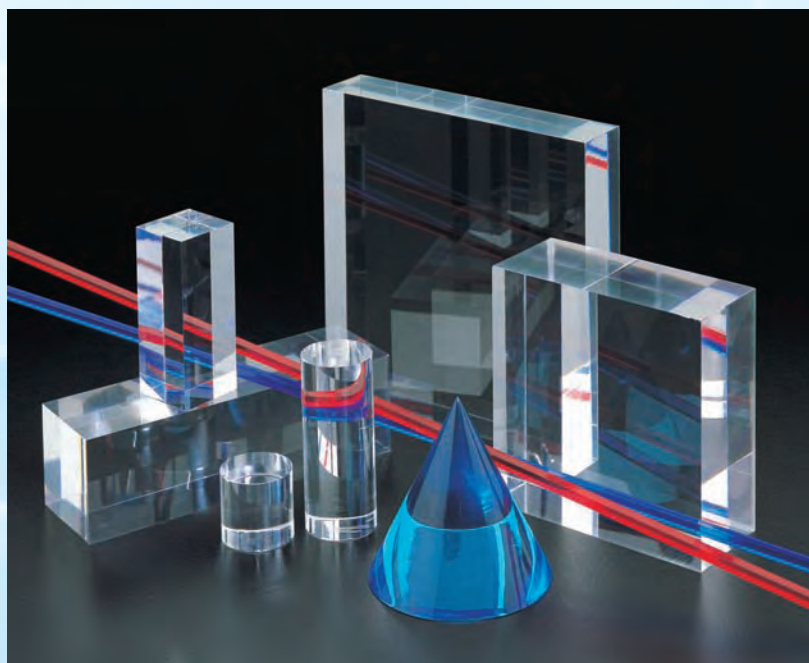


YSS High Quality Plastic Mold Steels

HI-PM™ Series



In compliance with advanced plastic molding technology

YSS plastic mold steels “HI-PM” series are increasing popularity in compliance with advanced plastic molding technology. “HI-PM” series are fulfilling demands of plastic industry for molds that provide crepe-and mirror-finishability and mold durability for corrosive gas generating and reinforced resins.

Mold Material and Application

Group	Hardness Employed [HRC]	Grade	Material Type	Application Example
Prehardened	29~33	HI-PM7	P20 Improved	Mold required good weldability & machinability (Autoparts, Home electronics, House equipment)
		HI-PM38	420 Improved	Flame retardant resin, Transparent parts, Rubber
		HI-PM77	420 Improved & Resulphurized	Corrosion resistant mold bases, Rubber mold
	(Round Bar) 38~42 (Flat Bar) 33~37	PSL	630 Improved	Mold for polyvinyl chloride, Frothy resin, Rubber
	37~42	CENA1	Cr Contained NiAl Precipitation Grade	Rust resistant mold with sensitive surface as mirror polishing, creping, EDM, Weldless Mold
	37~41	HI-PM MAGIC	P20 Improved	General Mass-Production Mold (Autoparts,OA equipment, Home Electronics)
		HI-PM PRO	P21 Improved	Parts associated with automobile headlamp production, Exterior of cellular phone
	38~42	FDAC	H13 Improved & Resulphurized	Engineering resin, Slide core
For Quench and Temper	50~55	HI-PM38	420 Improved	Mold for Anti-corrosion / Mirror polish (Cassette, Medical instruments, Food container, etc)
		HI-PM38S	420 Improved	Mold for super mirror polish (Optical disc / Lense)
	56~62	HI-PM31	D2 Improved	Wear resistant mold for engineering resin (Gear, Connector, IC)
		HAP5R	P/M HSS	Mold required high toughness & high hardness (Core pin, Thin wall)
	60~63	ZCD-M	D2 Improved	IC mold
	60~65	ZDP4	P/M Cold Die Steel	Reinforced and flame retardant engineering resin, IC mold, Slide parts, Cutter required exceptional wear resistance
For Aging	40~45	HI-PM75	High Hardness, Non-Magnetic, Resulphurized	Molding in magnetic field (Plastic magnet)
	52~57	YAG	Maraging Steel	Mold required exceptional toughness (Core pin, Thin wall) , Super mirror polish (Optical lense)



Resin Types and Grade Selection

Resin		Required Properties for Mold	Required Life and Grade Recommended			
			SHORT < 10 million	MEDIUM < 50 million	LONG < 100 million	MASS PRODUCTION > 100 million
Thermo-plastic	General	Machinability	HI-PM7	HI-PM7	HI-PM MAGIC CENA1 HI-PM PRO FDAC	HI-PM MAGIC FDAC) + Nitriding
	Engineering Resin	Wear Resistivity	HI-PM7	HI-PM7 + Nitriding	HI-PM-MAGIC FDAC) + Nitriding	HI-PM38 HI-PM31
	Reinforced	High Wear Resistivity	FDAC HI-PM MAGIC HI-PM PRO	HI-PM MAGIC FDAC) + Nitriding, Plating	HI-PM31	HI-PM31 + Plating ZDP4 HAP40
	Flame Retardant	Corrosion Resistivity	HI-PM38 (Prehardened) CENA1	HI-PM38 PSL	HI-PM38	HI-PM38 + Plating
	Transparent	Mirror Polishability	CENA1	CENA1 HI-PM38	HI-PM38	HI-PM38
Thermo-set	General	Wear Resistivity	HI-PM MAGIC HI-PM PRO FDAC	HI-PM MAGIC HI-PM PRO FDAC) + Plating	HI-PM31	HI-PM31
	Reinforced	High Wear Resistivity	HI-PM MAGIC FDAC) + Nitriding	HI-PM31	HI-PM31 ZCD-M) + Plating	ZDP4 + Plating

General Resin : PS, PE, PP, AS, ABS etc.

Engineering Resin : PC, PPE, PA, POM, PBT, PET etc.

Advanced Engineering Resin : PPS, PI, PES, PEEK etc.

