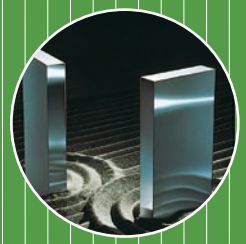
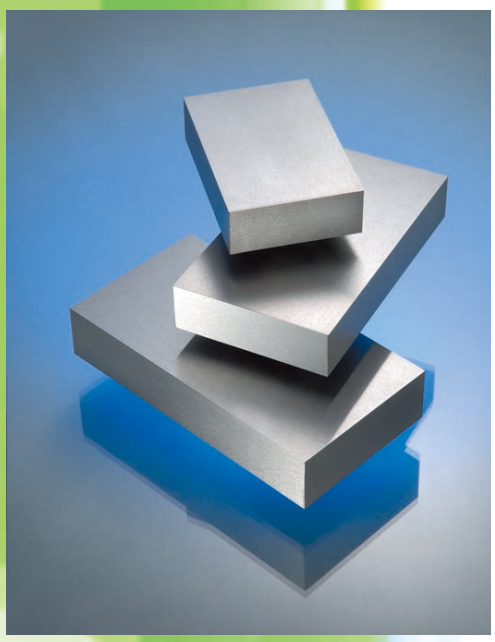


YSS
COLD WORKING TOOL Steel SLD-MAGIC™



New die steel seeking longer mold lifespan and total cost reduction.

Concept

SLD-MAGIC is the revolutionary next-generation die steel attaining both extended mold lifespan and outstandingly easy mold fabrication.

SLD-MAGIC

M: Materials Magic
A: Advanced
G: Gratifying
I: Innovative
C: Cold work die steel

SLD-MAGIC Features

Wear resistance
High hardness of 62HRC improves wear resistance by approximately 35%*.

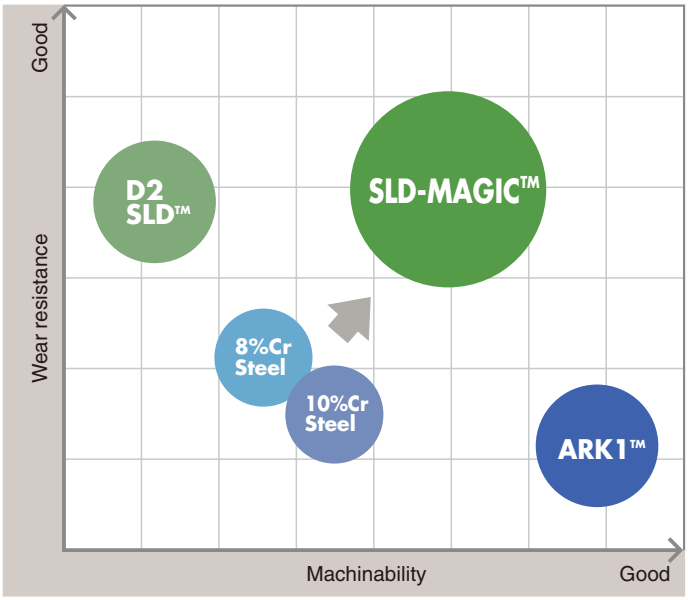
Surface treatment
Adherence between the coating layer and steel after surface treatment (CVD and other methods) is improved by approximately 30%*.

Heat treatment
Minimal deformation during heat treatment for a reduction of approximately 40%* in dimensional changes.

Machinability
Machinability improved by approximately 35%*

*Hitachi Metals comparison: Comparison against 8%Cr steel (Hitachi Metals product name:SLD8), a modified steel of D2.

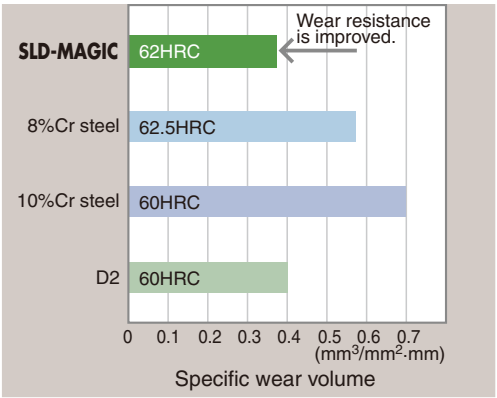
Relationship



Wear resistance

SLD-MAGIC increases wear resistance by approx. 35% compared with 8% Cr steel due to the control of carbide morphology.

