



YSS Advanced Plastic Mold Steel For General Purposes

HPM-MAGIC™

40HRC Prehardened Steel

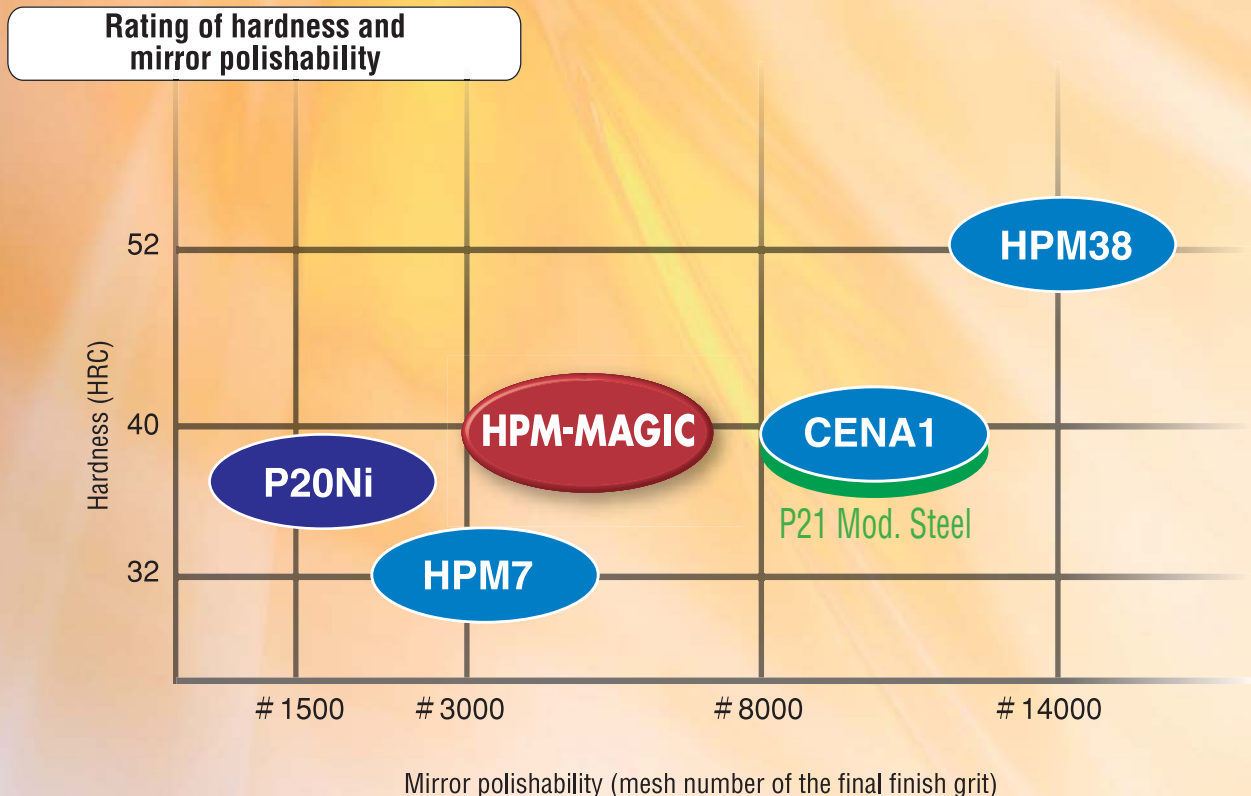
It is developed with a view of cost reduction of resin product manufacturing!

