

# Plastic Mold Steel

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|                              |                  |
|------------------------------|------------------|
| YONGJIN STECO CO.,LTD.       | : 82-31-363-2361 |
| Wonil Special Steel Co.,Ltd. | : 82-31-488-3952 |
| Kishin Corporation           | : 82-31-822-8711 |
| YOUNGDEUNGPO STEEL           | : 82-31-493-7900 |
| Hanlip Plastic Mould Steel   | : 82-31-433-4500 |
| DAEIL STEEL CO.,LTD.         | : 82-31-366-9105 |

### Plastic Mold Steel Series (based on forged products)

- TP series (VD material): TP1, TP4, TP4M, TP4MS, TP4MHH
- SMAT series (Specially refined material): SMAT E, SMAT F, SMAT V, SMAT G

### Production Range

- TP series (VD material): Thickness 200 ~ 1,100mm × width 200 ~ 1,900mm
- SMAT series (Specially refined material): Thickness 200 ~ 1,100mm × width 200 ~ 1,300mm (Max. 900,000mm<sup>2</sup> based on cross-section area)
- \* Products with sizes other than those listed above to be separately discussed

| Classification     | Steel grade | Chemical composition | Hardness (HRC) | Impact toughness (J/cm <sup>2</sup> ) | Tensile property |                  |            | Reduction of area |
|--------------------|-------------|----------------------|----------------|---------------------------------------|------------------|------------------|------------|-------------------|
|                    |             |                      |                |                                       | Yield strength   | Tensile strength | Elongation |                   |
| Pre-hardened steel | TP1         | S55C improved        | (HB)215        | 45                                    | 350              | 710              | 24         | 49                |
|                    | TP4         | P20 improved         | 25~32          | 40                                    | 730              | 900              | 15         | 50                |
|                    | TP4M        | P20+Ni improved      | 30~35          | 40                                    | 880              | 1040             | 20         | 56                |
|                    | TP4MS       | P20 improved         | 28~31          | 20                                    | 930              | 1050             | 15         | 37                |
|                    | TP4MHH      | P20+Ni improved      | 35~38          | 30                                    | 1030             | 1190             | 16         | 51                |
|                    | SMAT E      | P20+Ni improved      | 37~41          | 45                                    | 1050             | 1200             | 14         | 45                |
| Q/T steel          | SMAT F      | P21 improved         | 37~41          | 20                                    | 1060             | 1220             | 17         | 51                |
|                    | SMAT G      | STD61 improved       | 46~52          | 110                                   | 325              | 640              | 31         | 70                |
|                    | SMAT V      | STS420J2 improved    | 50~55          | 65                                    | 330              | 630              | 27         | 50                |

※ The data of impact toughness and tensile property of Q/T steel are based on SA heat treatment.

### Comparison of quality characteristics (Superior 5 - Good 3 - Poor 1)

| Classification     | Steel grade | Hardness (HRC) | Quality characteristics |               |                        |                      |             |                     |
|--------------------|-------------|----------------|-------------------------|---------------|------------------------|----------------------|-------------|---------------------|
|                    |             |                | Machinability           | Mirror-Finish | Photo-Etching property | Corrosion resistance | Weldability | Abrasion resistance |
| Pre-hardened steel | TP1         | (HB)215        | 5                       | 1             | 5                      | 1                    | 3           | 1                   |
|                    | TP4         | 25~32          | 4                       | 2             | 4                      | 2                    | 3           | 2                   |
|                    | TP4M        | 30~35          | 4                       | 3             | 4                      | 2                    | 3           | 3                   |
|                    | TP4MS       | 28~31          | 5                       | 3             | 3                      | 3                    | 5           | 3                   |
|                    | TP4MHH      | 35~38          | 4                       | 3             | 3                      | 3                    | 4           | 3                   |
|                    | SMAT E      | 37~41          | 3                       | 4             | 5                      | 3                    | 5           | 4                   |
| Q/T steel          | SMAT F      | 37~41          | 3                       | 4             | 4                      | 3                    | 5           | 4                   |
|                    | SMAT G      | 46~52          | 5                       | 5             | 3                      | 4                    | 3           | 5                   |
|                    | SMAT V      | 50~55          | 5                       | 5             | 3                      | 5                    | 3           | 5                   |

※ The above quality characteristic comparison is reference data obtained by carrying out qualitative comparisons based on the mold steel of SeAH.

