Precision Plastic Mold Steel
with Ultra Mirror-finish

SMAT E

TP4MHH

High-quality Plastic Injection
Mold Steel

SeAH Changwon Integrated Special Steel

A NEW CHAPTER TO THE FUTURE

Changwon Plant, the base camp for SeAH CSS to be a leader in global steel manufacturing

SeAH CSS is a leading South Korean special steel manufacturer. It produces cutting-edge materials for use by such industries as construction, consumer electronics, power generation, machinery, and shipbuilding. Its Changwon Plant, which occupies an area of 641,000 square meters, boasts an annualized output of 1.2 million tons of steelmaking. It is also the only company in South Korea that produces stainless steel round bars and wire rods through an integrated production system for high-grade special steel.
The company leads South Korea's steel market in a number of product categories, including stainless steel, tool steels, and special alloys. In particular, as the nation's only steel industry player to have a fully-integrated production system for seamless pipes, it recently began operating a plant specializing in the manufacture of large-diameter products.

History

1966
Founded as Samyang Special Steel Co., Ltd.

1975
Changed its name to Korea General Special Steel Co., Ltd

1976
Opened its Central Research Lab

1977
Opened a special steel production plant in Changwon
(for round bars, pipes and plates)

1980
Recognized for its annual export of USD 100 Mil

1982
Changed its name to SAMMI General Special Steel Co., Ltd

1991
Opened its second special steel plant
(for steelmaking, rolling and processing)

1997
Annexed to POSCO group
(for round bars and pipe business)

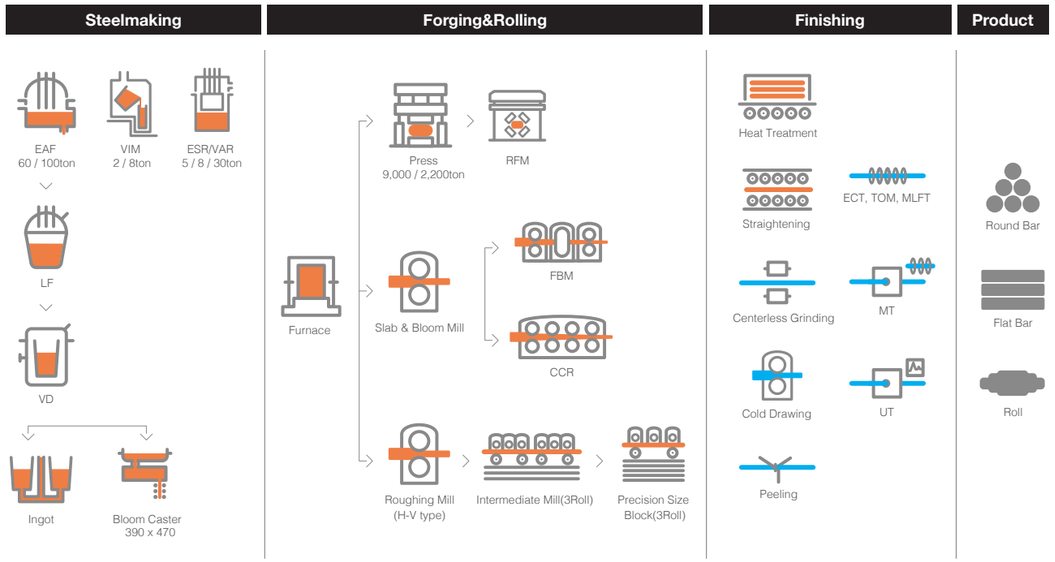
2006
Completed the 1st phase of its facility rationalization
(AOD, HV Mill, Second acid cleaning plant and more)

2007
Changed its name to POSCO Specialty Steel Co., Ltd

2012
Completed the 2nd phase of its facility rationalization
(60ton EAF, Bloom Caster, SBM and more)

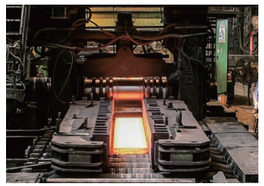
2015
Acquired by SeAH Group and changed its name to SeAH Changwon Integrated Special Steel Co., Ltd