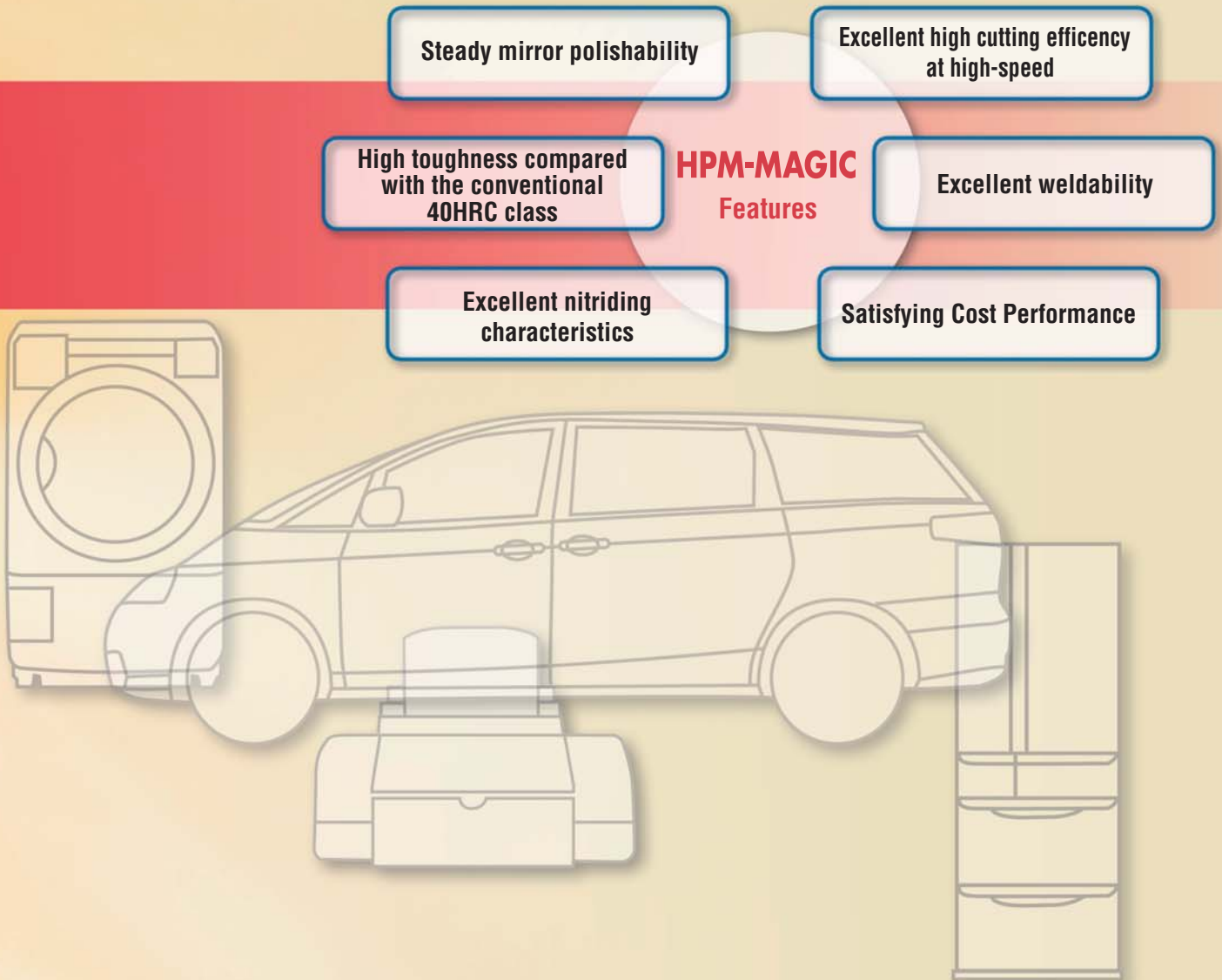
With high durability and steady mirror polishability which contributes to total Cost Reduction of resin product manufacturing.

HPM-MAGIC™

HPM-MAGIC is the steel for plastic molds which pursues practicability with consideration of performance balance.