Properties Comparison Table

Material (equivalent)	Machinability	Dimensional Change by Heat Treatment	EDM/Creping Texture	Mirror Polishability	Weldability	Rust Resistance	Wear Resistance	Toughness	Cost
HI-PM7	A	—	C	C	A	D	D	B	B
HI-PM77	B	—	D	D	C	B	D	C	C
PSL	D	—	B	C	A	A	D	B	D
CENA1	C	—	A	B	C	C	D	C	D
HI-PM MAGIC	B	—	B	C ⁺	A	D	D	B	C
HI-PM PRO	B	—	A	B	B	D	D	C	D
HI-PM1	A	—	D	D	D	D	D	D	C
FDAC	C	—	D	D	C	D	C	C	C
HI-PM38	C	A	A	A	C	B	C	C	D
HI-PM38S	C	A	A	A ⁺	C	B	C	C	E
HI-PM31	C	B	A	B	D	C	B	C	D
HAP5R	C	C	A	B	D	E	B	B	E
ZCD-M	D	C	A	D	E	C	B	D	D
ZDP4	E	D	B	B	E	C	A	E	E
HI-PM75	E	B	D	D	E	B	C	C	E
YAG	D	B	A	A	A	D	C	A	E
S55C (1055)	A	—	C	E	C	E	E	C	A
SCM440 (4140)	C	—	C	D	D	D	D	C	B

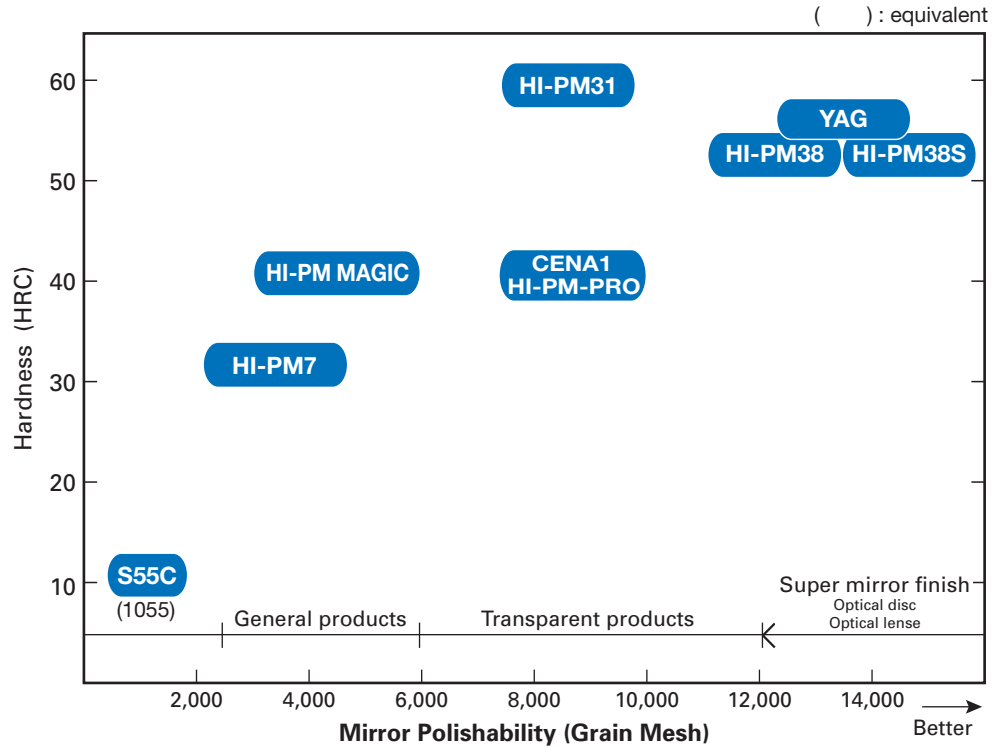
Ratings : A--Best C--Ordinary D, E--Poor

(Remarks) Please refer above as general concept.



Properties Comparison

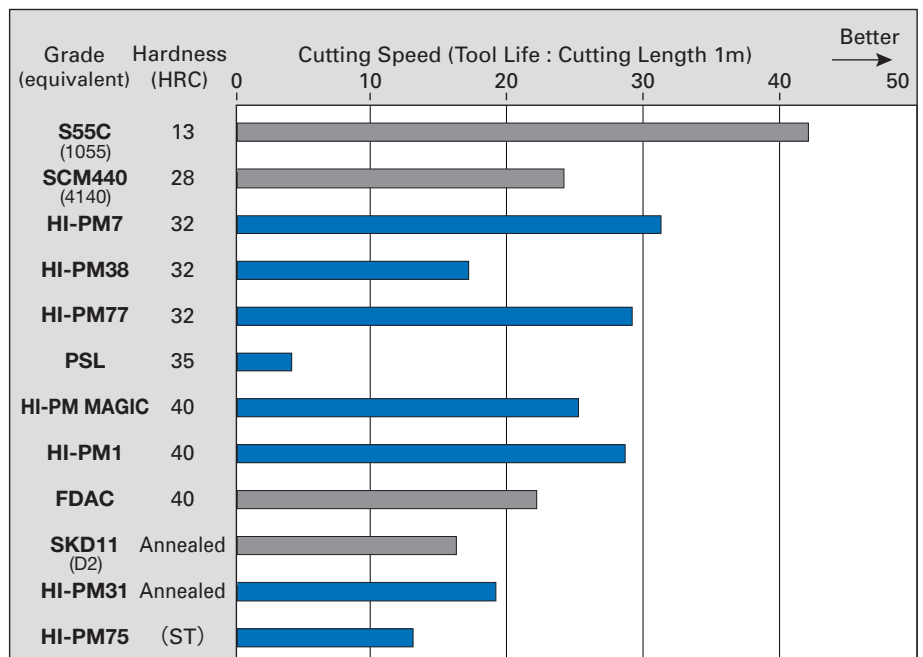
Polishing Property (Schematic Diagram)