## Free-Cutting Plastic Mold Steel

# TP4MS

### Characteristics

With the addition of 0.3 % sulfur, TP4MS steel has very superior machinability to TP4M, which is SNCM-based alloy mold steel, and is pre-hardened with a hardness of about HRC28~31. Free-cutting plastic mold steel TP4MS is characterized by the following:

- It has superior machinability to steel grade of other's brand.
- As its mechanical properties are uniform even in large products, it can be used for large/medium sized molds.
  - Thanks to the optimized alloy design and superior heat treatment technology, the mechanical properties and microstructure of the product's surface and the center part are uniform.
  - As it is supplied as pre-hardened steel, no separate heat treatment process is required.
- Weldability is superior and the increase in the hardness of the welds and Heat affected Zone is small.
- With little occurrence of pit or orange peel phenomenon, Mirror-Finish is good.
- Superior nitriding depth, etc., can be achieved with nitriding for same holding time as steel grade of other's brand.

### Application

As TP4MS steel has superior machinability and shows adequate Mirror-Finish, it can be used in diverse fields.

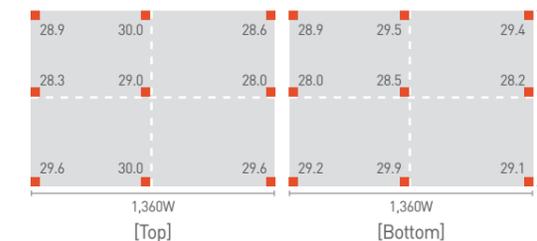
- Molds for automobile lamp lens, instrument panel and in-panel
- High quality large molds for TV Front Bezel, Rear Cover, etc.
- Molds for injection molded products with complex and exquisite shapes

Example)  
Injection molds for automobile lamps, interior/exterior decoration materials, TV Bezels, Cr/Al plated parts, refrigerator transparent containers, and other diverse products such as washing machines, air-conditioners, electric rice cookers and vacuum cleaners

### Basic properties

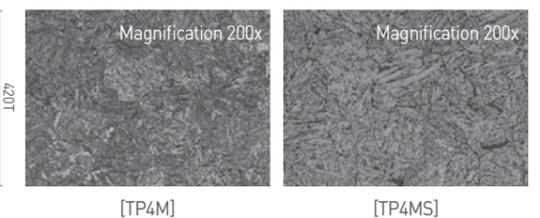
#### Hardness distribution

As a result of measuring the hardness at both sides of product 420 mm (T) × 1,360 mm (W), the hardness has been found to be between HRC 28.0 and 30.0 and the product has uniform mechanical properties showing a hardness deviation of not bigger than 3 points.



#### Microstructure

The microstructure of TP4MS comprises a uniform tempered martensite structure.



### Machinability

#### End-mill machining

Upon measuring the tool wear after end-mill machining TP4MS, it was found that, though superior to TP4M in the aspect of crater wear, its flank wear and corner wear are at the similar level to those of TP4M.

Machining conditions : Tool 100(4t) hard metal, dry type /ap 15mm, ae1mm, Cutting speed 80m/min, Spindle rotation speed 2550min<sup>-1</sup>

Feed rate : 820mm/min

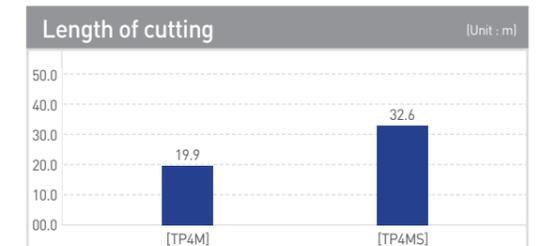


#### Gun drilling

The gun drilling properties of TP4MS were found to be very superior to those of TP4M as TP4MS was able to drill more than 32.6 m, while the maximum drilling length of TP4M was 19.9 m.