Ohgoshi-method wear test



Work material: SCM415
Friction distance: 400m
Friction speed: 0.76m/s
Load: 67N

Comparison of Properties

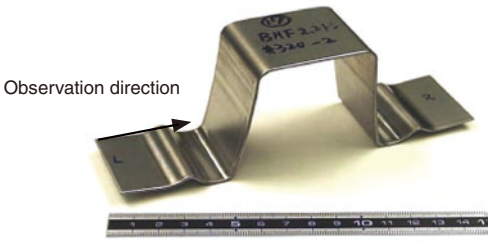
Grade	SLD-MAGIC	8%Cr Steel	10%Cr Steel	D2
Hardness (HRC)	60-62	61-63	59-61	58-60
Wear resistance	A	B	B	A
Surface treatment*	A	C	C	B
Toughness	B	B	C	C
Machinability	B+	C	B	D
Dimensional change by heat treatment	A	C	C	B
Weldability	B	B	C	C

Excellent "A" ⟷ Poor "D"

*Surface treatment properties are based on adherence between the coating layer and steel after surface treatment.
8%Cr steel and 10%Cr steel offer improved machinability for better processing that reduces the volume of hard carbides within steel, but are inferior to D2 in terms of wear resistance and galling.

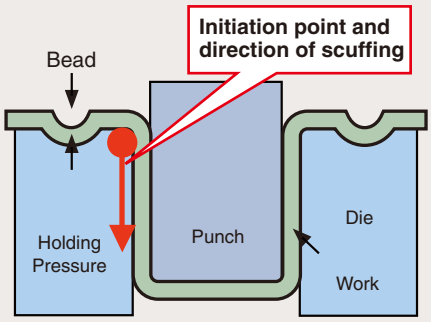
Scuffing resistance

SLD-MAGIC shows no scuffing on Hat Testing simulating practical mold wear phenomena.



Appearance of work Sample

Scuffing Test

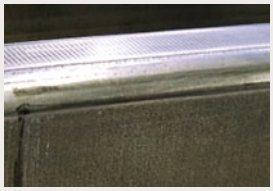


Schematic of test conditions

Scuffing Test Conditions
Press : 80ton Cranck Press
Velocity V : 40~75spm (19.2~36m/min)
Holding Pressure Ps : ~2.4ton/cm²
Length of Stroke : 60mm
Lubricant : Anti-rustoil applied and wiped away
Work : High-tensile-strength steel (590MPa)
Thickness 1.6mm (No plating)
Surface Roughness of the mold: Polished by #1000 (Ra=0.04μm)

Scuffing Observation

SLD-MAGIC



Mold surface

No scuffing

Work Surface

D2

Mold surface

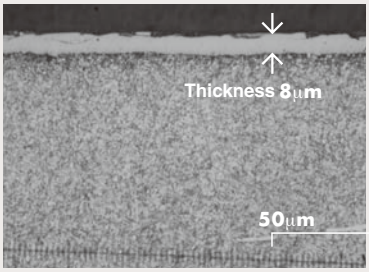
Scuffing

Work Surface

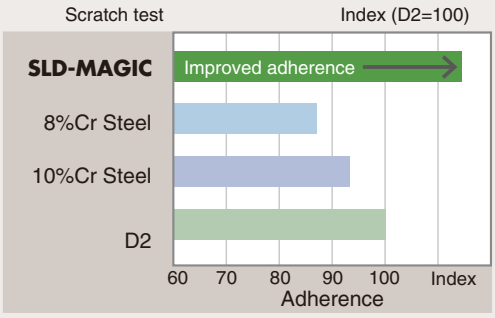
Surface treatment

SLD-MAGIC can be treated with hard coating (CVD, TD treatment etc.) under the same conditions as D2. SLD-MAGIC improves adherence between the coating layer and steel after 3-time surface treatment by approx. 30% when compared with 8%Cr steel, due to optimum alloy design.

Coating Layer by CVD method



Adherence between the coating layer and steel after 3-time CVD treatment.



Weldability

SLD-MAGIC shows lower susceptibility of cracking by welding compared with D2 and others.