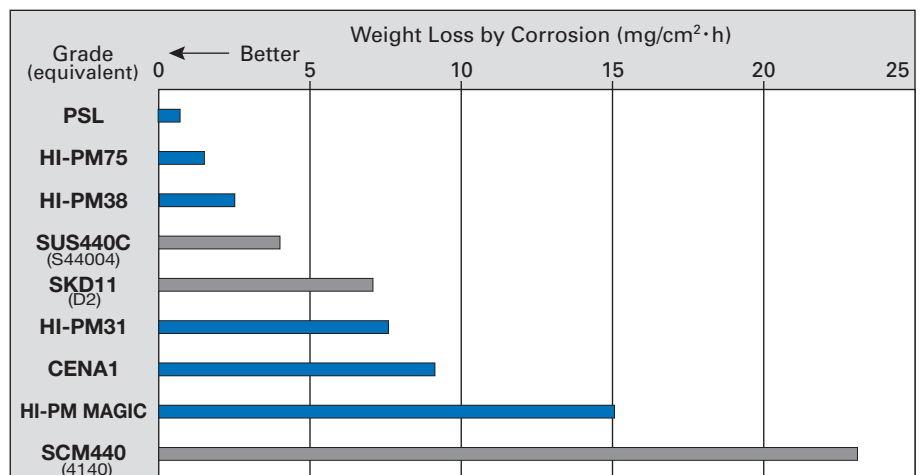
Machinability

Drilling

- Tool : SKH51 (M2) $\phi 10$
- Feed : 0.15mm/rev
- Depth : 30mm
- Dry



Corrosion Resistance (5% Sulfuric Acid Solution)

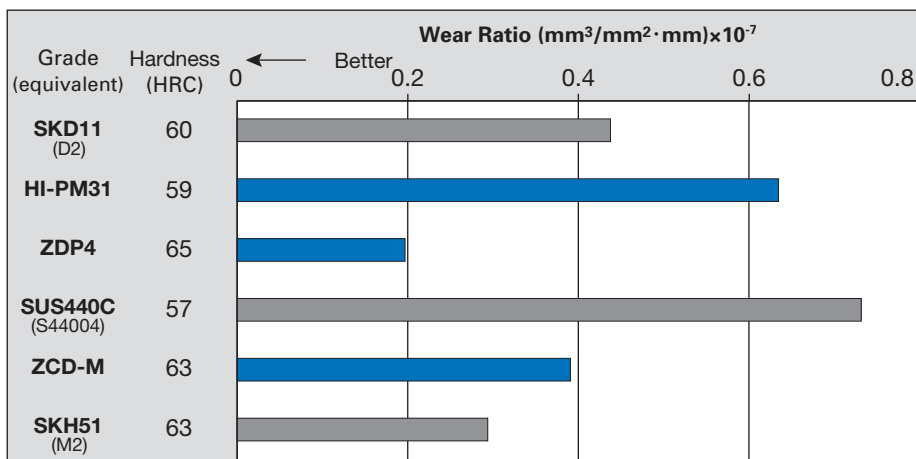


Properties Comparison

Wear Resistance

Ohgoshi Wear Test

- Work Material SCM415
- Load 67N
- Total Friction Length 400m
- Friction Speed 0.78m/sec



Mechanical Properties

Grade	Hardness (HRC)	Tensile Strength (N/mm²)	0.2%Yield Strength (N/mm²)	Elongation (%)	Reduction of Area (%)
HI-PM7	32	975	855	20	55
HI-PM38	52	1,910	1,620	13	35
HI-PM77	32	990	845	16	41
PSL	39	1,170	1,100	11	34
CENA1	40	1,225	1,150	15	50
HI-PM MAGIC	40	1,200	1,020	18	45
HI-PM PRO	40	1,200	1,020	17	45
HI-PM75	42	1,305	1,110	11	28
YAG	53	2,010	1,910	10	48

Physical Properties

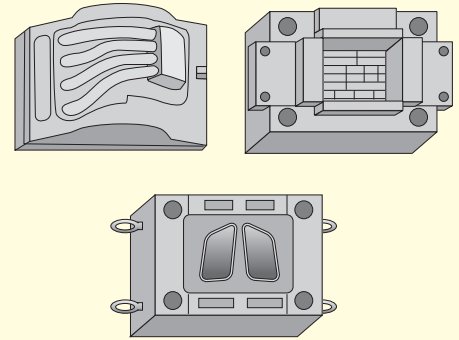
Grade	Thermal Expansion Coef. (×10⁻⁶/°C) Averaged Value from 30°C to Each Temp.				Thermal Conductivity (W/m·K)				
	100°C	200°C	300°C	400°C	20°C	100°C	200°C	300°C	400°C
HI-PM7	11.6	12.2	12.8	13.4	34.3	38.3	39.8	40.4	40.6
HI-PM38	10.4	11.1	11.5	11.8	22.1	25.5	26.7	28.5	29.6
HI-PM77	10.1	10.7	11.1	11.5	22.3	24.9	26.3	27.9	29.5
PSL	10.6	11.1	11.9	12.1	15.8	20.0	22.2	24.2	25.5
CENA1	10.8	11.5	12.0	12.4	20.5	22.9	25.9	28.2	30.5
HI-PM MAGIC	11.5	12.3	12.9	13.4	31.4	34.1	37.7	40.2	41.1
HI-PM PRO	12.7	13.0	13.3	–	28.3	31.9	35.4	38.3	–
HI-PM31	12.4	13.1	13.6	14.1	26.5	–	34.4	–	39.8
ZCD-M	10.5	10.8	11.5	11.9	16.4	19.4	22.0	25.3	24.4
HI-PM75	16.1	17.2	18.0	18.6	12.3	14.5	16.4	18.7	20.4
YAG	–	10.8	–	–	20.9	–	25.5	–	27.6

HI-PM MAGIC™

Prehardened: 37~41HRC

Advanced Plastic Mold Steel
for general purposes

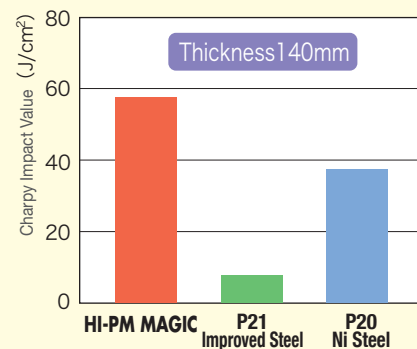
HI-PM MAGIC is a newly developed grade which has both high durability and excellent processability. Easy weldability will make setup of the new products of home electronics, OA equipments or Auto parts smoother.