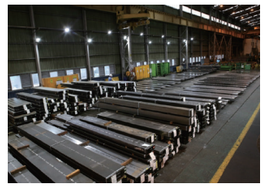
Manufacturing Process




Steelmaking


Forging


Rolling


Product

SeAH's Mold steel by
Advanced Technologies

SMAT E

Precision Plastic Mold Steel
with Ultra Mirror-finish

SMAT E

Precision plastic mold steel with ultra mirror-finish

HRC 40 pre-hardened steel, good for mold manufacturing

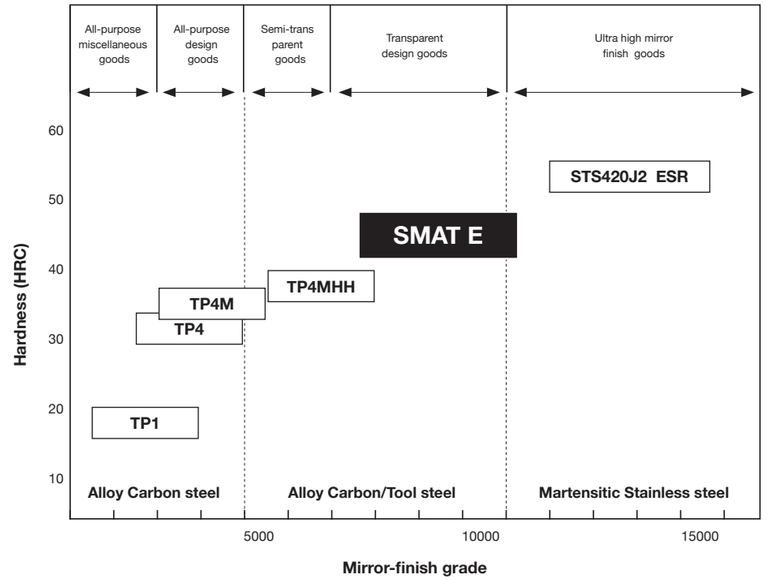
Well-suited for producing high mirror-polish/high precision plastic injection products

Low cost of mold manufacturing due to good machinability

Excellent for etching, electrical discharge machining and welding

Overview

SMAT E, mold steel for plastic injection molding, is electro slag remelting to minimize nonmetallic inclusions, ensure HRC 40 hardness, and feature excellent polishability.
Optimal design of alloy and advanced heat treatment techniques give uniform physical properties along the surface and center of the material. Also, as SMAT E is already QT heat treated in our factory, it can be used directly without any heat treatments.



Application

- With high mirror-finish, high-quality surfaces, suitable for texturing and photo-etching
- Transparent lens
- Injection mold with sophisticated cavity
- Having elegant surfaces like Cr plating
  ex) automobile lamps, TV bezels, transparent containers for refrigerators, cosmetic bottles, faucets, high-gloss consumer electronics goods(washing machines, air conditioners, rice cookers, vacuum cleaners)

Actual Performance Example

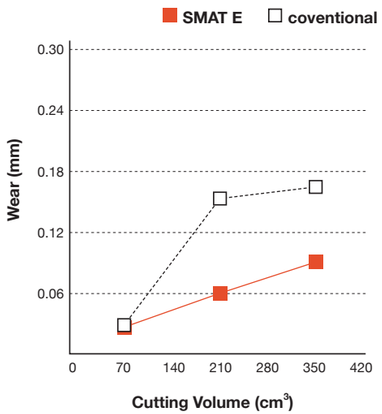
Application	Actual performance
Auto parts	SMAT E has an excellent machinability with less tool wear and good machined surface. And the production cost is decreased in machining a lot of volume per unit time because it can be machined at high cutting velocity. It can be applicable for auto parts required high mirror-finish due to less nonmetallic inclusions, easily lapping.
TV parts	Less tool wear during precise rib machining and better surface obtained. In particular, it has superior gun drill machinability to other materials imported. SMAT E has excellent polishability with a high gross surface, so it is appropriate as a material for ultra mirror-finish TV front bezels.
Faucets	SMAT E has excellent machinability for end mill/drill, and very high quality of mirror finish, over #8,000. When plated with chromium, the plated surface is uniformly polished with a high-quality finish.