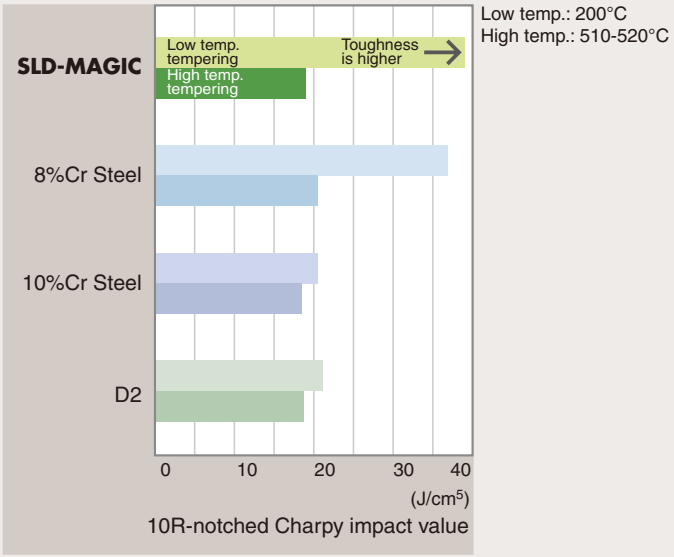
Pre-heating temperture	SLD-MAGIC	D2	8%Cr Steel	10%Cr Steel
Under 100°C	××	××	××	××
100~200°C	○	××	××	××
200~300°C	○	××	○	××
Over 300°C	-	○	○	○
Ranking of anti-cracking	A	C	B	C

Welding rod: SKD61 grade ϕ4.0mm
Welding current: 130A (AC)
××: Cracking occured at 3rd layer
○ : No cracking at 3rd laye

Toughness

SLD-MAGIC is superior to D2 in toughness. It can be used as a countermeasure to chipping and cracking with low temp. tempering.

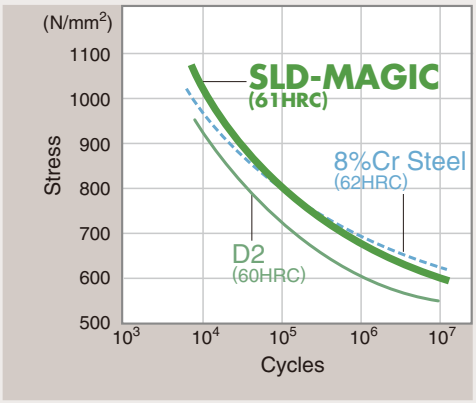
10R-notched Charpy impact value



Fatigue strength

SLD-MAGIC shows improved fatigue strength in comparison to D2 due to the control of carbide morphologies.

Rotating bending fatigue test



Physical Properties

Thermal expansion coefficient X10⁻⁶/°C	20~100°C	20~200°C
	11.7	12.3

Thermal conductivity W/m·K	Room temperature
	28.9

Specific gravity	Annealed	Quenched and tempered
	7.77	7.76

Young's modulus GPa	209

Transformation temperature	Ac1	Ms temperature
	850°C	166°C

Heat Treatment

It is possible to heat treat SLD-MAGIC under the same conditions as D2.

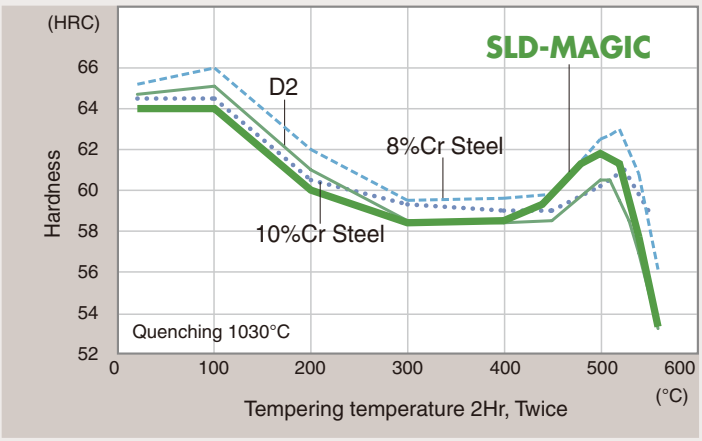
It is possible to obtain maximum hardness (60~62HRC) with tempering at around 500°C where dimensional change is near to zero, achieving both high hardness and less dimensional change.

Secular change of SLD-MAGIC after high temp. tempering is almost equivalent to that of D2, and smaller than 8% Cr steel. It is possible to reduce secular change via low temp. tempering, sub-zero treatment or stabilizing.