Home electronics, OA equipment, Auto parts

Features

- No heat treatment is necessary (37~41HRC)
- Good and stable polishability
- Steady machinability. Fits for high-speed high feed cutting
- Higher toughness compared with conventional 40HRC grades
- Easy Weldability
- Excellent nitriding properties
- Good EDM finishability
- Satisfying Cost Performance



Comparison of 2mmU notch
Charpy impact values
(example of measurement by our company)

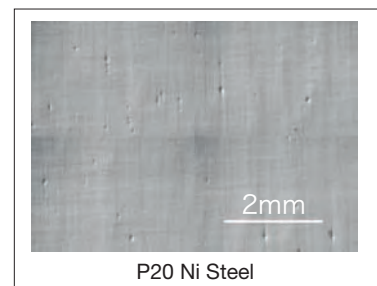
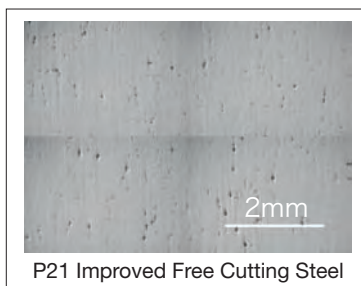
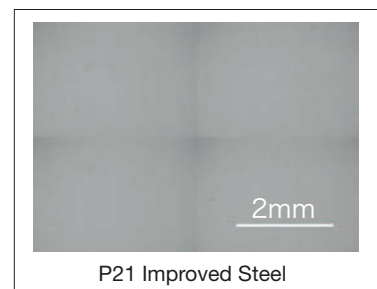
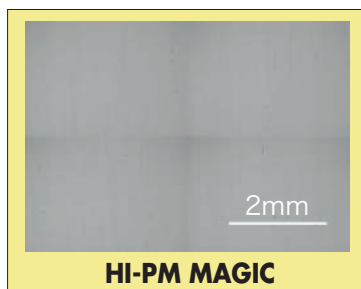
Application

- General resin products for home electronics, OA Auto and so on.

Efficiency

Mirror polishability

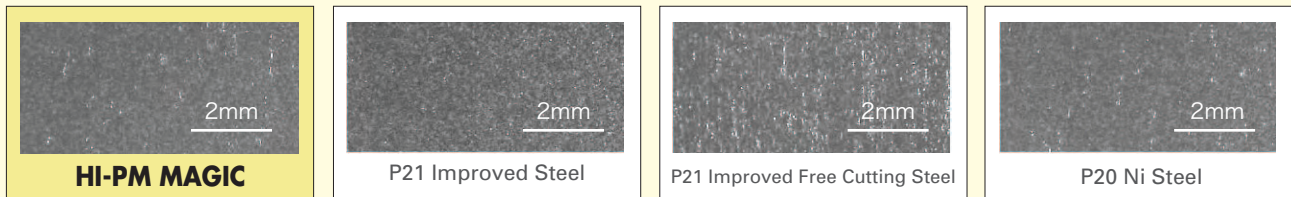
It has steady mirror polishability and supports grit size #5000 polish.



Differential interference figure comparison of
#5000 mirror polished surface
(2 x 2 sequential photographs)

Electric Discharge Machinability

Comparatively uniform electric discharge machined surface can be gained, as well as is relatively soft surface, so post-processing is easy.



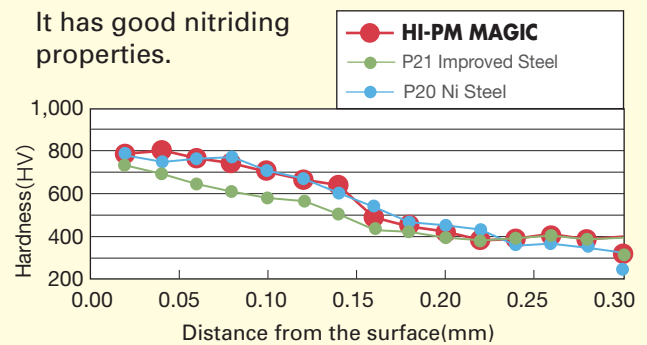
Crepability

It has good crepability.



Nitriding Property

It has good nitriding properties.



Nitriding property (540°C x 5h gas nitrocarburizing process)

Machinability

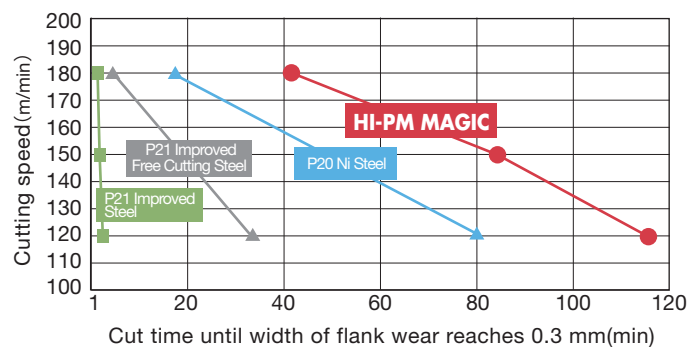
It has excellent machinability, especially under conditions with higher ejection volume of cutting chips (high efficiency), such as high feed processing.