Machinability

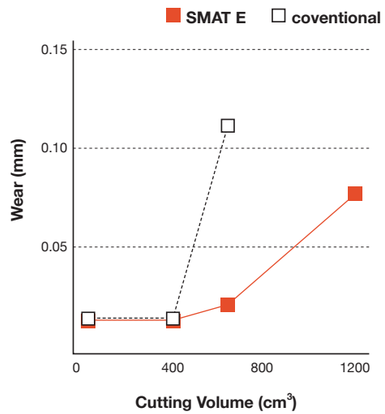
End mill

When machining SMAT E and conventional steel, for a given volume under the same conditions, the depth of tool wear in SMAT E was much lower. And the surface quality in SMAT E after machining was much superior to conventional steels.

HSS drill, Tool diameter 16Φ



WC drill, Tool diameter 16Φ



Tool life : HSS 0.3mm, WC 0.15mm / Machining condition : recommended by the tool manufacturer

Drill machining

The table below shows how many holes were machined by tools with HSS/WC materials and several diameters up to tool life. SMAT E was machined more holes than conventional steel.

(Unit : No. of holes)

Type		Max No. of Holes				
Tool Material	Grade	1Φ	3Φ	5Φ	7Φ	10Φ
HSS	SMAT E	0	12	16	75	174
	coventional	0	3	47	18	116
WC	SMAT E	580	492	385	133	90
	coventional	510	510	283	150	81

Tool life: HSS 0.3mm, WC 0.15mm
Unit: Number of holes that can be machined up to tool life

Machinability

Gun drill

Like drill, the table below shows how many holes were machined by tools with HSS/WC materials and several diameters up to tool life. It shows that SMAT E has an excellent gun drill machinability for making holes 10Φ and smaller, using for coolant holes.

Machining condition : Wet penetration work

(Unit : rpm, mm/min)

Φ30		Φ18		Φ10		Φ5	
Spindle Speed RPM	Feed Rate mm/min	Spindle Speed RPM	Feed Rate mm/min	Spindle Speed RPM	Feed Rate mm/min	Spindle Speed RPM	Feed Rate mm/min
389	30	800	40	1,400	50	3,000	40

Unit : Number of holes machined until tool life

Type	Max No. of Holes			
	Φ30	Φ18	Φ10	Φ5
SMAT E	9	6	6	27
coventional	0	1	1	1

Lapping

Balancing → **Dressing** → **Compound** → **Finish**

Balancing	Dressing	Compound	Finish
Oil stone #600 #1,200 #1,500 - #2,000	Sand paper #1,500 Black stone #2,000	Diamond paste #3,000 #8,000 #12,000	#10,000 #12,000

Surface reflection, post-polishing process

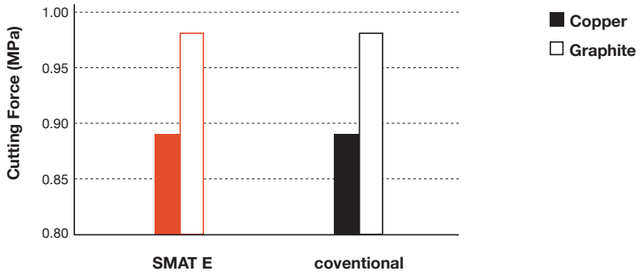
SMAT E has the level of mirror finish #8,000~ #12,000. No defects like pit and orange peel can be found, after lapping #12,000.

※ You should completely remove the remelted layer during lapping. If not, any defects like pit and orange peel can occur.