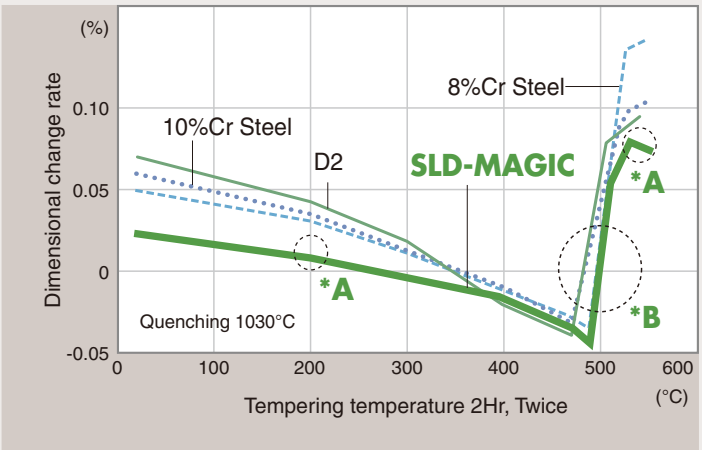
Standard Heat Treatment Conditions

Annealed Hardness	Quenching	Tempering	Hardness (HRC)
255HBW or under	1010~1040°C Air quenching	480~530°C Air cooling or 150~250°C Air cooling	60HRC or over

Quenched and tempered hardness

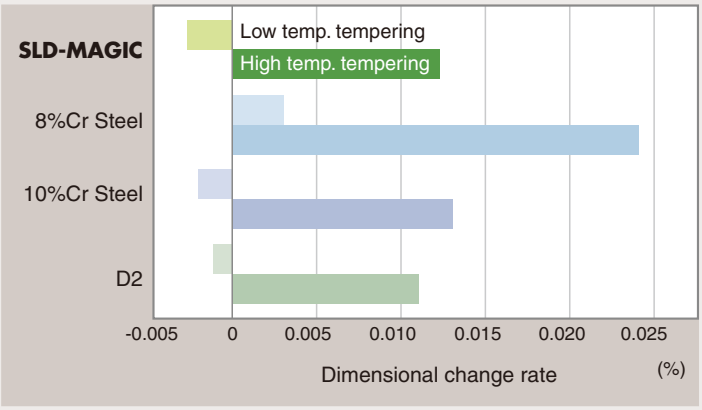


Dimensional change after heat treatment



*A: Minor dimensional change
*B: Minor dimensional change with maximum hardness

Secular change / Dimensional growth

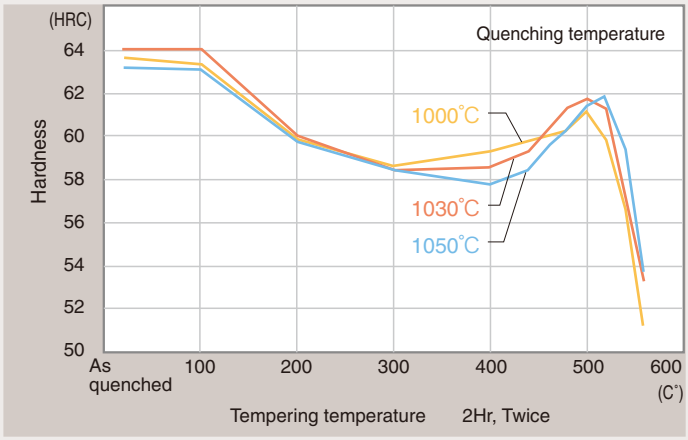


Size of test pieces: 45T X 90W X 200L
Austenitizing: 1030°C
Low temp. tempering: 180°C X 2times
High temp. tempering: 520°C X 2times
Measure: 200mm direction
Dimensional change after 6 months posterior heat treatment

Heat Treatment

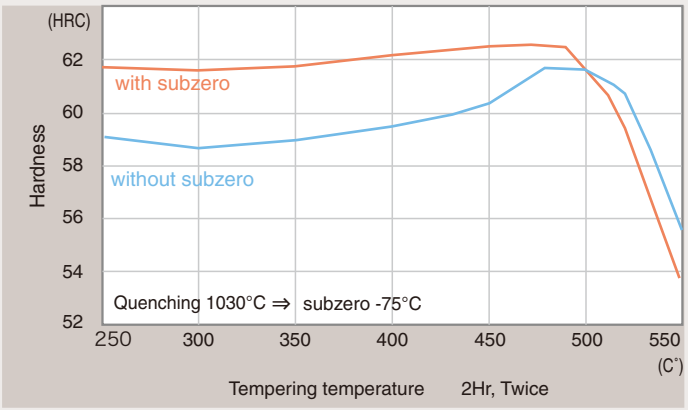
SLD-MAGIC shows stable both high hardness and very little dimentional change at around 1020-1030˚C hardening temperature.