A (Excellent) ⇔ D (Poor)

Cutting Volume (cm ³ /min)	Example of processing method (Tool)	Steel Grade			
		HI-PM MAGIC	P21 Improved Steel	P21 Improved Free Cutting Steel	P20 Ni Steel
>10	Face milling cutter, high feed radius mill	A	D	C	B
1-10	Solid high feed end mill	A	C	B	B
0.1-1	High-speed steel drill, solid ball end mill	B	A	A	C
0.01-0.1	High-speed steel drill, small end mill	B	A	A	C

High feed radius mill

In comparison with the conventional steel, it is possible to achieve significant improvement in cutting efficiency.



High feed radius mill V-T diagrams

40HRC Prehardened Grade

CENA1™

Prehardened: 37~42HRC

Precipitation Hardening,
Rust-Resisting Grade
for Precise Mold

CENA1 is new concept grade breaking through with rust resistivity and excellent machinability. CENA1 has exceptional high purity and suit for critical surface finish.

Features

- No heat treatment is necessary. Uniform hardness distribution.(37~42HRC)
- Higher rust resistivity compared with P21 type grade.
- Excellent mirror polishability, crepe- and EDM finishability.
- Good weldability with least hardness elevation.
- Good nitriding hardenability and can be used for wear resisting application.

Application

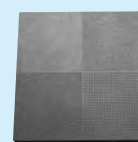
- Most Suitable for Weldless Molding
- Countermeasure against corrosion by gas generated from resin.
- Other Critical Surface Finish Molds. Engineering resin products



TV Glossy Frame
(Weldless Molding)



Non-glare Treatment Sample



Creping Sample

HI-PM PRO™

Prehardened: 37~41HRC

Precipitation Hardening,
Rust-Resisting Grade
for Precise Mold

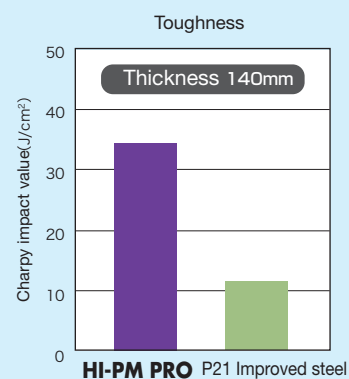
HI-PM PRO is the steel for plastic molds which precise pursues consistency in production to meet requirement for elaborately designed products.

Features

- "Hardness" (37 to 41HRC) which is suitable for mass production of resin products by precision molding.
- "Excellent machinability for high quality appearance" supports excellent mirror polishability, creping, EDM surface (thanks to the special melting method)
- "Toughness and machinability" supports stable mold making and productivity.

Application

- The parts associated with automobile headlight production
- The exterior of cellular phone



Comparison of 2mmU notch
Charpy impact values

HI-PMTM 7

Prehardened: 29~33HRC

For Medium and Large Mold
for General Application

HI-PM7 is plastic mold steel prehardened to 29~33HRC fitted for medium and large size mold, having good machinability and weldability. In addition, it has good mirror polishability and EDMachinability to make itself one of the best steel in this class grade.

Features

- Uniform hardness distribution even in large crosssection. (29-33HRC)
- Machinability is better than P20 or free machining steel.
- Excellent weldability with least hardness elevation.
- Good mirror polishability.
- Less streak texture and least hardness elevation on EDM surface makes finishing easier.
- Excellent toughness.
- Excellent nitriding property.

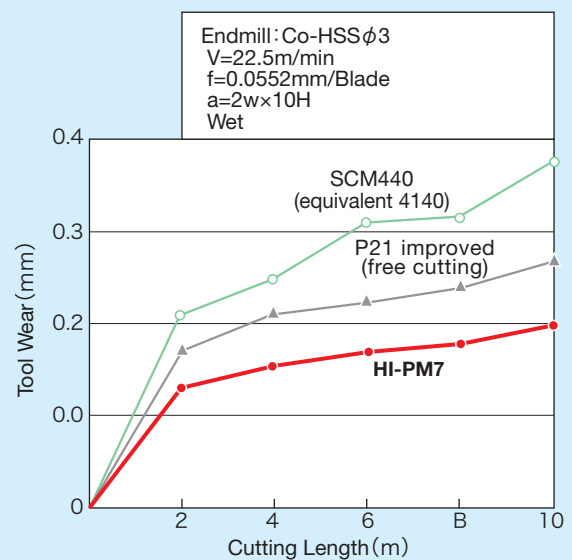
Application

- Auto parts: Headlamp, Tail lamp, Inner panel etc.
- Home electronics, House equipment: TV cabinet, Air conditioner housing etc.
- Others large daily goods, Large container, Pipe, Rubber

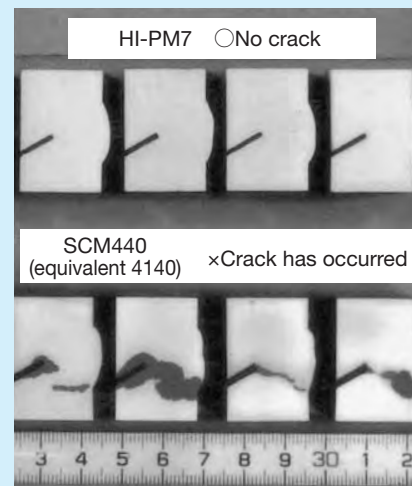
Inner Panel



Tail Lamp



Machinability Comparison



y-groove Weld Crack Test

JIS Z 3158
TIG Welding
No pre-heating / No post-heating

HI-PM™ 38

Prehardened: 29~33HRC
Hardenable to: 50~55HRC

For Anti-Corrosion and
Mirror Polish Mold

HI-PM38 is Mo contained 13Cr martensitic stainless steel prehardened to 29-33HRC, manufactured by consumable electrode remelting method, further hardenable to 50-55HRC. It is fitted for molds which require corrosion resistance and superb mirror polishability. In addition, it suits for precise heat treatment. Excellent corrosion resistance also makes mold storage easier.