- » "Hardness" (37 to 41 HRC) supports quantity production of precision molding for resin products
- » "High toughness and excellent weldability" reduce problems when developing new products
- » "Excellent high cutting efficiency at high-speed and steady mirror polishability" improve working efficiency, and save energy





Characteristics Comparison

Excellent "A" ↔ Poor "D"

Item		HPM-MAGIC	P21 Mod. Steel	P20 Ni Steel
Durability	Hardness (HRC)	40	40	40
	Toughness	A	D	B
Weldability		A	B	D
Mirror polishability (≥#5000)		B	A	C
EDM Finishability		B	A	B
Machinability		B ⁻	B	C

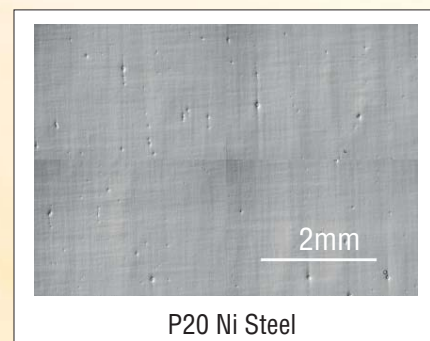
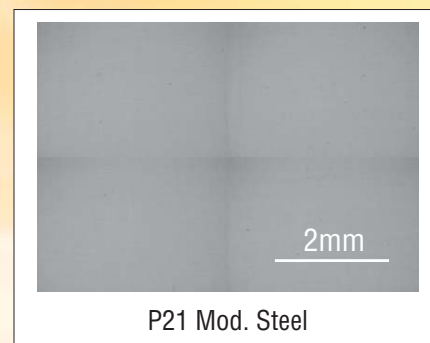
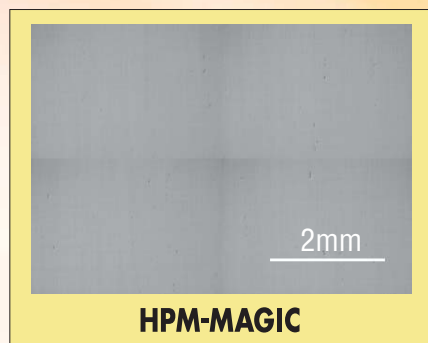
■ Compared steels

Indicates respectively P20Ni steel - the same as AISI P20 steel with added 1% Ni;
 P21 Mod. steel - NiAl precipitation hardening type low carbon steel (same as our company's HPM 50);
 P21 Mod. free cutting steel - free cutting steel (same as our company's HPM 1).

HPM-MAGIC™ combines both, "steady mirror polishability" and "high toughness".

Mirror polishability

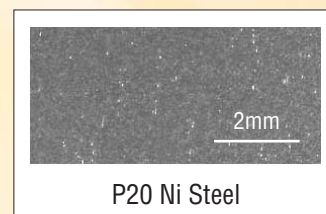
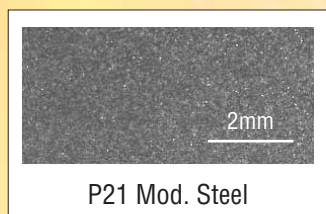
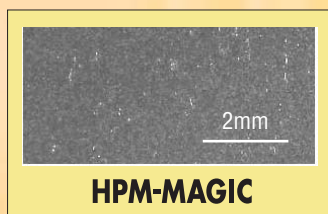
It has steady mirror polishability and supports grit size #5000 polish.



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

Electric Discharge Machinability

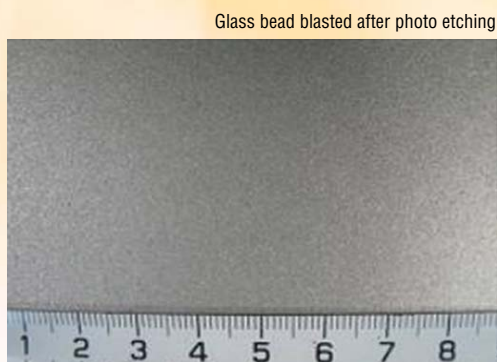
Comparatively uniform electric discharge machined surface can be gained, as well as is relatively soft surface, so post-processing is easy.