The difference of quenching temperature



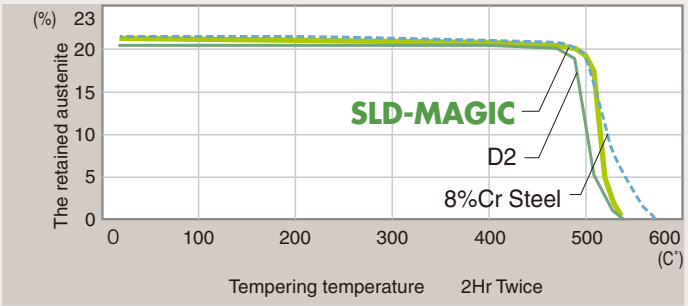
To add subzero treatment, SLD-MAGIC can achieve high hardness (62HRC) by both high and low temp. tempering. To combine subzero and stabilizing treatment is very effective for reducing secular distortion.

The subzero treatment and hardness



SLD-MAGIC shows almost the same decomposition behavior of the retained austenite, as that of conventional D2.

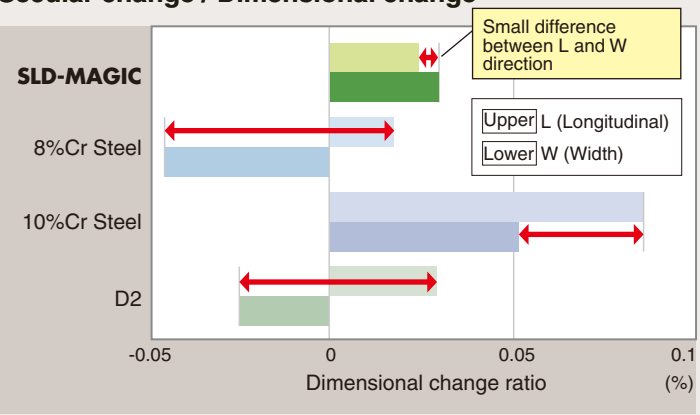
The retained austenite



Heat Treatment

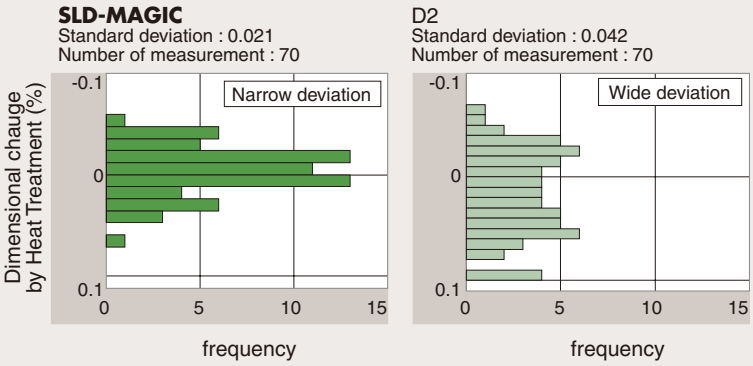
SLD-MAGIC shows smaller in dimentional change difference in the longitudinal, width and thickness directions, compared to D2 or 8%Cr steels.

Secular change / Dimensional change



SLD-MAGIC shows narrow deviation of dimensional changes by heat treatment, as a result, the better dimensional tolerance can be attained.

Deviation comparison of dimensional changes of actual mold after heat treatment.

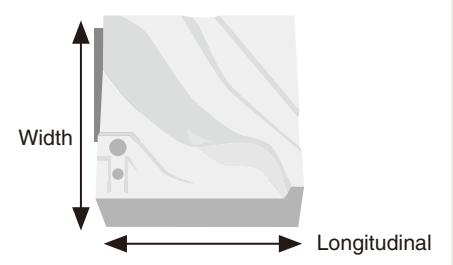


For example, in case of separation type molds, mold set up time was largely decreased because of narrow dimensional deviation.