Features

- Excellent mirror polishability
- Better corrosion-resistivity than 420.
Chromium plating is not necessary.
- Least heat treatment deformation, best fitted for precise mold.
- As HI-PM38 is supplied as prehardened condition, it can be used without further heat treatment also.

Application

- Transparent items: Lense, Container for cosmetics, etc.
- Flame retardant resin products: Home electronics, OA equipment
- For saving plating: Food container, Medical instruments

Heat Treatment

- Quenching: 1,000~1,050°C Air Cooling
- Tempering: 200~ 500°C Air Cooling

HI-PM™ 38S

Prehardened: 29~33HRC
Hardenable to: 50~55HRC

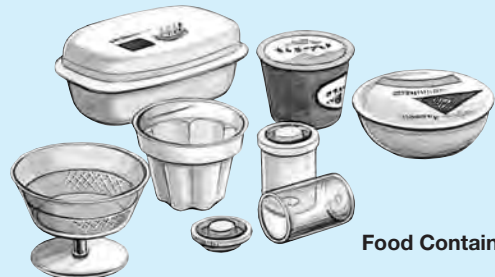
For Super Mirror Polish
Mold

Features

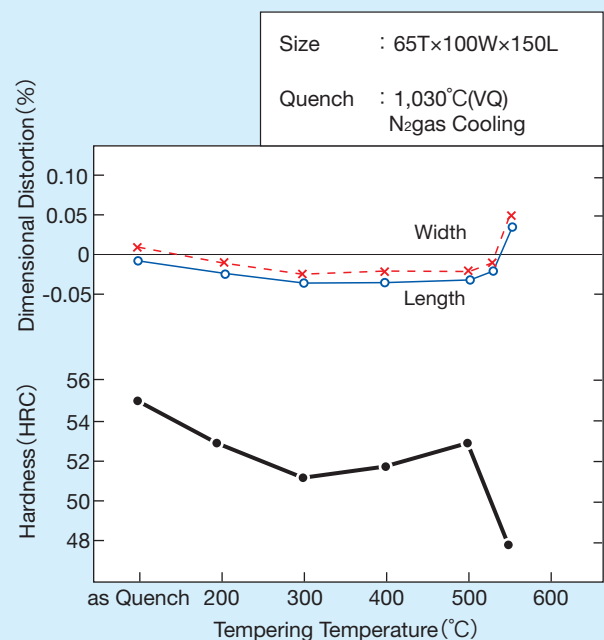
- Superior mirror polishability to below 0.01μm surface roughness.
- Other features are same as HI-PM38.
- CD, DVD, MO, and optical lense



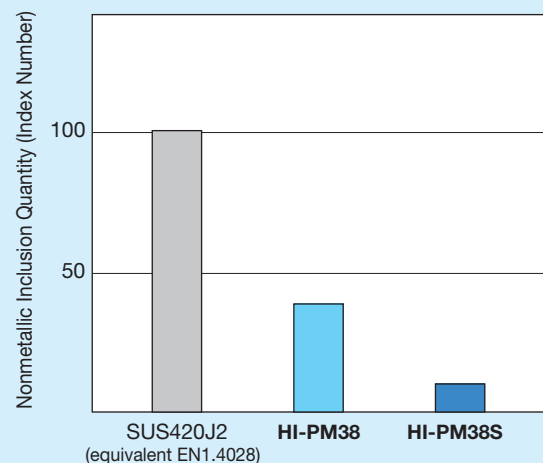
CD,DVD



Food Container



Heat Treatment Properties of HI-PM38



Purity of HI-PM38S

Prehardened Stainless Grade

PSL™

Prehardened: 33~37HRC (Flat bar)
38~42HRC (Round bar)

For Higher Grade
Anti-Corrosion Mold

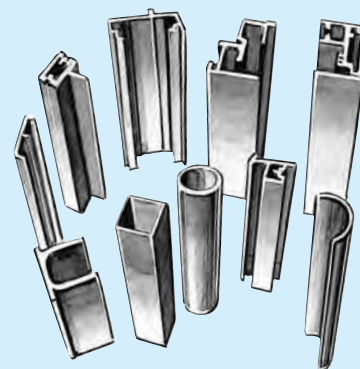
PSL is precipitation hardening stainless steel which shows superior corrosion resistance as used for corrosive gas yielding resins or resins with flame retardant additives without plating.

Features

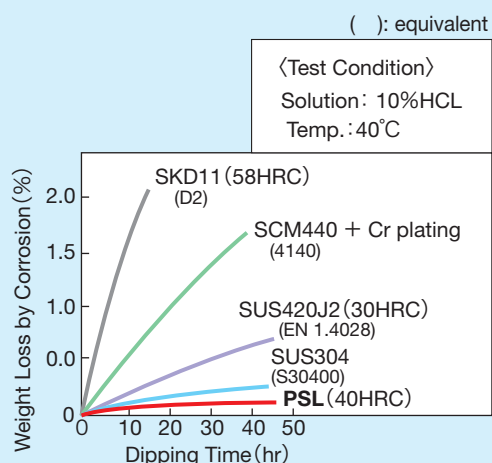
- Best corrosion resistance among plastic mold steels. Plating is not needed.
- Least hardness elevation on EDM or welded surface and easier finishing jobs.

