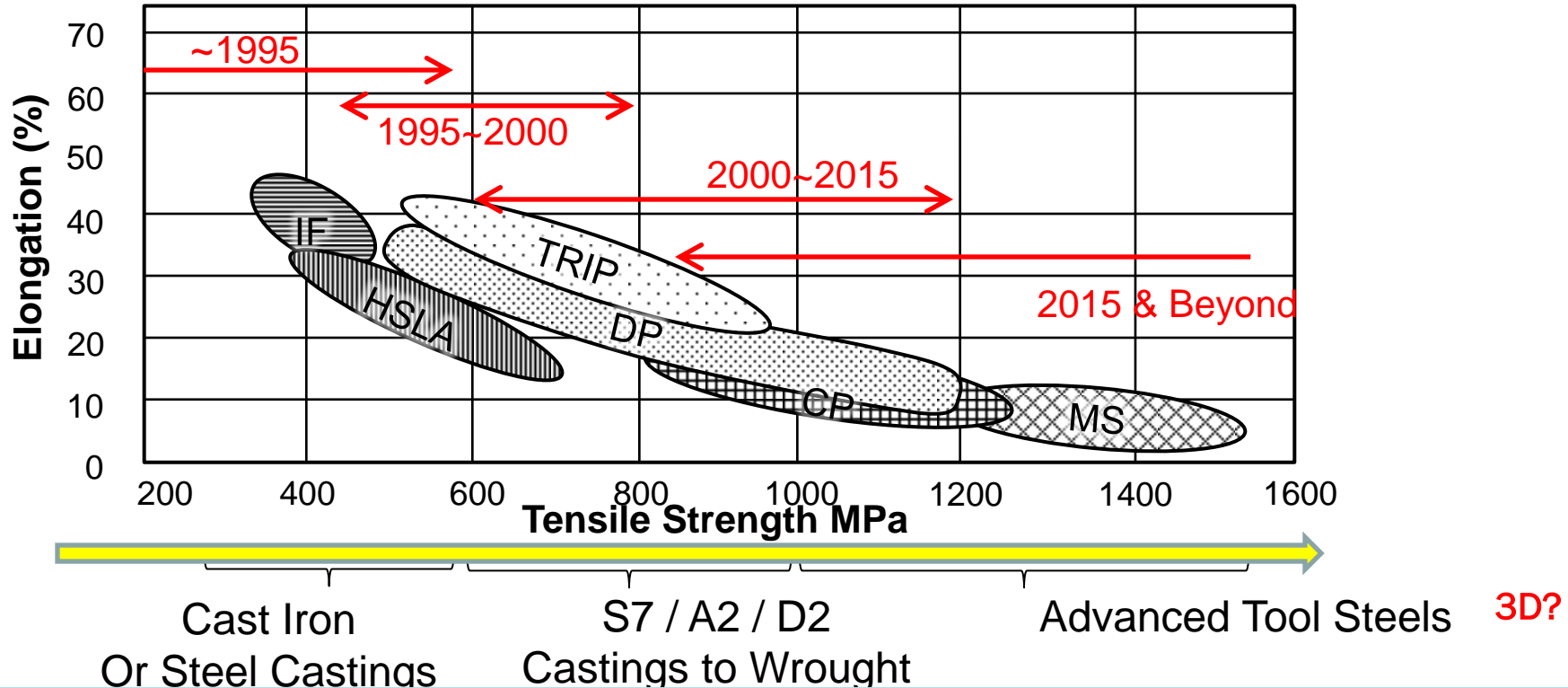
Hitachi Tool Steel Manufacturing Process



Ask Your Tool Steel supplier.....

- *Test Certifications (actuals from Mill Source)*
- *Method of Manufacturing*
 - *Forged, Rolled , etc.*
- *Recommended Heat Treat*

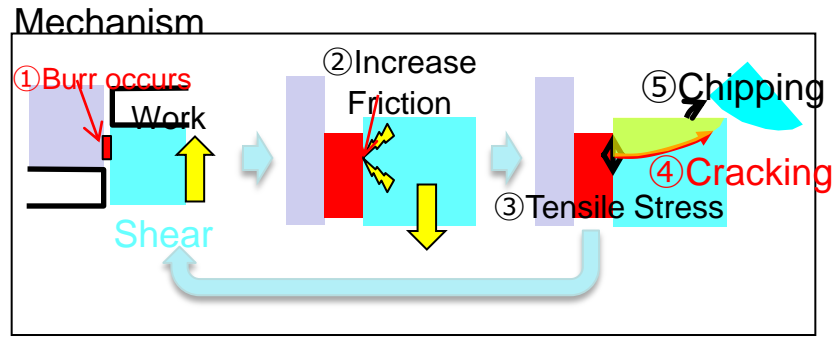
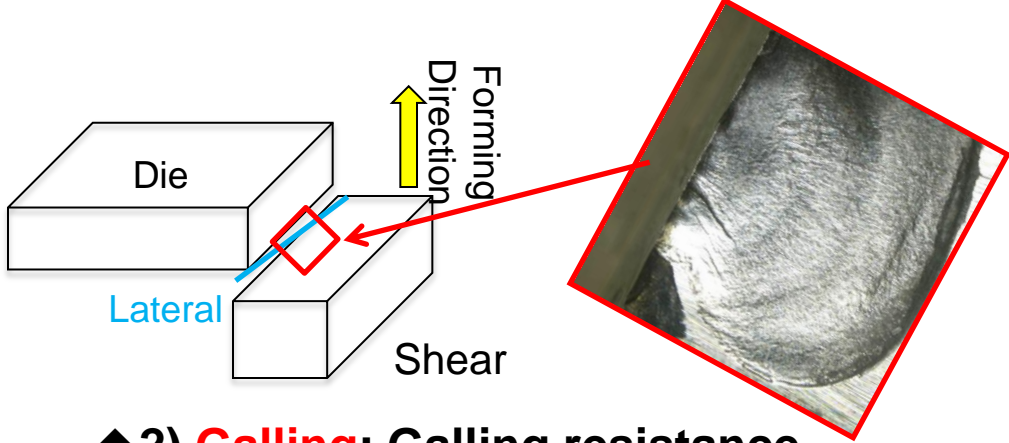
Sheet Metal (Part Material) Trends



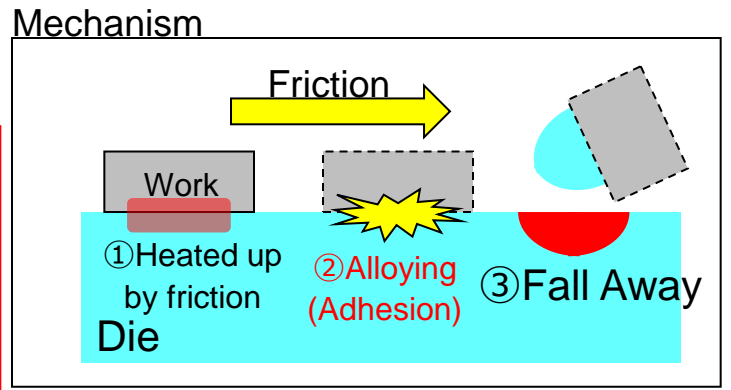
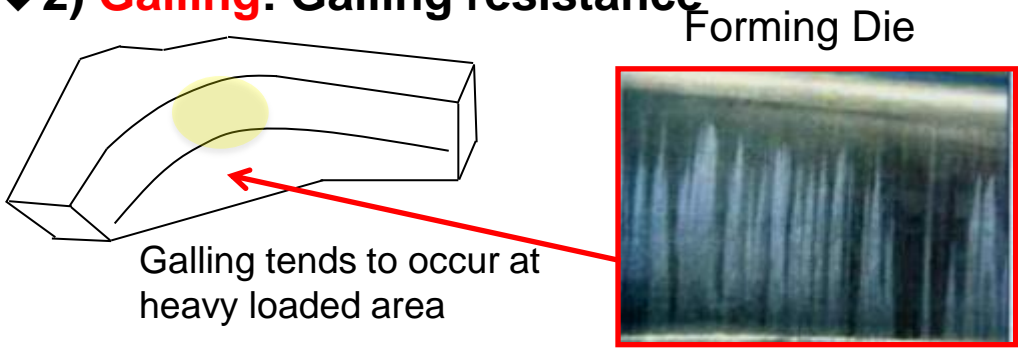
Advanced grade die materials are needed for forming AHSS.
“Die Standards” have not kept up with increased strength trend