Electrical Discharge Machining

SMAT E is easy to EDM due to uniform microstructure, good cleanliness.
At the same conditions, the surface roughness of SMAT E is similar to conventional steel's.
It is highly easy to lap, because the remelted layer(white layer) is much thinner.
* EDM : Electrical Discharge Machining

Surface roughness



Tool name : AGIETRON EXACT3 / Liquid dielectric : K-501 / Electrode : Copper, Graphite
Target Ra : 0.8㎛

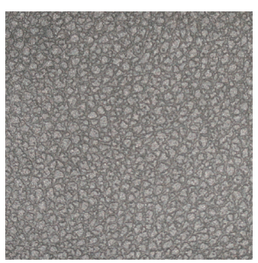
Machining condition

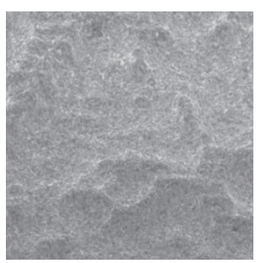
	Copper				Graphite			
	STEP1	STEP2	STEP3	STEP4	STEP1	STEP2	STEP3	STEP4
T [μs]	37	27	24	21	27	21	15	12
P [μs]	21	15	13	18	10	12	8.7	5.6
I [μs]	4.4	3.2	2.4	1.8	4.4	3.2	2.4	1.8
U [μs]	180	180	180	180	100	100	100	100
Ra	2.51	1.78	1.26	0.89	2	1.41	1.12	0.89
Vw [mm^3/min]	7.0	3.0	1.0	0.5	6.5	2.5	1.0	0.5

Photo-etching

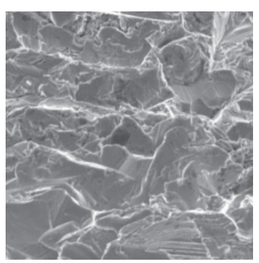
SMAT E has excellent photo-etching property. Especially, you can get an uniform surface quality without any defects after photo-etching. The reason is due to reduction in non-metallic inclusions and segregation by ESR process.

Used for car's In-pannel for brand H / Target etching depth : 140㎛





Magnified by 50X



Magnified by 2,000X

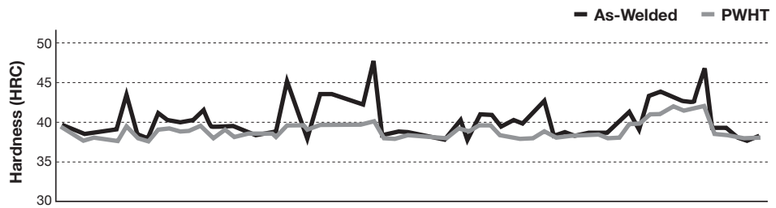
Welding

Weldability

SMAT E has good arc-stability, the flow of molten pool, high wettability, and the shape of weld beads. And the hardness distributions after PWHT at 530~550°C are lowered to raw material's.

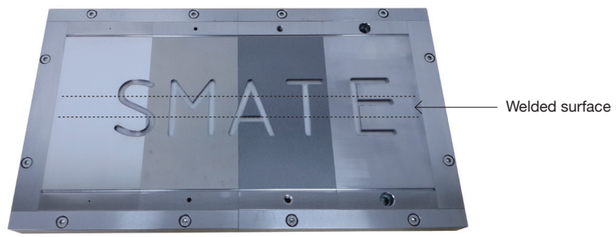
Used machine : Lorch V30
Welding methodology : GTA overlay welding
Welding rod materials : NICHIA(日) CM-3R, CM-4MR
Pre-heated to : 150°C, 300°C

Hardness along the surface after PWHT



Lapping, photo-etching, EDM and machining after welding

No defects such as weld lines or air bubbles were found when Lapping, photo-etching, EDM and machining after welding.



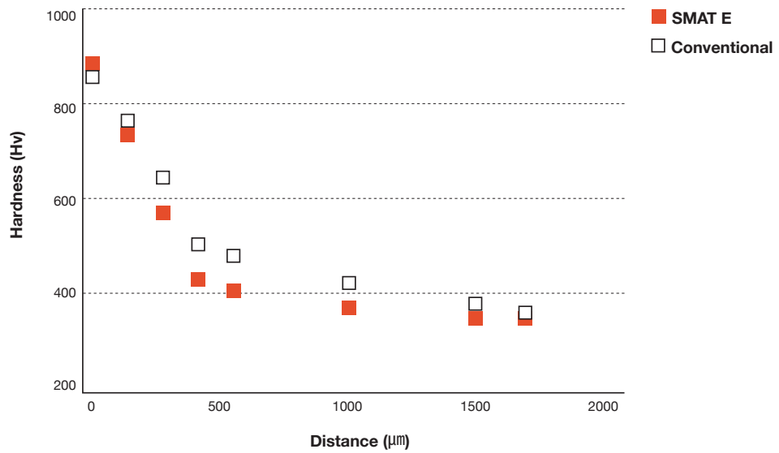
Lapping Photo-etching EDM Machinging

Nitriding

Hardness distributions

After nitriding at the same conditions, a hardness was measured from surface to center. The hardness of the nitrified surface was over Hv 850 and the nitrified depth was more than 200㎛.