Application

- Polyvinyl chloride : Pipe fittings, Pipe, Sash etc.
- Resins with flame retardant additives
- Precision mold for rubber



PVC Extruded Products



Corrosion Resistivity Comparison

HI-PM™ 77

Prehardened: 29~33HRC

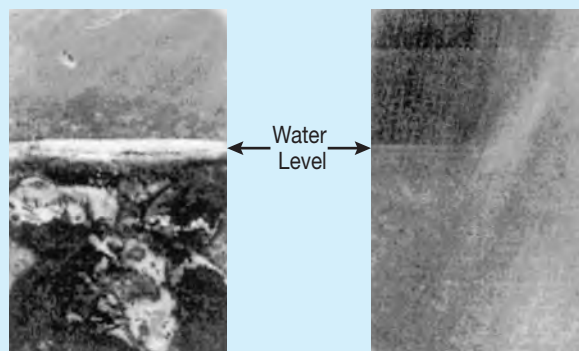
Free Machining Martensitic
Stainless Grade for Mold
Base

Features

- Good corrosion resistance and well fitted for rust protection of water cooling holes or surface of mold base.
- Excellent machinability
- Prehardened and good mechanical properties

Application

- Holder for compact disc mold or lense mold.
- Holder for food or medical container mold and precise engineering resin mold.
- Mold for rubber
- Anti-corrosive support tools



S55C
(equivalent 1055)

HI-PM77

Rust after 1 month dipping in water

High Wear Resistance Grade

HI-PMTM 31

Hardenable to : 55~60HRC

High Wear Resistant Grade
for Mass Production

H-PM31 is wear resistant plastic mold steel with fine carbide uniformly distributed by means of appropriate alloy design and consumable electrode remelting process. Least heat treatment distortion, it suits for precise heat treatment.

Features

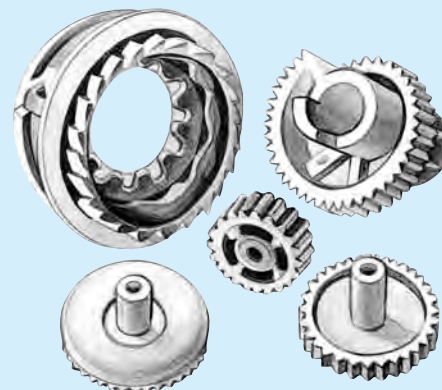
- Wear resistance is as high as JIS SKD11(D2).
- Much better machinability and grindability than JIS SKD11(D2).
- Least heat treatment deformation, best fitted for precise mold.
- Good mirror polishability crepe and EDM finishability
- High hardness and toughness, enough against chipping or breakage

Application

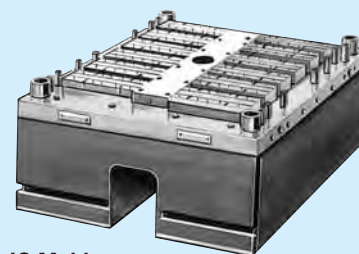
- Engineering resin products and thermosetting resin products
- Precise mold: IC mold, Connector, Watch parts, Camera parts

Heat Treatment

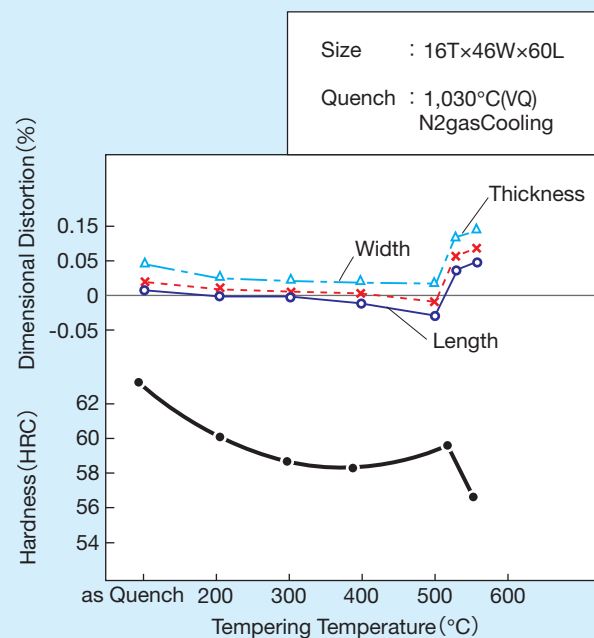
- Quenching : 1,000~1,050°C Air Cooling
- Tempering : 200~ 550°C Air Cooling



Engineering Resin Gear



IC Mold



Heat Treatment Properties of HI-PM31

YAG™

Hardenable to: 52~57HRC

**Super High Toughness
Maraging Steel**

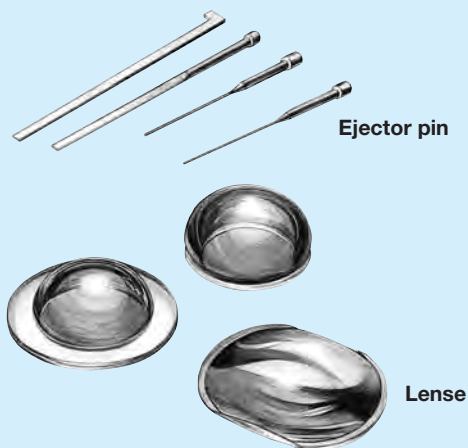
As YAG is delivered as solution heat treated condition, you are advised to conduct aging at 480~520°C in order to get hardness between 52~57HRC after engraving cavity.

Features

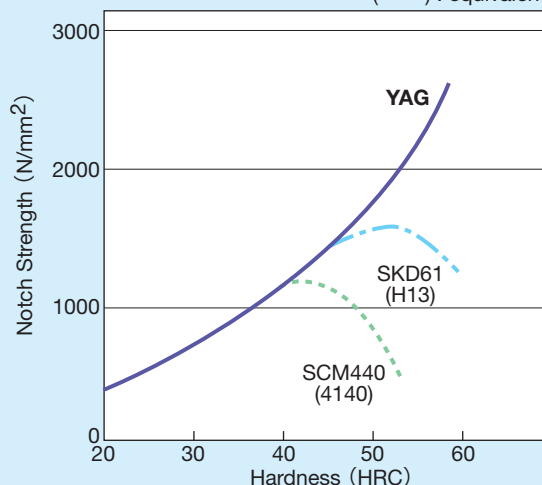
- Superior toughness and mechanical properties under high hardness and best fitted against breakage
- Super mirror polishability
- Hardness of 55HRC is obtainable by aging at 500°C with least distortion

Application

- Optical lense
- Thin core pin
- Ejector pin, either of small dia meter or of long length



() : equivalent



Relationship between Hardness and Notch Strength

HI-PM™ 75

Hardenable to: 40~45HRC

**Non-Magnetic High
Hardness Free Machining
Plastic Mold Steel**

Features

- Permeability(μ) is 1.01, equally non-magnetic as 304
- 40~45HRC is obtainable by aging of 700°C×5h and has higher wear resistance.
- Good nitriding properties

Remarks:

Slower machining recommended as it is easily hardened by machining.