3 Common Failure Modes

◆1) **Chipping:** Toughness is required for trims, flanges, pierce & punches

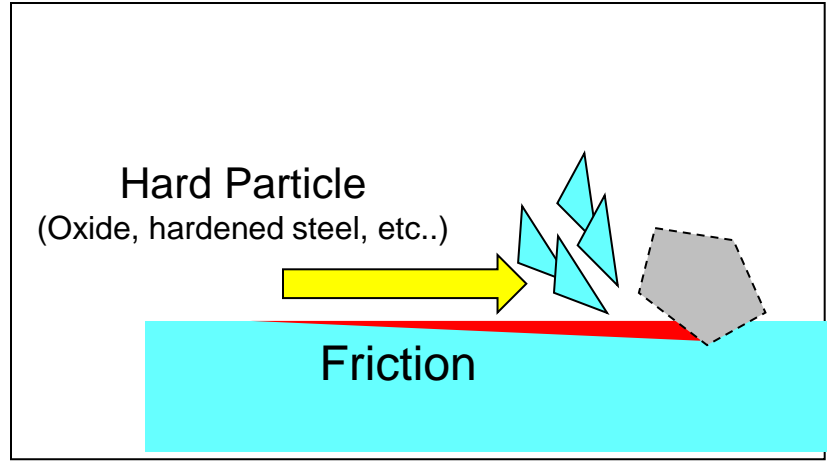
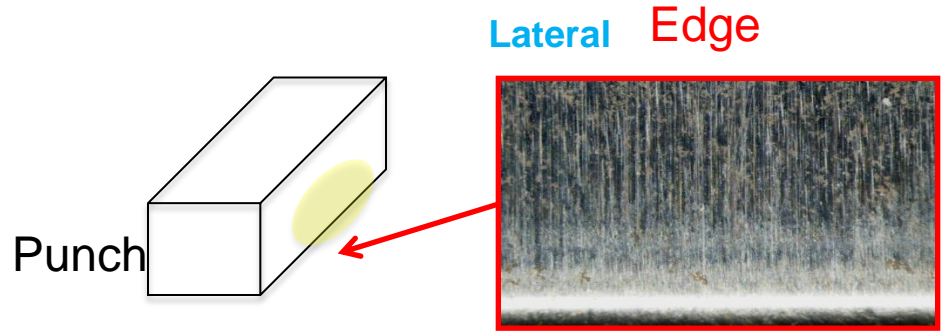


◆2) **Galling:** Galling resistance



◆ 3) **Wear:**

- **Surface Coating advancements have greatly improved steel performances**



Questions about Stamping Die Application

- Part material
 - Aluminum or Steel: What type & thickness?
- Press Size (Servo or Mechanical) & Strokes per minute cycle
- Current Die Construction
 - Progressive or Transfer?
 - Castings? Inserts?
 - Tooling steels used ?
 - What coating?
- Die Clearance
- Heat Treating Recipe
- Welding (In House? Outsource? Consumable used?)
- Failure Observations: What Happened?
- What's been tried so far?

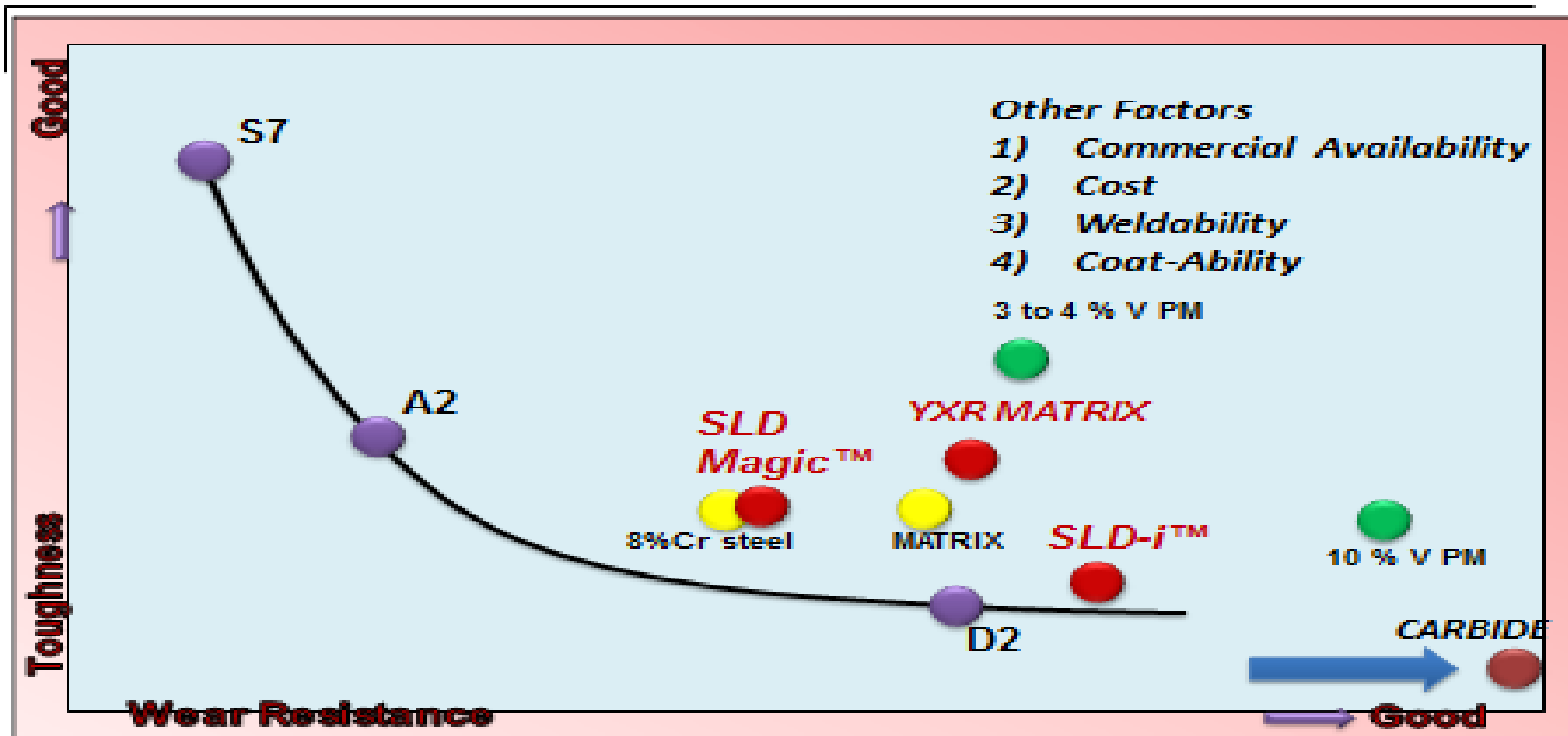
*Solution & Engineering Center
Matsue, Japan*

Standard Grades for Tooling

Chemical con			
Grade			
A2	AISI	JIS	DIN
D2			
S7	D2	SKD11	DIN 1.2379
M2	A2	SKD12	Din 1.2601
H13	S7	N/A	N/A
MATRIX : YXF	H13	SKD61	DIN 1.2344
SLD Magic			
8% Cr	M2	SKH51	DIN 1.3343