Example of dimensional change for insert type mold.

Grade	Direction	Original Dimension (mm)	Dimensional Change (mm)	Dimensional Change Ratio (%)	Mold set up time
SLD-MAGIC	W	295	-0.030	-0.010	46 ←
	L	250	+0.010	+0.004	
D2	W	295	-0.090	-0.031	100(Index)
	L	250	+0.130	+0.052	

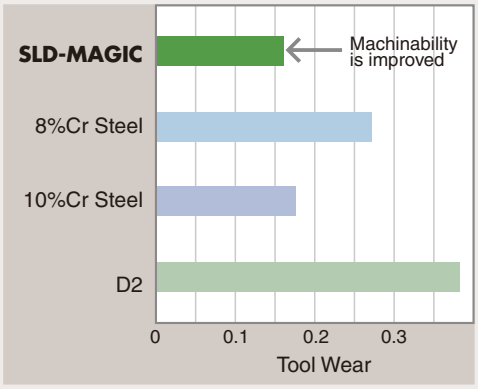
54% reduction of mold ajusting time after heat treatment



Machinability

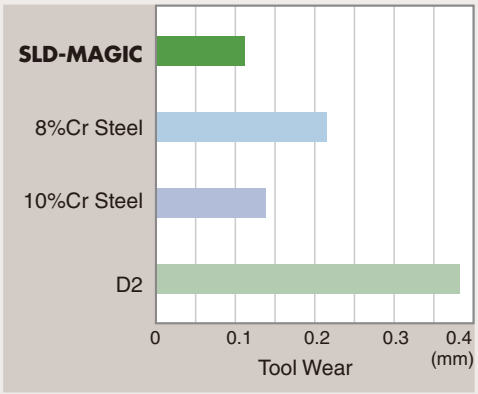
SLD-MAGIC improves machinability on face mill by over twice that of D2 and by approx. 35% compared to 8% Cr steel. It also demonstrates superior machinability using other tools.
Mold processing time is shortened due to enhanced machinability.
The lifespan of cutting tools is increased, thus reducing direct purchasing costs of tools.

ø125 Face Mill



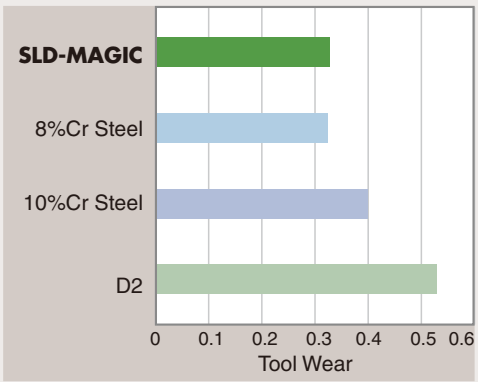
Work: Annealed condition
Tool: Coated carbide chip, 1chip only
Cutting speed: 120m/min, Dry
Feed: 0.13mm/blade
Depth of cut: 2^{Z} X 90^{W}mm,
Cutting distance: 4m

End Mill



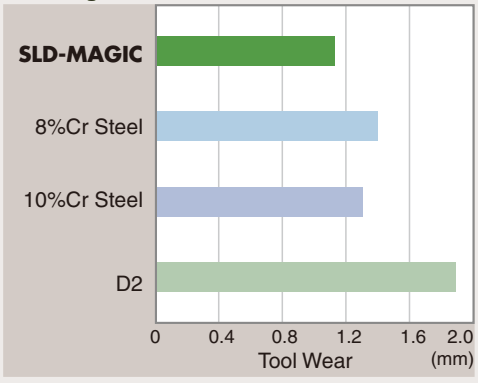
Work: Annealed condition
Tool: End mill ø8 (Co-HSS)
Cutting speed: 30m/min,Down-cut,Wet
Feed: 0.05mm/tooth
Depth of cut: 15^{Z} X 0.5^{W}mm,
Cutting distance: 5m

Drill



Work: Annealed condition
Tool: Drill ø5 (Co-HSS)
Cutting speed: 20m/min, Wet
Feed: 0.05mm/ev
Depth of hole: 25mm, 200Holes

ø63 High feed cutter



Work: Annealed condition
Tool: Coated carbide chip
Cutting speed: 150m/min, Dry
Feed: 1.3mm/tooth
Depth of cut: 1mm,
Cutting distance: 60m

Machinability

SLD-MAGIC can enhance tool lives because of lower cutting tool temperatures.