Drilling conditions : Tool 100 hard metal, wet type /depth of cut 510mm, Cutting speed 60.3m/min, Spindle rotation speed 1920min<sup>-1</sup>

Feed rate : 38mm/min





# High Hardness Plastic Mold Steel TP4MHH

## Characteristics

TP4MHH is a mold steel with high hardness between HRC35 and 38 produced by adjusting the amount of hardenability element compared to that of TP4M, an SNCM-based alloy mold steel.

High glossy plastic mold steel TP4MHH is characterized by the followings:

- Pre-hardened steel with hardness between HRC35 and 38 which allows easy production of molds
  - The mechanical properties on the surface and at the center are uniform due to optimized alloy design and superior heat treatment technology.
  - As a pre-hardened steel, no separate heat treatment process is required.
- Suitable for molding of high gloss and high precision plastic injection mold
  - Superior Mirror-Finish to TP4M steel
- Mold production costs saved thanks to superior machinability.
  - Machinability is superior as the mechanical properties of the surface and the center are uniform.
- As its Photo-Etching properties are superior, it can be used for mold with hairline etching.

## Application

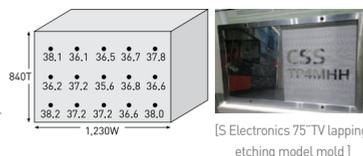
TP4MHH can be used in diverse fields, such as for high glossy and precision plastic injection mold.

- Molds required to have superior Mirror-Finish to that of the TP4M steel
- High-quality large sized molds for TV Rear Cover, etc.
- Molds which will have uniform etching, such as hairline etching, applied to the large cross section
- Molds for injection molded products having a complex and exquisite shape
  - Example) Injection molds for interior/exterior decoration materials, TV Bezel, Cr/Al plated parts, refrigerator transparent containers, and other diverse products such as washing machines, air-conditioners, electric rice cookers and vacuum cleaners

## Basic properties

### Hardness distribution

After cutting a product of 840 mm [T] x 1,230 mm [W] into two equal pieces, the hardness of the cut surface was measured. It was found to be between HRC 35.6 and 38.1 and the product had uniform mechanical properties showing a hardness deviation within 3 points.



## Machinability

### Gun drilling

As the hardness of TP4MHH is high, if spindle rotation speed and feed rate are too high, early tool breakage may occur. The optimum drilling conditions are a spindle rotation speed of 1,440 rpm and a feed rate of 28mm/min.

Machining condition: Length of cut [53D], Wet type and open hole  
Tool diameter: Ø10, Optimum machining condition to be derived  
Specimen size: 460\*150\*530

| Spindle speed (rpm) | Feed rate (mm/min) | Number of holes machined | Length of cut (mm) |
|---------------------|--------------------|--------------------------|--------------------|
| 1,920               | 38                 | 5                        | 2,650              |
| 1,440               | 32                 | 10                       | 5,300              |
| 1,440               | 28                 | 28                       | 14,840             |

### End mill

The tool wear was measured after carrying out 3 passes in the following machining conditions using tools of diverse materials and diameters:

Specimen size: 70T x 120W x 190L, Tool wear was measured after 3 machining passes.  
Wet machining, Tool manufacturer: Taegu Tec [WC]

| Material | Tool Diameter (mm) | Machining condition    |                    |                 | Tool wear (µm) |
|----------|--------------------|------------------------|--------------------|-----------------|----------------|
|          |                    | Spindle speed (mm/min) | Feed rate (mm/min) | Amount cut (mm) |                |
| HSS      | Ø16                | 280                    | 45                 | 8               | 0.68           |
|          | Ø5                 | 3,020                  | 190                | 2.5             | 0.05           |
| WC       | Ø16                | 1,090                  | 110                | 8               | 0.13           |

### Drilling

After drilling the samples under the following drilling conditions using tools of diverse materials and diameters until breakage, the number of holes drilled and the tool wear were measured.