Tool Steel Alloy Design

OUR HERITAGE, YOUR ADVANTAGE YASUGI SPECIALTY STEEL

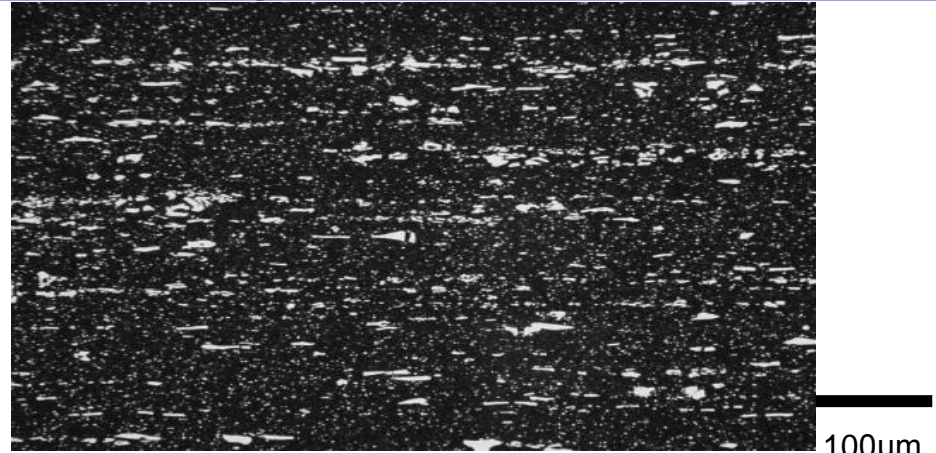


Microstructure

D2



SLD-i



100µm

Coarse & directional carbide

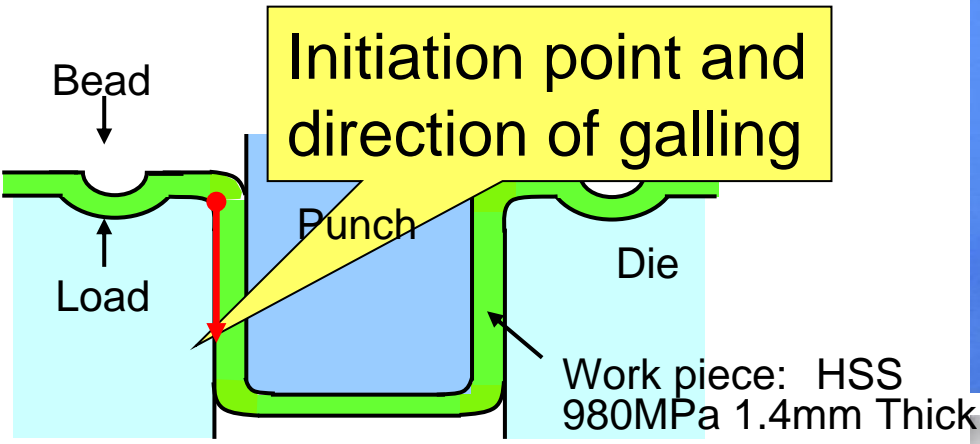
- Large & anisotropic deformation after heat treatment
- Medium galling & wear resistance
- Characteristics will be affected by grain direction

Small, dense & homogeneous carbide

- Small & isotropic deformation after heat treatment
- Same HT & Chem as D2
- Good galling & wear resistance
- Achieve higher hardness than D2/1.2379

Bending test

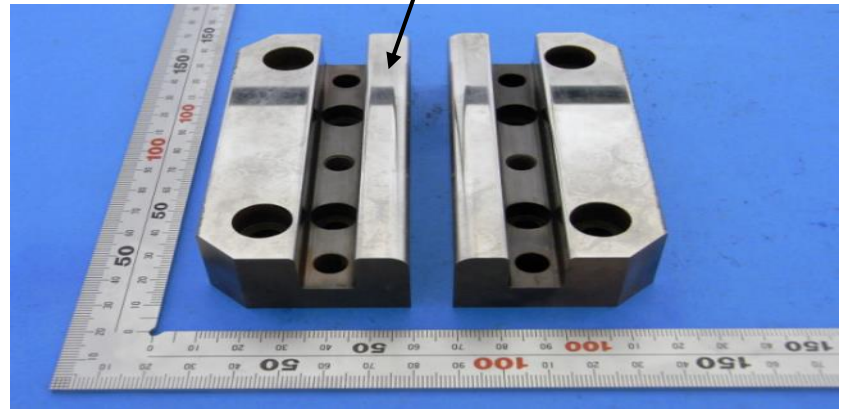
Conditions



Schematic diagram of test condition

Dies

Polished by #8000 paper (2-4 μ m)
Hardness: 60HRC

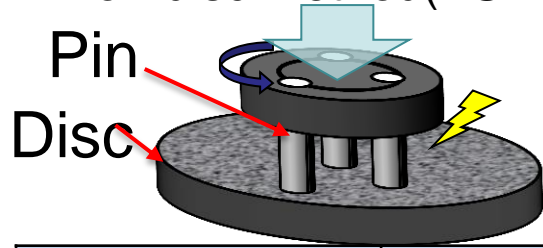


Work piece after test

Abrasive Wear Test

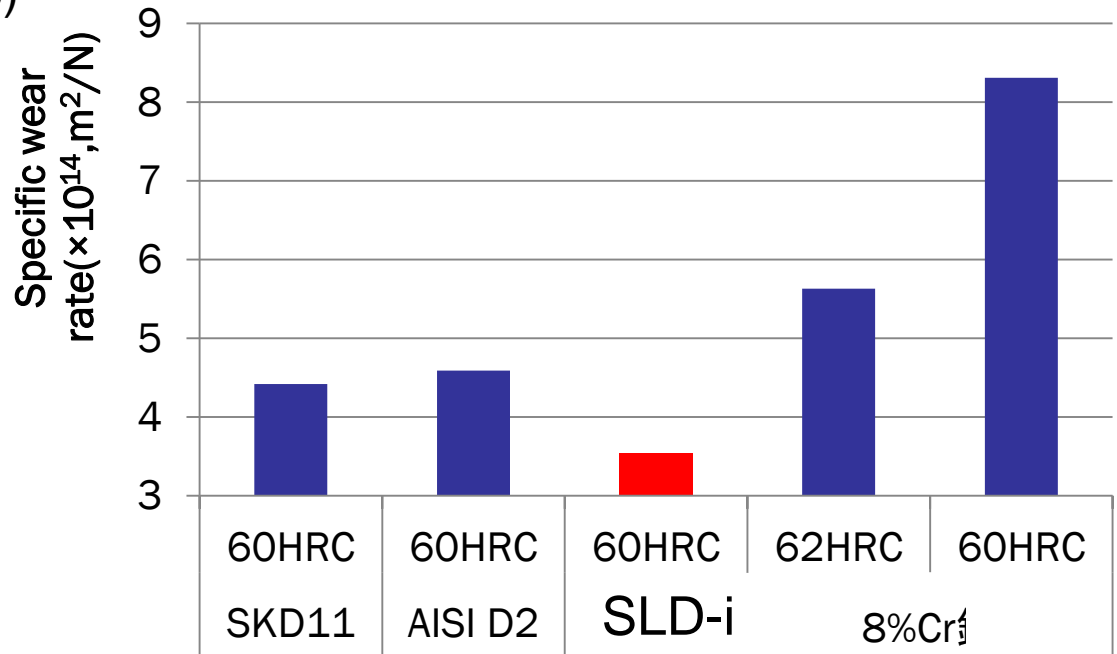
Conditions

Pin-on-disc method (ASTM G99-05)



Item		Condition
Test piece	Grade	D2, SLD-i, and 8Cr
	Hardness	60,62HRC
Disc		Alumina
Surface pressure		7.8 MPa
Friction Speed		0.42 m/s
Friction length		377 m