● Comparison of electric discharge machined surface

Crepability

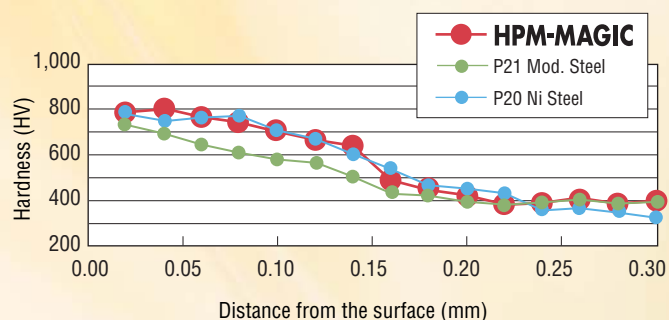
It has good crepability.



● Example of precise creping

Nitriding Property

It has good nitriding properties.



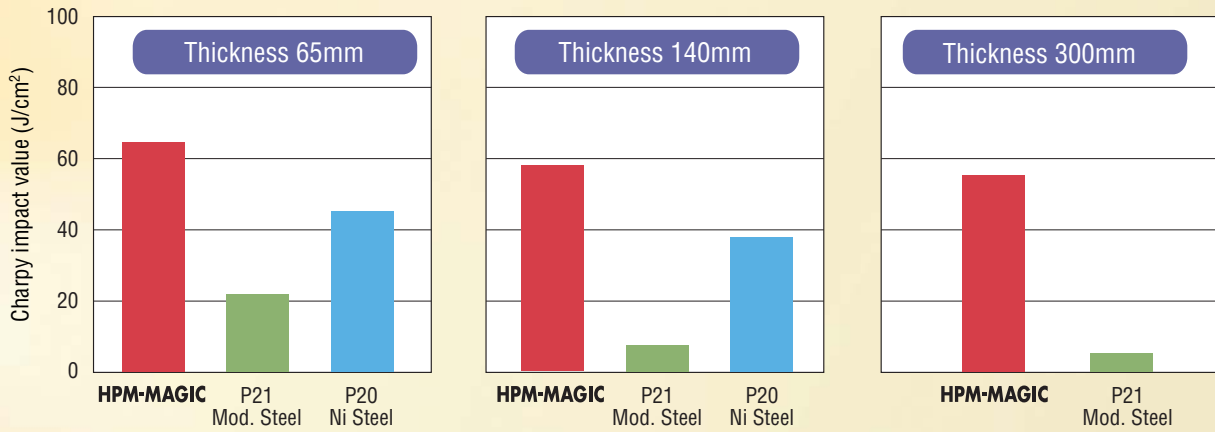
● Nitriding property (540°C × 5h gas nitrocarburizing process)

The mold steel for general purpose equips with characteristics needed for resin products forming molds.

Toughness

Properties in comparison with the conventional prehardened steel are that it is extremely tough, and gives little difference in material dimensions.

It is also suitable for big molds, and there are few worries about unexpected damage to the mold.

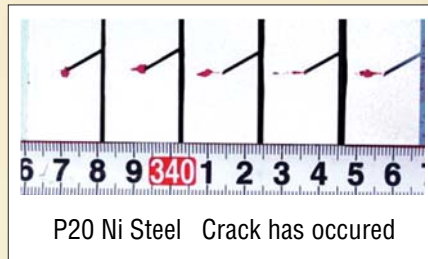


● Comparison of 2mmU notch Charpy impact values, classified by material dimensions (example of measurement by our company)

Weldability

The susceptibility of weld cracks is low. The hardness of welded part does not become high, and so welding application and post-processing are easy, and uniform finishing is allowed.