Specimen size: 70T x 120W x 190L, The number of holes drilled and the tool wear were measured after drilling until the tool broke.

Wet drilling, Tool manufacturers: YG1 [HSS], Taegu Tec [WC]

| Material | Tool Diameter (mm) | Machining condition    |                    |                   | Tool wear (µm) | No. of holes machined |
|----------|--------------------|------------------------|--------------------|-------------------|----------------|-----------------------|
|          |                    | Spindle speed (mm/min) | Feed rate (mm/min) | Depth of cut (mm) |                |                       |
| HSS      | Ø3                 | 1,880                  | 94                 | 7D                | Broken/181     |                       |
|          | Ø7                 | 730                    | 94.9               | 7D                | Broken/27      |                       |
| WC       | Ø3                 | 6,000                  | 780                | 6D                | 0.09/851       |                       |
|          | Ø16                | 4,800                  | 912                | 6D                | 0.05/322       |                       |



# High Gloss Precision Plastic Mold Steel SMAT E

[SeAH's Mold by Advanced Technologies Excellent]

## Characteristics

SMAT E is precision plastic mold steel with hardness of HRC40 and the following characteristics:

- Superior Mirror-Finish
  - Non-metallic inclusion is minimized through a special refining process.
  - Occurrence of pit type defects during injection molding process after lapping is minimized.
- Excellent machinability
  - The mechanical properties and microstructure of the product surface and center are uniform due to superior heat treatment technologies.
  - Uniform machinability is secured through optimization of the chemical composition and control of the microstructure.
- Good weldability
  - Diverse SNCM-based welding rods can be used and weld lines after welding and lapping are minimized.
  - Welding workability such as welding bead geometry, wettability and so on is good.
- Good electric discharge machining property
  - When a Cu/graphite electrode is used, the machining time and the quality of the machined surface are good.
- Superior nitriding property
  - The thickness of the nitrified layer can be easily controlled as required by the customer.

## Application

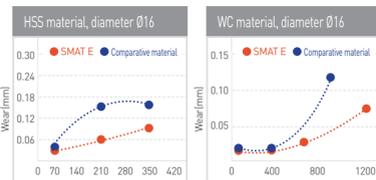
SMAT E can be used in diverse fields, such as for molds for high-gloss precision injection-molded products.

- Molds with superior surface quality such as Mirror-Finish, Photo-Etching and electric discharge machining
- Molds for transparent lenses
- Molds for injection molded products having a complex and exquisite shape
  - Example) Injection molds for high-gloss products such as automobile lamp lenses, TV front bezels, cosmetics cases, faucet fittings, high gloss home appliances, washing machines, air-conditioners, electric rice cookers and vacuum cleaners

## Machinability

### End mill machining

The tool wear was measured after carrying out machining of a same volume in the same machining conditions as those of a comparative product, and the tool wear was found to be smaller and the quality of the machined surface to be better than the comparative product.



Criteria for tool service life: HSS 0.3 mm, WC 0.15 mm  
Machining conditions: conditions recommended by the tool manufacturer

### Gun drilling

After measuring the maximum number of holes that are drilled until the tool broke under the same conditions, a more number of holes were drilled than the comparative product. The gun drill machinability of SMAT E is particularly excellent in the diameter under Ø10, which are the most widely used for drilling coolant holes when manufacturing molds.