Results



Impact Toughness



Test results of SLD-MAGIC[®] by customers

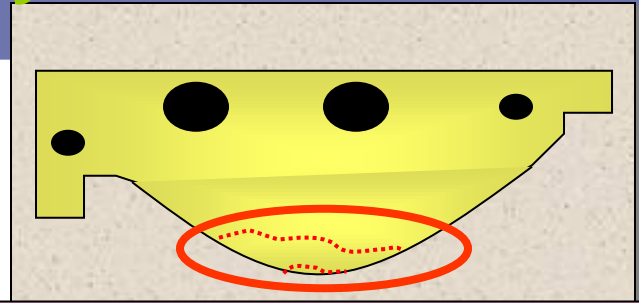
Product : Liquid crystal panel parts
Forming : Blanking
Present: 8%Cr steel
Work material : SS 3 mm thick

Less wear
⇒ **Die life 30%UP**

	Present	S-MAGIC
Grade	8%Cr steel	
Hardness	60~62HRC	60~62HRC
Heat treatment	Temper 505°C	Temper 480°C
Distortion	0.05%	-0.01~0.02%
Machinability	Normal	Good
Life	30,000 hits	>40,000 hits
Damage	Burr(wear out)	Small wear(carry on)

Test results of SLD-MAGIC[®] by customers

Product : Automobile parts
Forming : Blanking
Present: D2
Work material : 780MPa AHSS : 1.8 mm



(SLD-MAGIC) Small crack
⇒ Possible to repair by welding
⇒ Die life is longer

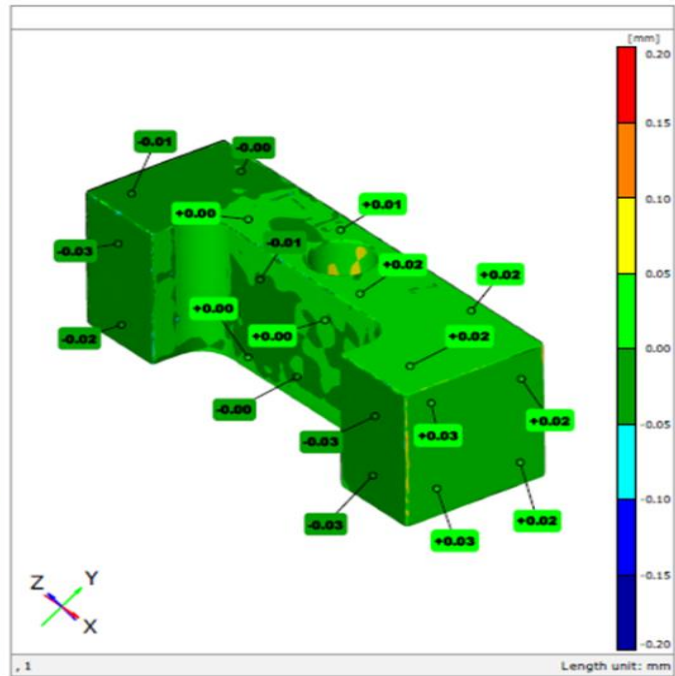
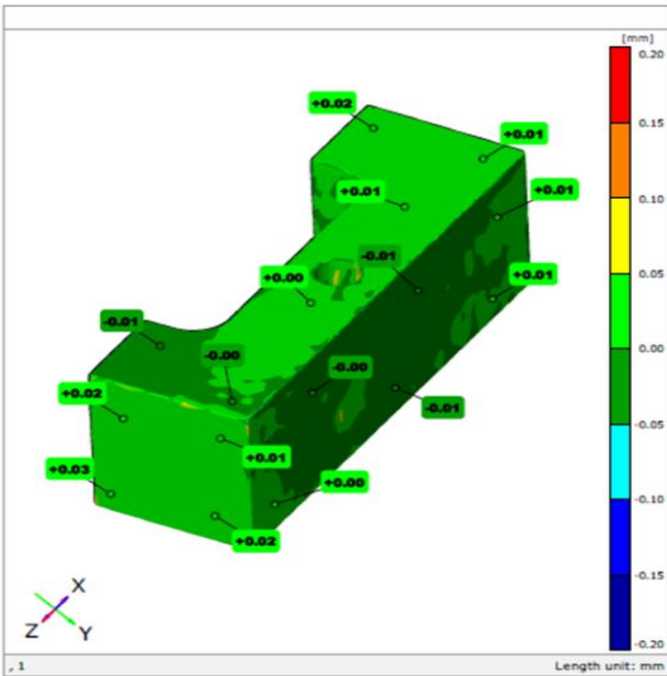
	Present	SLD-MAGIC
Grade	D2	
Hardness	58~60HRC	58~60HRC
Heat treatment	Temper 170°C	Temper 170°C
Life	6,000~15,000shots large crack	>40,000shots ※repaired by welding at 25, 000 hits

Heat Treatment Deformation Minimization

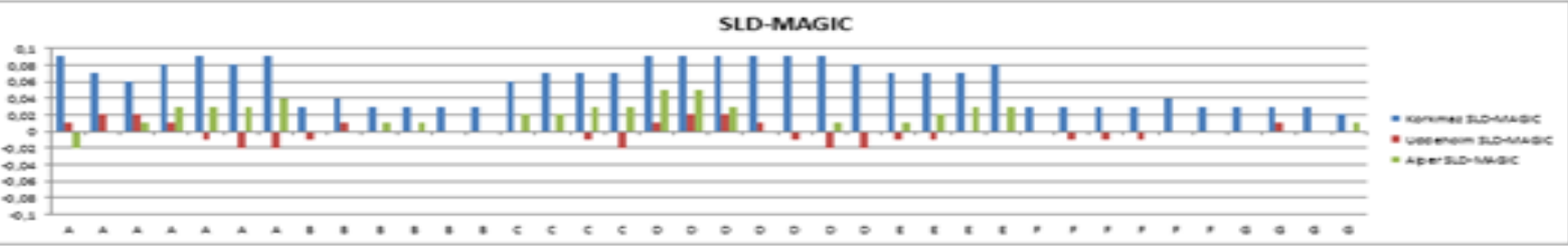
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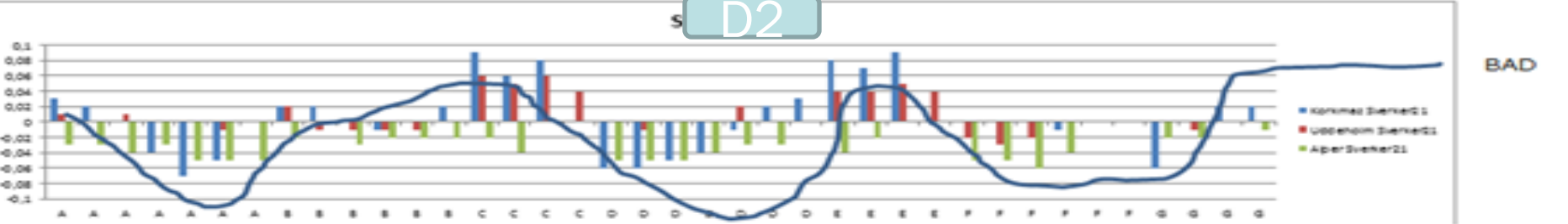
SLD-I 2 Isıl İşlem Öncesi ve Sonrası Karşılaştırma (UDDEHOLM)_05052017



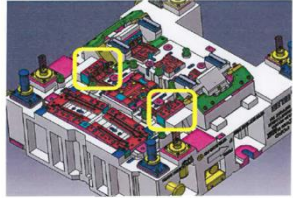
Distortion on SLDi vs D2



S **D2**

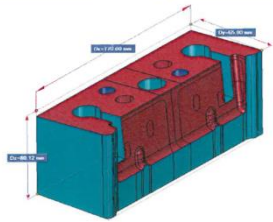
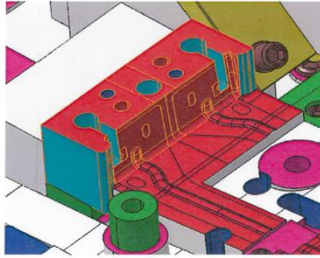


Example Part material 2.5 mm thick Aluminum



P552 LOT#2
FL Stage

180mm x 75mm x 90mm
QTY(2)



Before test:

- D2 had to be re-conditioned @ 80,000 strikes due to galling
- Re-Polish, re-coated

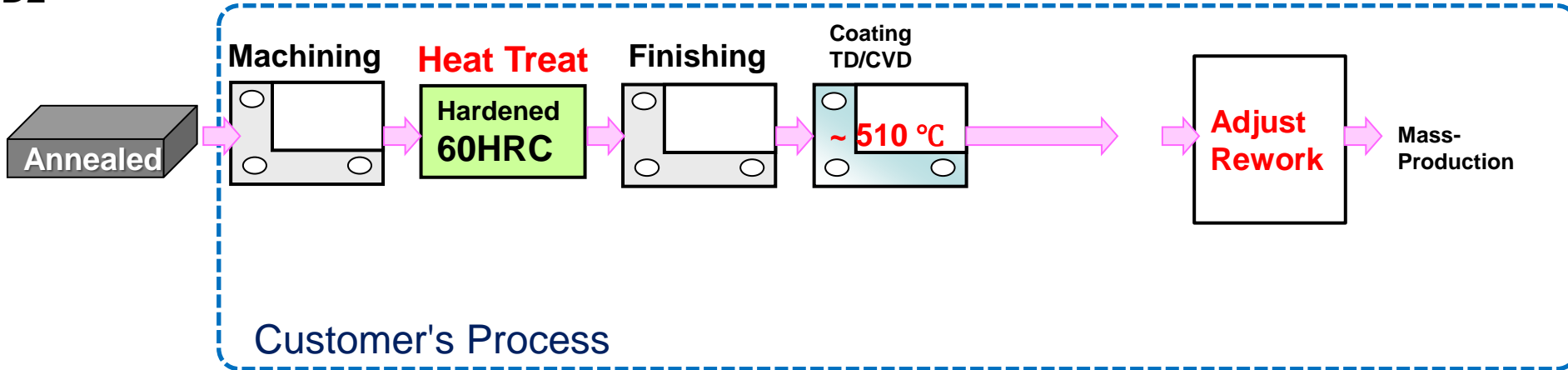
Start SLDi (HITACHI D2)

Test SLD-i material (Hitachi Metal) Full Harden 62HRC only

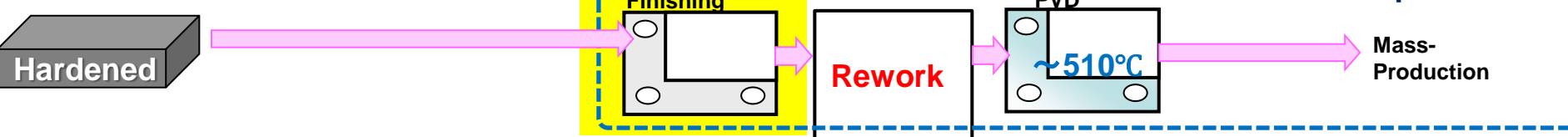
- Maintain steel polish 1/ month (Ave. 65,000 hit)
- Maintenance time reduced to 83% from original condition
- **SLDi steel is better result than D2+Coating**

Concept of Pre-Hardened Die Steels

D2



SLD-F NEW STEEL



Machining of Pre-Hard Tool Steels @ 60 HRC

- 1) Machine Tool
 - Rigid Construction:
 - High Spindle Speed:20,000+
- 2) Cutting Tool
 - Solid Carbide with ductile properties for interrupted cut
- 3) Consistent substrate of Die Steel

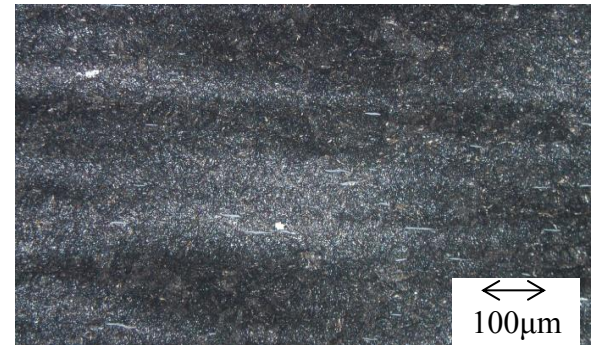
Effect on Machinability

Table. Chemical composition (mass%)

	C	Si	Mn	S	Cr	Mo	V	Al	Nb
SLD F	Lower than D2	Higher than D2	Higher than D2	Trace	Lower than D2	Higher than D2	Trace	Trace	-
D2	1.55	0.3	0.4	-	11.8	0.8	0.8	-	-
8Cr(A)	0.9	0.9	0.5	-	7.8	2.5	0.5	-	-
8Cr(B)	1.1	0.9	0.4	-	8.3	2.1	0.5	Trace	Trace

Decreasing carbides

Belag formation

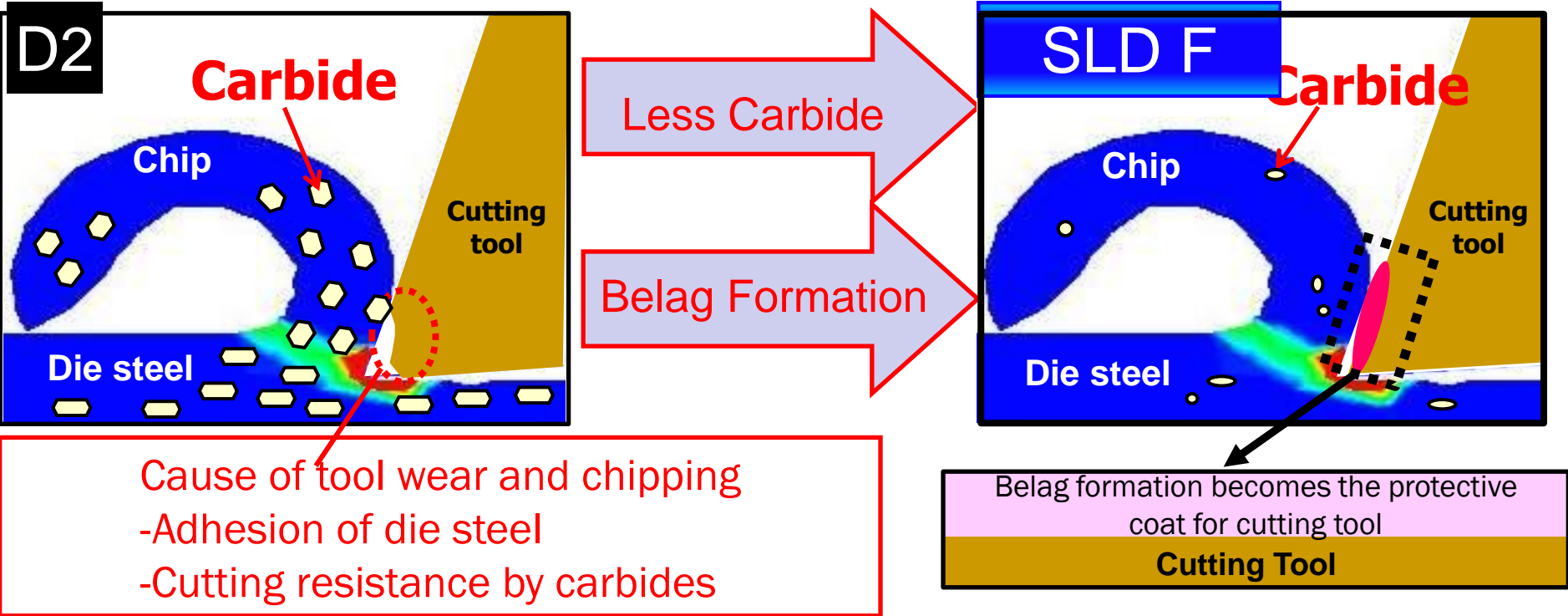


A sample microstructure of SLD- F

-SLD- F has good machinability even @ 60HRC due to less primary/ secondary carbide.

-In order to prevent the wear and improve the life of die, PVD coating on the surface of the dies is recommended.