Application

- Plastic magnet
- Wear resistant, non-magnetic supportive tools



Plastic Magnet

Higher Grade Polishing Method of Plastic Mold

Polish procedure	● Polish by oil grinding stone (use kerosene)	-----	#180→#240→#320→#400→#600→#800
Example	● Polish by oil sand paper (use kerosene)	-----	#600→#800→#1000→#1200→#1500
	● Finish Polishing by diamond compound (use felt cloth)		#1800→#3000→#8000→#14000 (9μm) (6μm) (3μm) (1μm)

Important points of polishing

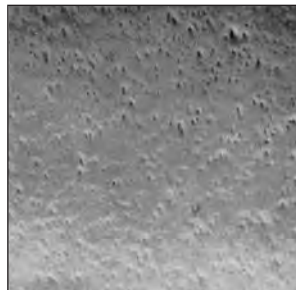
1. Each procedure is to be strictly kept.
2. When changing from one number to another, check if there are remained scratch by changing polishing direction. (move 45-90 degrees)
3. When changing numbers, wash and remove last polishing grains completely.
4. Polishing by diamond compound needs to be done in short times. Excessive polish can produce pinholes or orange peel.
5. To avoid alumina and chromium oxide as the polish capabilities are lower than diamond.
6. During long interruption, the object must be protected from the rust.

Remarks:

- A. For superior polishing use diamond compound.
Don't use alumina nor chromium-oxide compound.



Diamond Compound Finish

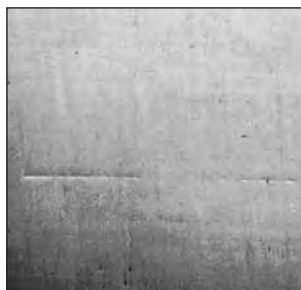


Aluminium Oxide Finish Not Good



Chromium Oxide Finish Not Good

- B. Load for polishing should be kept lowest possible.
C. Foregoing polish should be done prudently.
D. Rust proof measures must be taken in any interruption of jobs.



Scratch remains due to overload.



Seam and pinhole texture at crossing by less foregoing polish



Pinhole texture by inappropriate rust proof.

Welding of Plastic Mold

Attentive points

1. Preparations before welding
 - A. Form of location to get welded should be made smooth as Figure 1.
 - B. Cracks and treated surface (nitrided or plated) must be eliminated.
 - C. Oil, dust, moisture and scale must be removed thoroughly.

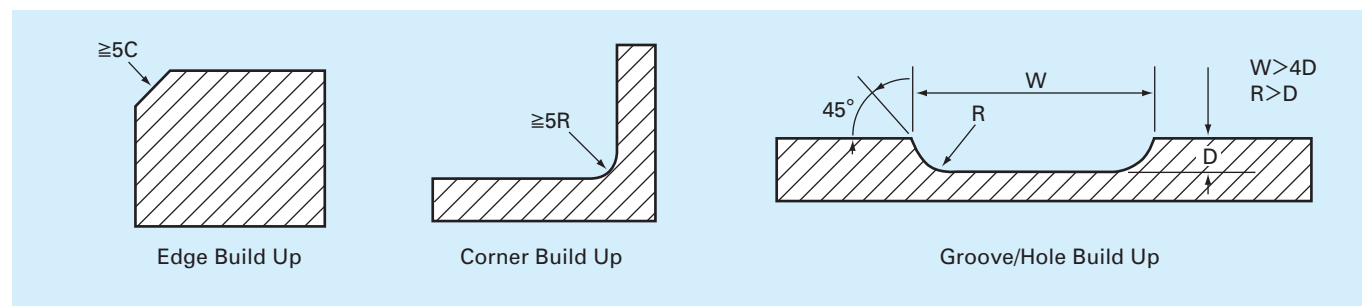


Figure 1. Standing shapes for build up welding

2. Welding rod

- A. Welding rod of similar composition as mold is to be used so that welding may not bring about unevenness of mirror finish or creping surface.
When the mold is made from HI-PM MAGIC, use welding rod made from HI-PM MAGIC-W.
Likewise, in case of TIG welding there are T-HTM-31 and T-HTM38 in the market for welding for mold made from HI-PM31 and HI-PM38.
- B. In case of using coated electrode, welding rod should be dried by heating to 250-300°C before using.
- C. For cavity welding, TIG welding should be applied.
(TIG : Tungsten Inert Gas)

3. Welding

- A. Figure2 shows example of actual welding jobs of representative grades.
- B. Tempering should be conducted soon after welding in case of prehardened steel or hardened and tempered steel according to Figure 2.
Tempering is effective to protect mold from crack and to stabilize mirror finish and creped surface by having uniform hardness and structure.

Mold Steel	Welding	Welding Rod	Condition	Heat Cycle
Grade				
HI-PM MAGIC	TIG	HI-PM MAGIC-W	●TIG Welding Rod Current { 2.4φ 80~160A { 3.2φ 110~200A Flow Rate 10~15ℓ/min	Pre-heat 150~300°C Welding Post-heat 150~300°C (Cool Slowly) (Stress relieving for correcting deformations and precise creping) 450~550°C Air Cooling
	TIG	HI-PM7-W	●Shielded Metal Ark Welding Rod Current { 3.2φ 90~120A { 4.0φ 130~160A	Pre-heat 100~150°C Welding Post-heat 200~300°C Cool Slowly Tempering 500~600°C 1hr/25mm Air Cooling
HI-PM7	Shielded Metal Ark	TH-50		

Figure 2. Welding procedure

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