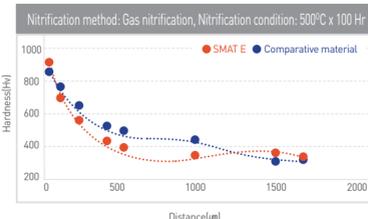
Recommended drilling condition: 10Ø 1200rpm Feed 25-35mm/min, 8Ø 1400rpm, 27-35mm/min

| Classification | Material            | Tool diameter (mm) |     |     |     |
|----------------|---------------------|--------------------|-----|-----|-----|
|                |                     | Ø30                | Ø18 | Ø10 | Ø5  |
| HSS            | SMAT E              | 0                  | 12  | 16  | 75  |
|                | Comparative product | 0                  | 3   | 47  | 18  |
| WC             | SMAT E              | 580                | 492 | 385 | 133 |
|                | Comparative product | 510                | 510 | 283 | 150 |

Drilling condition: Length of cut (30D), Wet type and open hole / Measurement of the maximum number of holes drilled until the tool broke

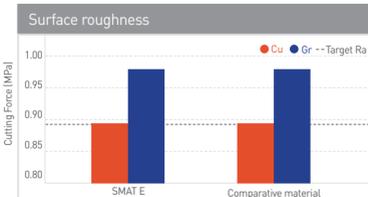
## Nitriding property

Measuring the hardness on the surface after carrying out nitriding in the conditions same as those of the comparative product, surface hardness of Hv850 or higher was secured and the nitriding depth is good, showing a value of 200 µm or deeper.



## Electric discharge machining

SMAT E has a good electric discharge machining property. After carrying out electric discharge machining in the following conditions, the electric discharge machining property was shown to be same as that of the comparative product and, as white layer was thin, the next process lapping is easy.

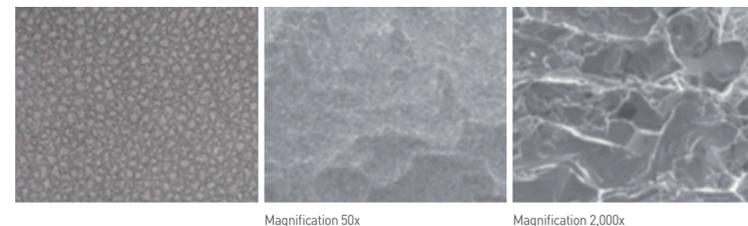


Equipment used: AGIETRON EXACT3, Electric discharge oil: K-501, Electrode: Cu (Copper), Gr (Graphite), Target Ra: 0.09µm

## Photo-Etching

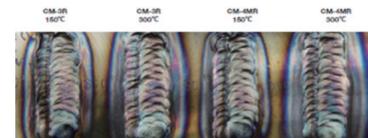
SMAT E is produced by Special refining process, like Electro Slag Remelting, so micro segregation is minimized and microstructure is uniform and dense. And an uniform Photo-Etching surface can be obtained.

Used for molds for automobile interior parts of Company K / Target etching depth: 140 µm



## Welding property

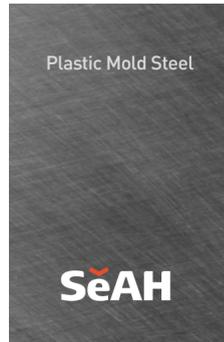
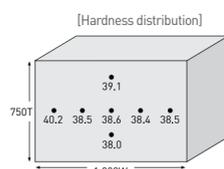
The arc stability, wettability and bead appearance are good during welding and, after carrying out heat treatment at a temperature between 500 and 550°C, the hardness of the welds and heat affected zone becomes similar to that of the parent material.



[Appearance and geometry of beads after welding]

## Mechanical properties

After measuring the hardness on the cut surface of a product of 750 mm [T] x 1000 mm [W] after cutting it in lengthwise, the hardness was about HRC 38 to 40.2 and, with the superior forging and heat treatment technologies of SeAH CSS, the product was found to have a uniform mechanical properties showing a hardness deviation between the surface and the center part within about 3 points.



# High Corrosion-resistant Precision Plastic Mold Steel SMAT V

[SeAH's Mold by Advanced Technologies Victory]

## Characteristics

SMAT V steel is a premium stainless steel and is characterized by the following:

- Superior corrosion resistance
  - It is modified by STS420J2 and alloy elements like Ni, Cr, N, which have strong corrosion resistance, have been optimized.
  - Corrosion by Chlorine in the coolant hole and Corrosion caused by H<sub>2</sub>O in the air during long-term storage are minimized.
- Mirror-Finish of #12,000 or higher is secured.
  - Non-metallic inclusion is minimized by specially refining process.
  - When it is QT heat treated, the hardness more than HRC 50 can be secured.
- Superior wear resistance
  - Due to high hardness and the formation of fine carbides, resins with high glass fiber content can be used.
- Good machinability
  - Due to full annealing heat treatment, the machinability is good.
  - Dimensional stability is secured through QT heat treatment.