Mechanism of better machinability



Cause of tool wear and chipping
-Adhesion of die steel
-Cutting resistance by carbides

Belag formation becomes the protective coat for cutting tool

Cutting Tool

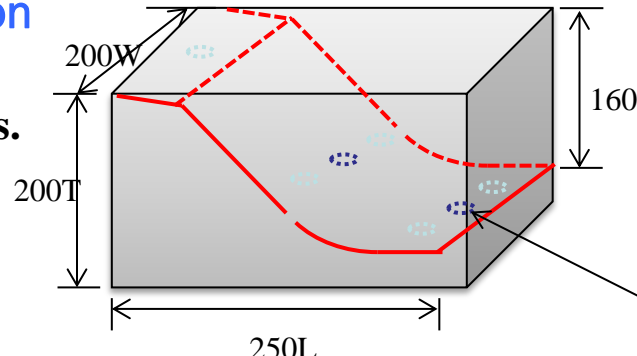
- Being less the carbide contribute to being less cutting resistance.
- Oxide layer formation called “Belag” on the surface of the cutting tool during cutting plays prevent the cutting tool from chipping.

Simulation : Process cost and lead time of Pre-Hard

PROCESS	Time	Time	Cost	Cost
	D2 Annealed	SLD F New Steel	D2 Annealed	SLD F New Steel
	+ HT	Pre-hard 60 HRC	+ HT	Pre-hard 60 HRC
Raw Steel			\$600	\$1,105
Drilling	.5 Hr.	3.5 Hrs.	\$240	\$1,440
Milling	10 Hrs.	16 Hrs.	\$4,160	\$6,260
HT Prep	2 Hrs.	0	\$290	0
HT	72 Hrs.	0	\$245	0
Fin Mach.	12 Hrs.	12 Hrs.	\$2,000	0
	96 Hrs.	31 Hrs.	\$7,535	\$8,805

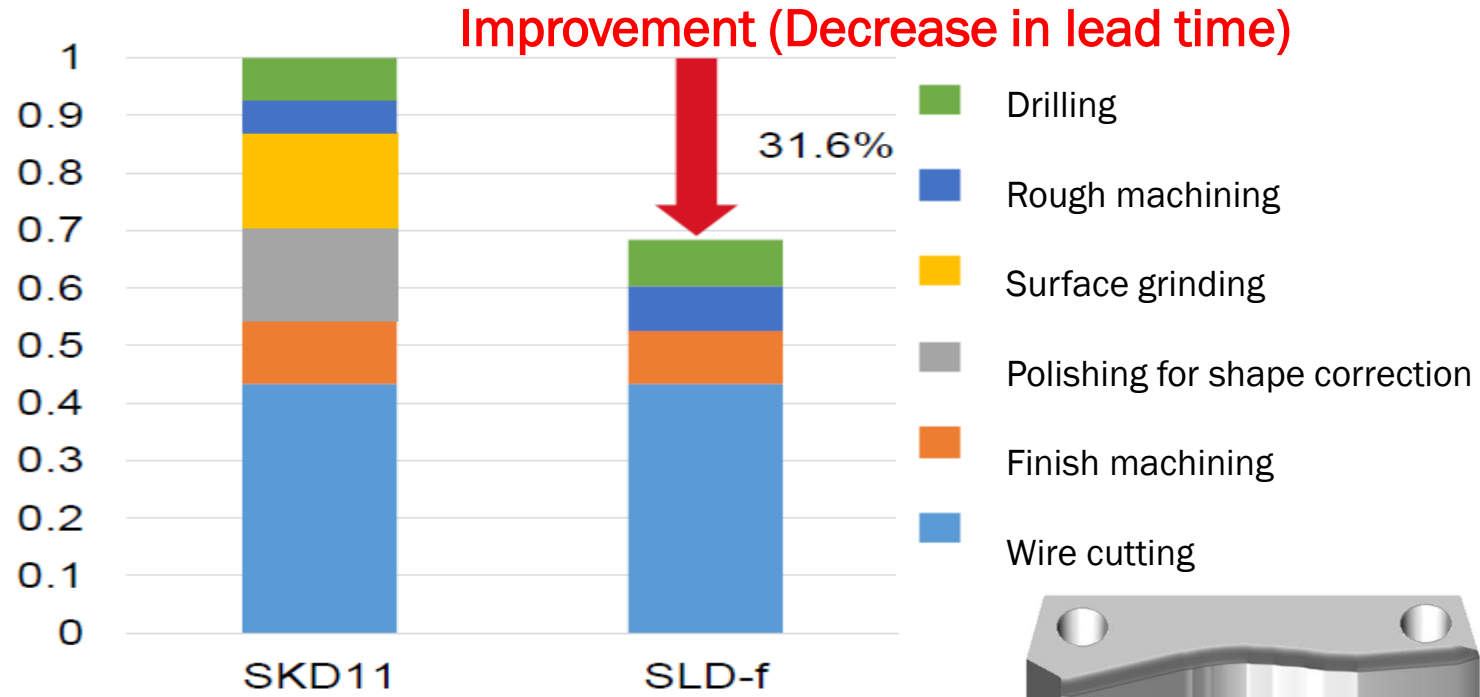
Condition of simulation

Material weight : 160 lbs.

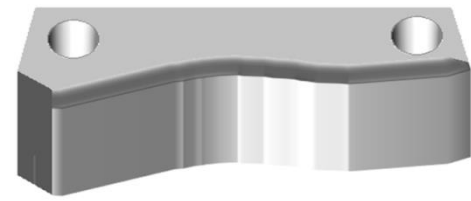


Lead Time comparison : DieMaker (Automotive) in Japan

Total process time for die-making



Die size; 390x150x130 mm (50kg)



- Demands on Die Materials
 - Wear
 - Conductivity
 - Watch for industry developments on 3D Additive Mfg. inserts w/ conformal cooling lines
- Use of higher alloyed Die Steel

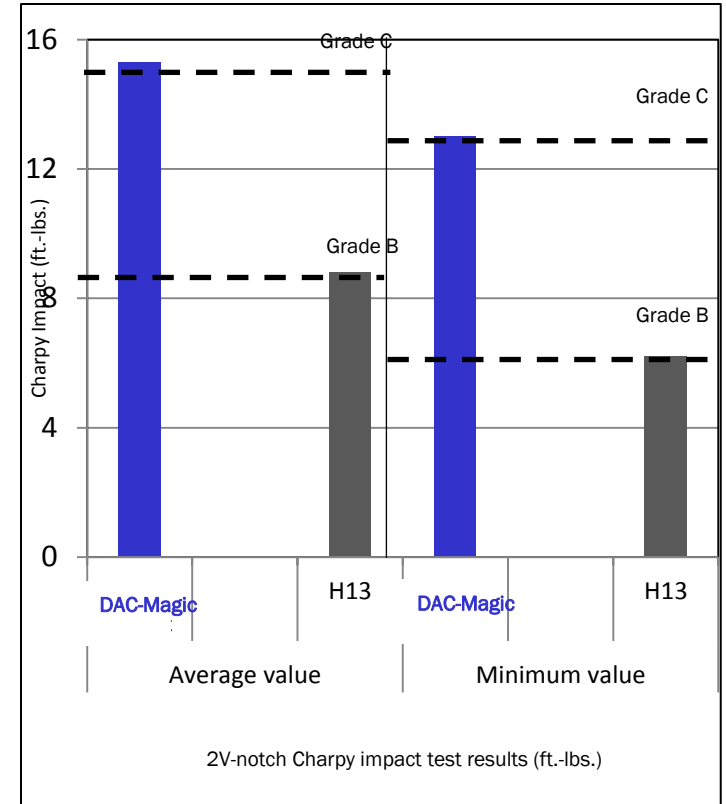
Hot Work Die Steels: NADCA Rated

Cross Reference Guide to Special Quality Die Steels

NADCA Grade	Trade Name	Type	Preheating Temp, °F(°C)	Austenitizing/Hardening Temp. °F(°C)
A	Type H13- Premium*	A1885	1100-1250 (595-675) 1500-1560 (815-850)	1885 (1030)
B	Type H13-Superior	B1885	1100-1250 (595-675) 1500-1560 (815-850)	1885 (1030)
C	Type 2367 & Modified			
	Uddeholm Dievar	C1850	1100-1200 (595-650) 1500-1560 (815-850)	1850 (1010)
	Hitachi DAC MAGIC	C1870	930-1290 (500-700) 1380-1470 (750-800)	1870 (1020)
	Böhler W403 VMR	C1885	930-1020 (500-550) 1375-1475 (745-800)	1885 (1030)
	Ellwood ExEll Hot Die	C1885	1100-1200 (595-650) 1475-1525 (800-830)	1885 (1030)
	Kind RPU	C1885	1100-1200 (595-650) 1500-1560 (815-850)	1885 (1030)
	Schmolz+Bickenbach Thermodur 2367	C1885	1100-1200 (595-650) 1500-1560 (815-850)	1885 (1030)
	Daido DH31-EX	C1885	1020-1200 (550-650) 1470-1560 (800-850)	1885 (1030)