Susceptibility of weld cracks



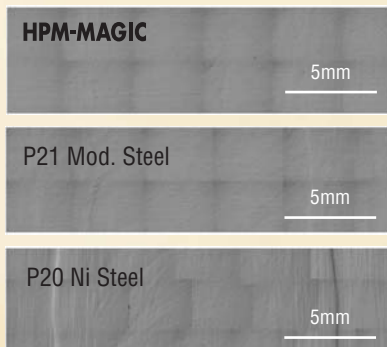
[Welding conditions]

- JIS-Z3158 Y-groove weld cracking test
- Welding Process : TIG welding
- Welding Rod : The welding rod for mold material
- Welding Current : Direct current 140A
- Ar Gas Flow Rate : 8 L/min
- Preheating : 180°C
- Post-Heating : None

● Penetrant indication after Y-groove weld cracking test

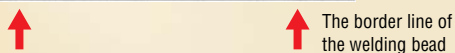
Polish characteristics after welding

Unevenness does not occur easily in the process of the mirror surface polishing and creeping after welding.



[Welding conditions]

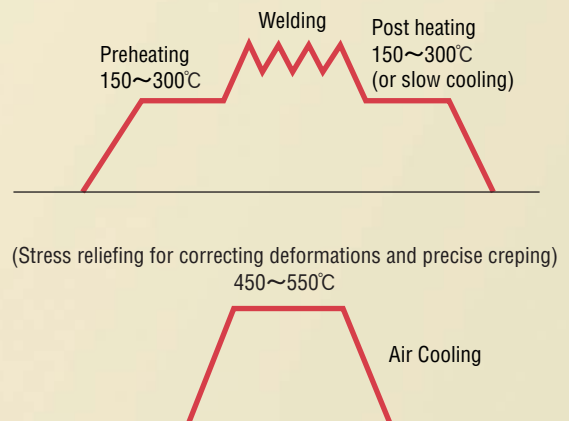
- Welding Process : TIG
- Welding Rod : The welding rod for mold material
- Welding Current : 80 to 120A
- Ar Gas Flow Rate : 10 L/min
- Preheating : 250°C
- Post Heating : 400°C



● Differential interference micrographs comparison of the polish surface after welding

Welding application line chart

Usage of HPM-MAGIC-W welding rod is recommended.



HPM-MAGIC™ allows application of high-speed high efficiency cutting.

Machinability

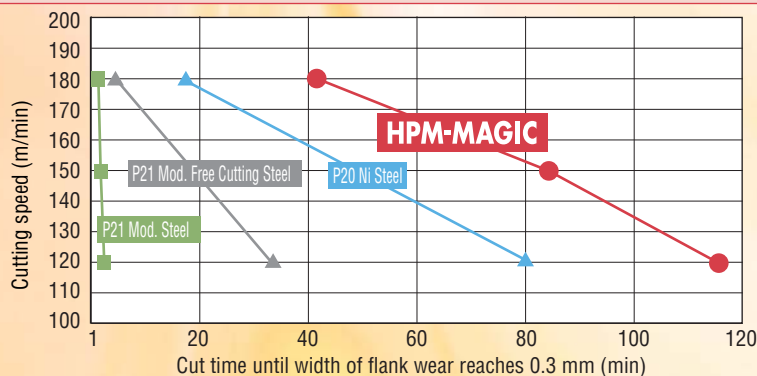
It has excellent machinability, especially under conditions with higher ejection volume of cutting chips (high efficiency), such as high feed processing.

Cutting Volume (cm ³ /min)	Example of processing method (Tool)	Steel Grade			
		HPM-MAGIC	P21 Mod.Steel	P21 Mod. 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

A (Excellent) ↔ D(Poor)

High feed radius mill

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



[Cutting conditions]

Cutting speed $V_c = 120, 150, 180$ m/min
 Feed per tooth $F_z = 1.0$ mm/tooth
 Cutting depth and width $a_p \times a_e = 0.7 \times 32$ mm
 Cutter = $\phi 63$ - 4 teeth (Hitachi Tool Engineering, TYPE ASR)
 Insert = CY250 (EDNW15T4TN-15)
 Overhang = 200 mm

● High feed radius mill V-T diagrams

End mill

Little damage on the tool at high-speed and at big load conditions is also a strong point.