## Application

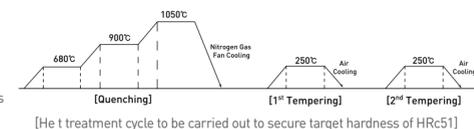
SMAT V can be used in diverse fields, particularly plastic injection molds in the following special conditions:

- In severe corrosive environments
  - Used for resins that generates strongly corrosive gas during the injection process.
- Wear resistance
  - Injection molding of thermosetting resin and the resin to which a high content of glass fiber is added.
- Mirror-Finish
  - Production of optical appliances such as transparent lens, glass, etc. and parts of medical instruments

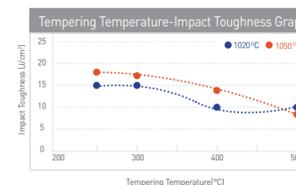
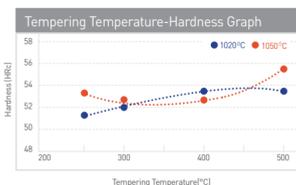
## Quenching and tempering

### Heat treatment cycle

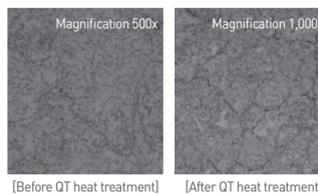
For quenching, the material shall be put into the furnace and heated up to a temperature between 550°C and 900°C in one step or two steps, and then a final temperature between 1020 and 1050°C shall be maintained for 30 minutes/in. It is cooled down through pressure nitrogen cooling. Double Tempering after cooling between 250°C and 500°C for 60minutes/in. should be carried out immediately, accordingly, depending on the hardness requirements. For example, if target hardness of HRC51 is desired, the following heat treatment cycle is suitable:



### Tempering Temperature-Hardness/Impact Toughness Graph



### Microstructure resulting from the tempering temperature



## Cleanliness

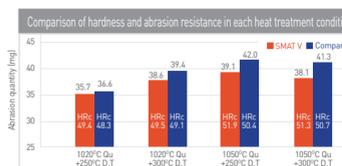
The cleanliness of SMAT V is equivalent to or better than that of steel grade of other's brand and, as the size of the non-metal inclusion is tiny, it is advantageous in lapping.

| Classification             | SMAT V                  |   |     | Company A                                |   |     | Company B                           |    |     |
|----------------------------|-------------------------|---|-----|--|---|-----|-------------------------------------|----|-----|
|                            | Globular Oxide Thin 1.0 |   |     | Alumina Thin 0.5 Globular Oxide Thin 1.0 |   |     | Globular Oxide Thin 1.5 / Heavy 0.5 |    |     |
| Cleanliness                | N                       | O | H   | N  | O | H   | N                                   | O  | H   |
|                            | 324                     | 9 | 1.0 | 154                                      | 6 | 1.1 | 123                                 | 34 | 1.8 |
|                            | Inclusion size 3~7µm    |   |     | 3~11µm                                   |   |     | 3~22µm                              |    |     |
| Photo (Magnification 200x) |                         |   |     |  |   |     |                                     |    |     |

## Wear resistance

Test equipment and test conditions

- OGOSHI Type abrasion tester
- material quality: Hard metal [WC], Hardness HRC 77, Diameter [30 mm], Thickness [3.2 mm]
- Rotating speed: 1.58 m/sec
- Abrasion distance: 200 m



When lapping a surface that has gone through electric discharge machining, generation of pits can be reduced by sufficiently removing, in the primary process, the case white layer generated during the electric discharge machining process.