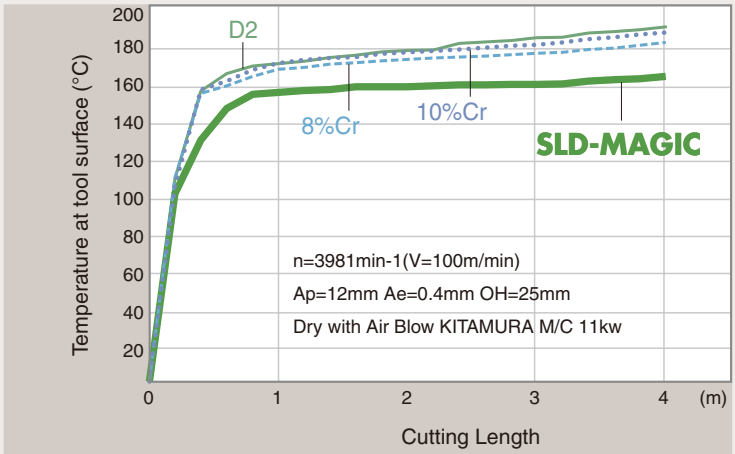
Color of chips

SLD-MAGIC

D2
(Tempered color)

Cutting tool temperature comparison

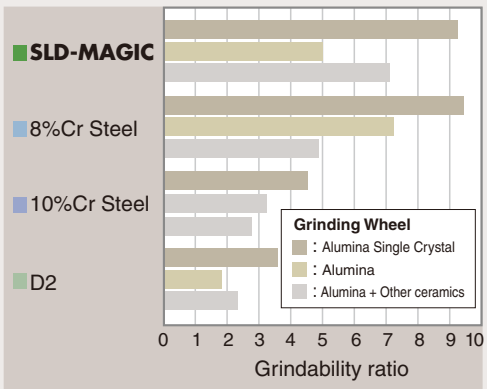
CEPR6080 (ultrafine particle WC) (ø8 X 6NT TiAlN)



Grindability

Grindability of SLD-MAGIC is better than those of D2 and 10% Cr steel, and almost equivalleut to 8% Cr steel.

Grindability comparison as a function of diffenent grinding wheels



Grinding test conditions
- Work 50 X 90 X 200L (Heat treated condition)
- Machine: Reciprocal Type

Grinding Conditions
- Wet Traverse Grinding
- Velocity of Wheel 33m/sec
- Table velocity 0.33m/sec
- Undercut 5μm/pass
- Cross Field 5mm/lap
- Spark out 1lap
- Total undercut 0.1mm

- Grinding ratio Ground off amount/wear of wheel
- Grinding ratio is higher the better

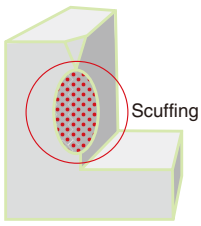
Application Examples

In addition to prolonging the lifespan of molds, SLD-MAGIC also enables remarkably easy mold fabrication, thereby contributing to total cost reduction and shorter processing times in the automobile and mold industries.

01 Bending die for automotive parts

Inner parts
Work 440MPa (t3.2)

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	59~61HRC	60~62HRC
Heat treatment	High temp. Tempering	High temp. Tempering
Surface treatment	CVD (TiC)	CVD (TiC)
Lifespan	1,300 pcs	156,000 pcs
Cause	Severe galling	Less galling

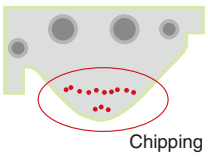


Mold lifespan significantly improved

02 Blanking die for automotive parts

Function parts
Work 590MPa (t7.0)

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	58~60HRC	58~60HRC
Heat treatment	170°C Tempering	170°C Tempering
Machinability	Bad	Good
Lifespan	15,000 pcs Max.	40,000 pcs carrying on
Cause	Severe chipping	Less chipping

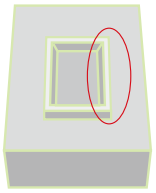


Mold lifespan more than doubles

03 Blanking die for electrical appliances

Electrical appliances
Work Film

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	58~60 HRC	58~60 HRC
Heat treatment	530°C Tempering	530°C Tempering
Machinability	Bad	Good
Lifespan	650,000 pcs	1,020,000 pcs
Cause	Early wear out	Less wear