Yield , Tensile Strength and Impact Strength

	Room temperature		650°C	
	Yield strength	Tensile strength	Yield strength	Tensile strength
DAC-Magic NADCA Class C	1238	1479	454	686
	<i>4% Better</i>	<i>2.5% Better</i>	<i>5% Better</i>	<i>12% Better</i>
NADCA Class B (H13)	1211	1444	433	610

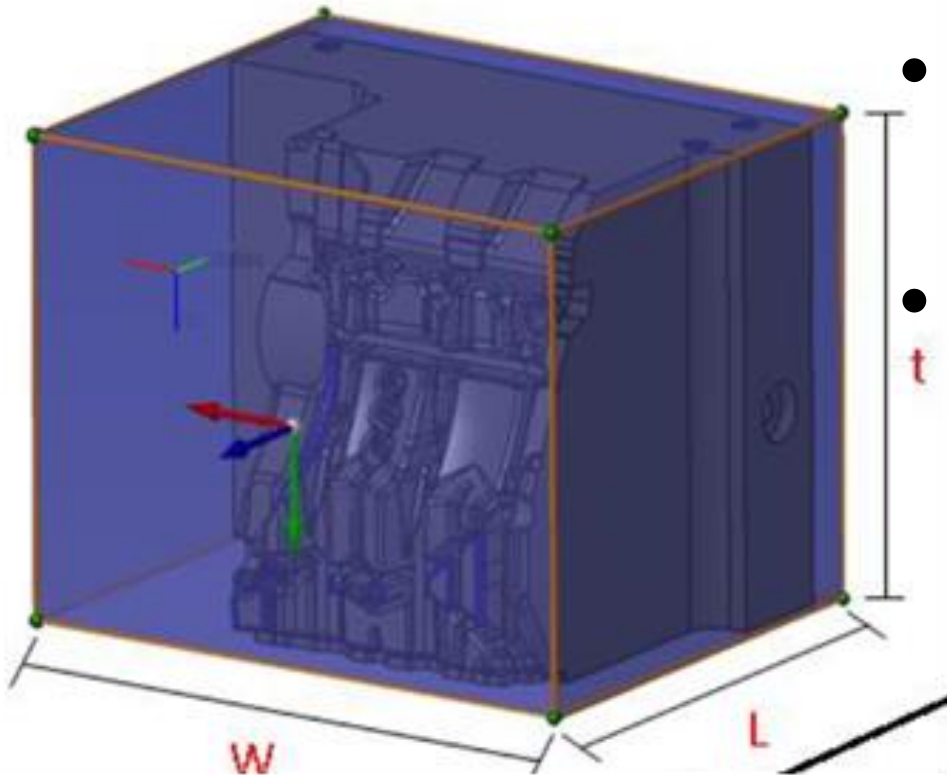


Case studies



Applications	Formed Article	Die	Work piece	Die material	Conventional Coating	Comparison (Die life)
Cold stamping	Lower arm	Bending	590MPa HSS (3.6mm)	SLD-MAGIC*	TiCr	× 8.1
Cold stamping	Exhaust part	Throttling	Stainless steel (1.4mm)	Cold Work tool steel	V +Nitriding	× 7.5
Cold stamping	Exhaust part	Mandrel	Stainless steel	YXR*7	TiCN +Nitriding	× 5
Cold stamping	Driving part	Burring punch	—	SLD-MAGIC*	VC	× 4
Cold stamping	Clutch part	Burring punch	—	SLD*	VC	× 7
Hot Stamping	Pillar	Bending	1470MPa (1.4mm)	Hot Work tool steel	AlCr CrWN	× 3
Hot Stamping	Pillar	Bending	1470MPa (1.4mm)	Hot Work tool steel	Nitride + V	× 2

DOES GRAIN DIRECTION ON DIE INSERTS MATTER?

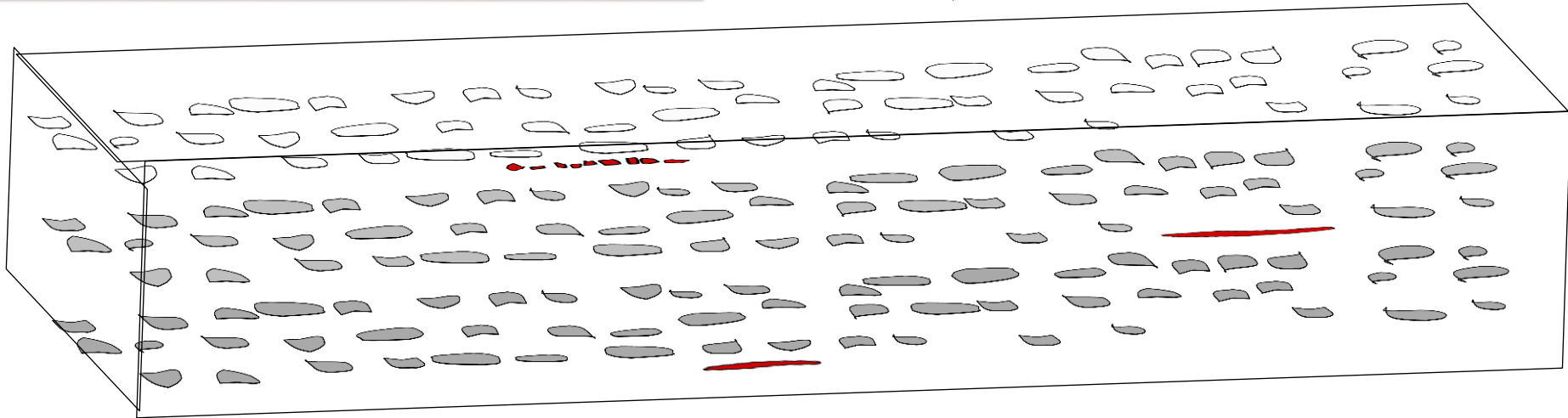


- *What is anticipated highest Impact Area ?*
- *Is Grain direction detectable?*
 - *Can this detail be marked?*