[Cutting conditions]

- Processing model : Vertical type machining center (BT40)
- Tool used : CEPR6080TH ($\phi 8$ - 6 teeth square end mill)
- Cutting speed : 200 m/min
- Main axis revolution : 8,000 min⁻¹
- Feed per tooth : 0.05 /tooth
- Cutting depth : 12 (1.5D)
- Cut width : 0.8 (0.1D)
- Cutting fluid : Air blow
- Cutting time : 50 min

● Comparative example of tool damage in high load conditions of coating carbide end mill

Drill

Please pay attention to the ejection of cutting chips by choosing proper stepped drilling for longer tool life.

The strong point is that there is little wear in comparison with P20Ni steel



● Tool Wear Comparison

[Cutting conditions]

- Drill : $\phi 4.9$ powder high-speed steel + coating
- Hole depth : 25 mm
- Number of holes : 100 holes
- Cutting speed : 20 m/min
- Main axis revolution : 1,299 min⁻¹
- Feeding speed : 65 mm/min
- Feed per revolution : 0.05 mm/rev
- Step feed : 2.5 mm
- Coolant : water-soluble cutting fluid External oil supply

Reduction of working time in mold production is expectable.

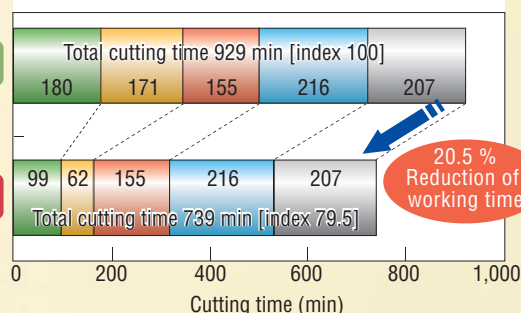
Example of trial calculation of working time in mold processing



Simulated mold
130 × 300 × 480 (mm)

P21 Mod. Steel

HPM-MAGIC



- 1st cut (High feed radius mill)
- 1st cut (Solid end mill)
- Finish processing (Square end mill)
- Finish processing (Ball end mill ≥ ø 6)
- Finish processing (Ball end mill < ø 6)

Examples for Application

Usage	Conventional applied steel	Good Evaluated properties	Mold external appearance
Molding tool for intake manifolds	P21 Mod. Steel (40HRC)	<ul style="list-style-type: none"> Good Machinability (20% work improvement) Electric Discharge Machining surface (4μm surface roughness) Weldability Ease of polishing (working time) 	
Molding tool for copying machine cases and trays	P21 Mod. Steel (40HRC)	<ul style="list-style-type: none"> Machinability Crepability Weldability 	
Molding tool for rear combi lamp lenses	P20 + Ni Steel (32HRC)	<ul style="list-style-type: none"> Mirror polishability (easy gloss reproduction) Mirror quality of product Machinability Weldability 	

Mechanical Properties

Steel Grade	Representative example of the tensile test results			
	0.2% Yield strength (N/mm ²)	Tensile strength (N/mm ²)	Elongation (%)	Reduction of area (%)
HPM-MAGIC	1,020	1,200	18	45

Physical Properties

	Steel Grade	20°C	100°C	200°C	300°C
Thermal conductivity (W/m • K)	HPM-MAGIC	31.4	34.1	37.7	40.2
	P21 Mod. Steel	28.5	32.6	36.4	38.7
	P20 Ni Steel	32.4	36.5	39.9	40.8
Thermal expansion coefficient* (×10 ⁻⁶ /°C)	HPM-MAGIC	—	11.5	12.3	12.9
	P21 Mod. Steel	—	12.5	12.8	13.2
	P20 Ni Steel	—	11.2	12.0	12.7
Young's modulus (GPa)	HPM-MAGIC	206	—	—	—
Density (g/cm ³)	HPM-MAGIC	7.85	—	—	—

*The average value from 30°C

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