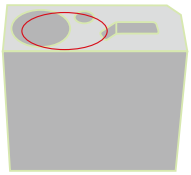


Mold lifespan 50% up

04 Blanking die for electrical appliances

Optical parts
Work SPCC (t0.8)

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	60~62HRC	60-62HRC
Heat treatment	200°C Tempering	480°C Tempering
Machinability	Bad	Good
Lifespan	100,000 pcs	100,000 pcs carrying on
Cause	Burr (Wear out)	Reduce wear by half

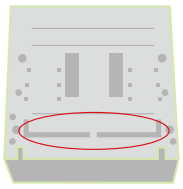


Mold lifespan doubles

05 Blanking die for electrical appliances

Liquid crystal panel parts
Work SUS304 (t0.3)

	Present condition	Evaluation
Grade	8%Cr Steel	**SLD-MAGIC**
Hardness	60-62HRC	60~62HRC
Heat treatment	505°C Tempering	480°C Tempering
Dimensional change	0.05%	-0.01-0.02%
Lifespan	30,000 pcs	40,000 pcs carrying on
Cause	Burr (Wear out)	Less wear



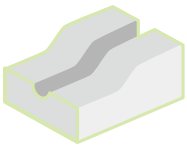
Mold lifespan 30% up

⚠ Note: The above-listed data is for application examples only and this data does not assure performance.
It is not suited for molds with EDM finished surface that require a high degree of mirror finish such as plastic molds.

06 Die for hydroforming

Exhawst pipe
Work Steel tube

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	56HRC	58HRC
Heat treatment	High temp. Tempering	High temp. Tempering
Distortion by heat treatment	Very hard to adjusting the upper and lower die blocks clue to large dimensional changes	Reduction of adjusting time of the upper and the lower die blocks
Machinability	Bad	Improved. Adjusting is finished only by one chip used.

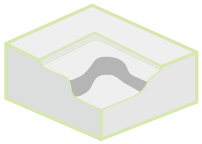


Mold adjusting time is reduced because of small dimension change of upper and lower die blocks by heat treatment

07 Die for cold press

Automobile parts
Work Hight-tensile
-strength steel

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	58~60HRC	60~62HRC
Heat treatment	High temp. Tempering Large dimensional ohange	High temp. Tempering Deviation is reduced to 1/2. Ajusting time is reduced
Surface treatment	TD	TD
Cause	Ball End Miuing Exchanging chips quite offen	The number of exchanged chips is reducedto 1/5~1/10 compared to D2. Feed rate is increased to 1.7 times.

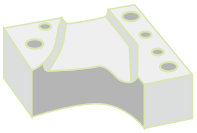


Small dimension deviation

08 Die for cold press

Inner parts
Work 440MPa (t2.3)

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	58~60HRC	60~62HRC
Heat treatment	High temp. Tempering	High temp. Tempering
Surface treatment	TD	Dimensional Changes by TD is within 5/100
Lifespan	5500 pcs	Continuing beyond 15,000
Problem	Scuffing	



Mold lifespan is improved by almost 3 times.

09 Die for cold press

Inner parts
Work 780MPa (t2.3)

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	59~61HRC	60~62HRC
Heat treatment	High temp. Tempering	High temp. Tempering
Surface treatment	TD	Dimensional Changes by TD is small
Machinability	Bad	The life of chips used is 10 times longer than D2 cases.
Problem	Mochinabiliry and dimension change	

Small dimension changes after TD treatment

10 Die for cold press

Insert blocks

	Present condition	Evaluation
Grade	D2	**SLD-MAGIC**
Hardness	59~60HRC	59~60HRC
Heat treatment	High temp. Tempering	High temp. Tempering
Deformation of datum plane	All 26 pieces deformed over 0.02	Only 1 piece out of 26 pieces deformed 0.02mm.
Adjustment time	100 min.	0 min.

Adjustment time is reduced because of redused the number of deformed blocks.

⚠ Note: The above-listed data is for application examples only and this data does not assure performance.
It is not suited for molds with EDM finished surface that require a high degree of mirror finish such as plastic molds.

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- Please contact a representative of our Specialty Steel Division if there are any questions or problems.

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