EXAMPLES of GRAIN

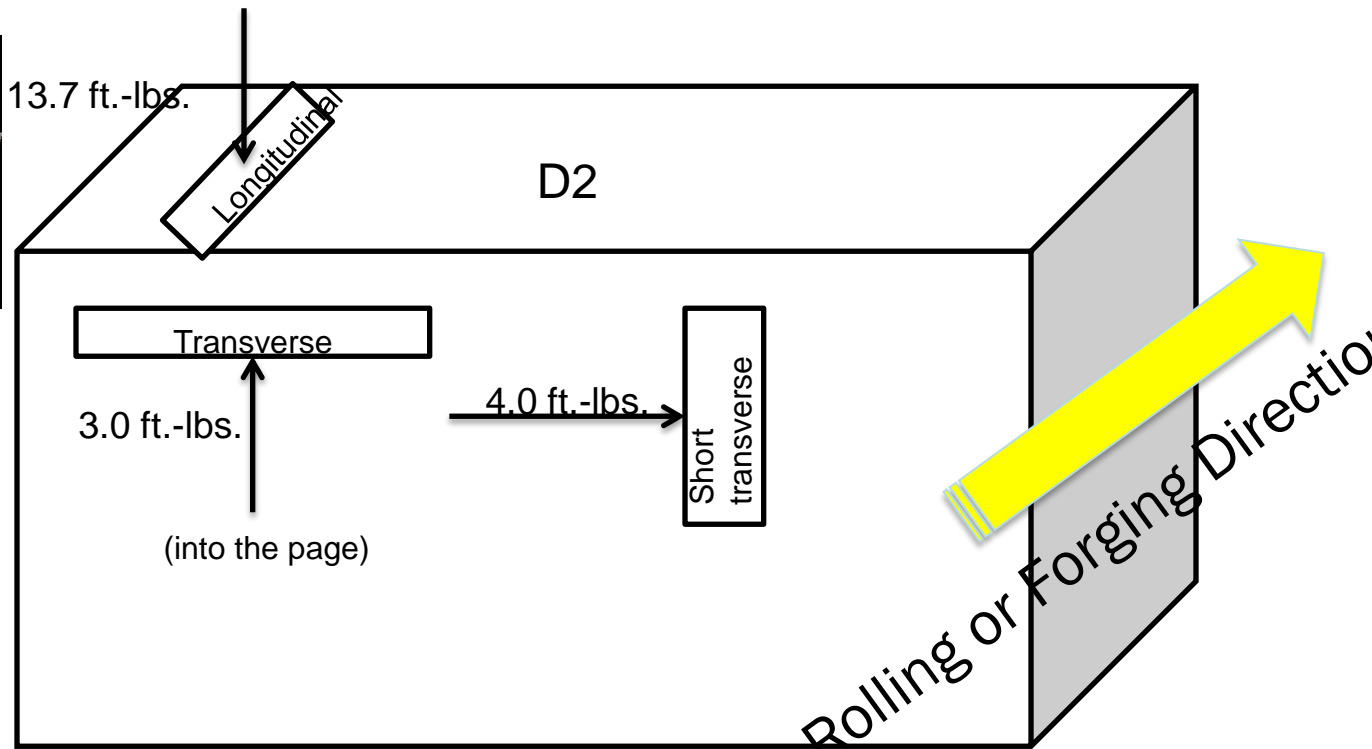
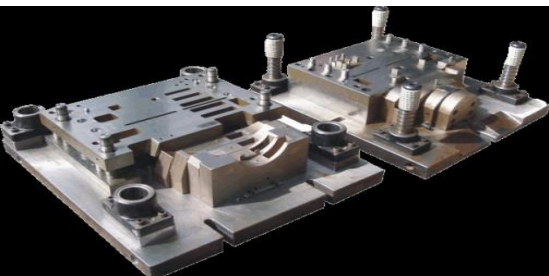


Rolling or Forging Direction



Orientation Diagram

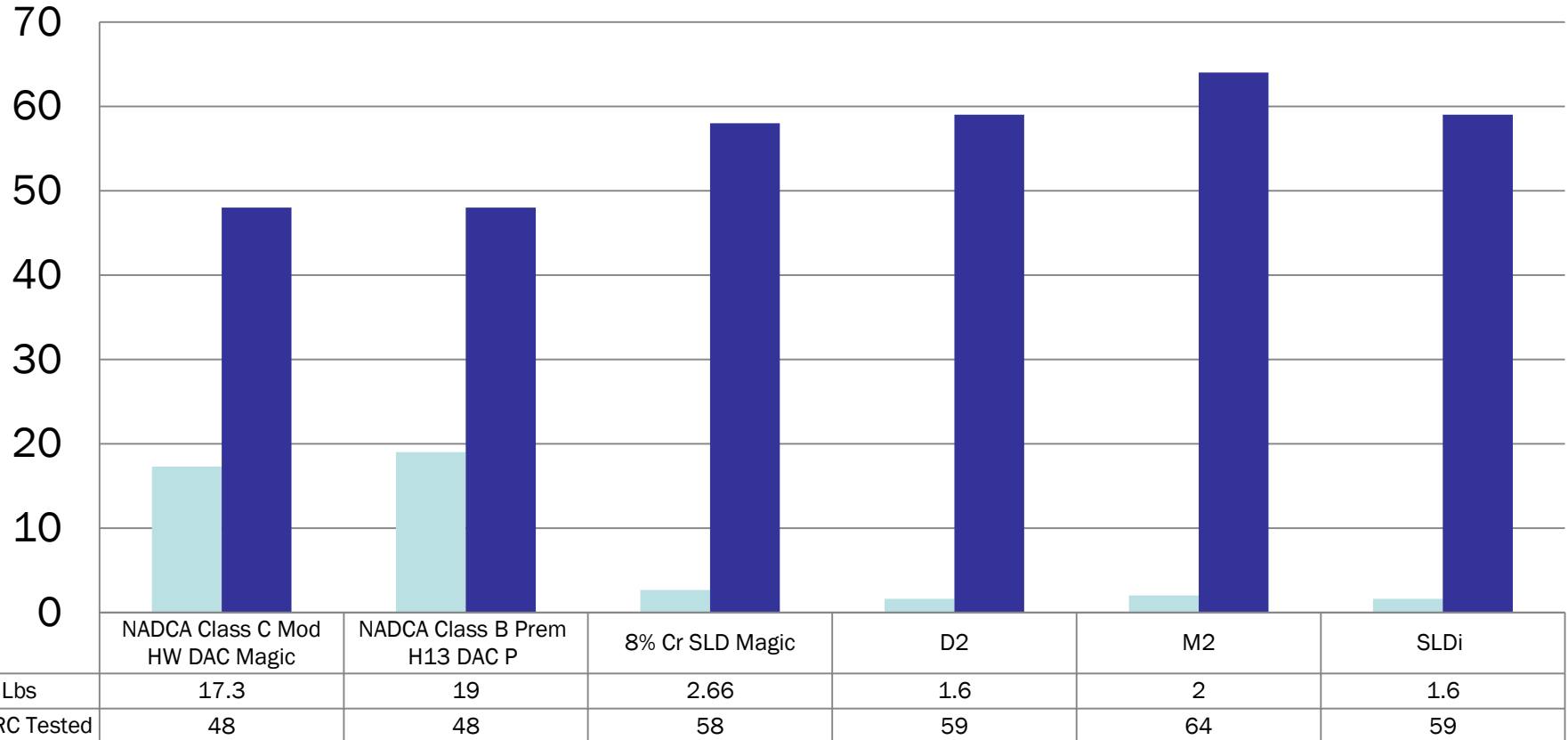
Arrows indicate the direction of the impact force



CONCLUSION:

Grain Matters

Impact Toughness Tests: Short-Transverse



Conclusions

- Review Die Standards & allow for areas requiring better tooling steels in trouble-spots
- Compare results with other steels in side by side like-environments
- Insist on controlled HT path & Welding steps
- Ask for grain orientation on larger cross sections
- ***“If you can’t use a better tool steel, use your tool steel better”***

For More Information

THANK YOU

Thomas Bell

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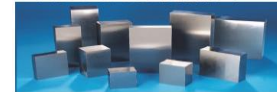
- Sources for More Info
 - *Exova Element Lab*
 - *Mitsubishi – Hitachi Tool*
 - *Ceratizit Carbide & HB Carbide*
 - *BayCast*
 - *AutoSteel Partnership: Great Designs in Steel*
 - *TCI* *Coatings in Olivet, MI*
 - *Schuler*



TOOL & DIE STEELS
for AHSS & Hot Stamping Tooling

- Standards: A2, D2, S7, M2, H13
- Specials: SLDi, SLD Magic, YXR-Matrix, HAP PM Steel

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Blocks

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