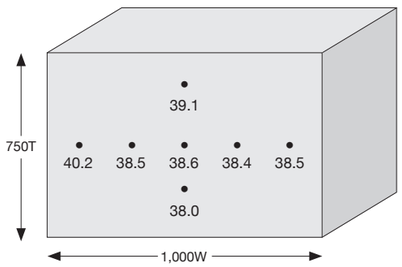
Methodology : Gas nitriding / Nitriding condition : 500°C×10Hr



Physical Properties

SMAT E shows almost uniform hardness distribution even in the large cross-section material 750Tx1,000W. The hardness is HRC 38~40.2, less than HRC 3 point between surface and core owing to advanced technologies in forge and heat treatments.

Hardness



Mechanical Properties

Hardness (HRC)	Impact toughness (J/cm^2)	Tensile properties			
		Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Reduction of Area (%)
40	53	1,000~2,000	1,100~1,300	14	45

Tool for Plastics

TP4MHH

High-quality Plastic Injection Mold Steel

TP4MHH

SeAH CSS's high-hardness steel for plastic injection molds

HRC 35-38
pre-hardened steel,
good for an injection
mold

Well-suited for
producing high mirror-
finish/high precision
plastic injection
products

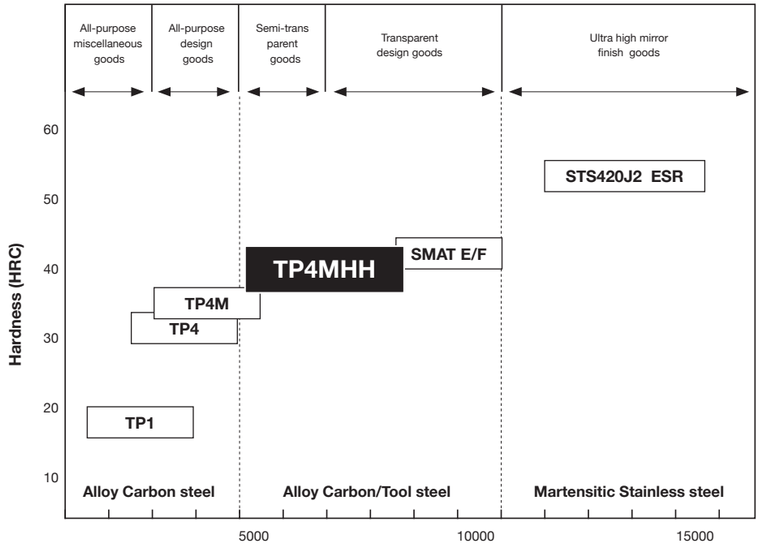
Lower a production
cost due to good
machinability

Excellent for
photo-etching
like hairline etching

Overview

TP4MHH has higher hardness, HRC 35~38, than TP4M's. The level of hardness and mirror-finish is between TP4M and SMAT Series. As a result of alloy design and the technique of heat treatment, it has uniform hardness and microstructure in large sectional dimension. It can be used directly without any hear treatments. Because it is supplied as pre-hardened steel with QT heat treatment.

Steel grade for mold



Application

- Mold steel demanding higher polishability than TP4M
- Mold steel with hairline etching such as TV back covers
- Automobile headlamps / tail lamp molding
- Mold steels for injection products with sophisticated and elaborate designs
- High-quality mold steel such as automobile bumpers

Chemical Composition

Grade	C	Si	Mn	Ni	Cr	Mo	Special Elements
TP4M	0.28	0.25	0.85	0.50	1.70	0.40	Added
TP4MHH	0.28	0.25	1.20	0.50	1.90	0.40	Added

With an increased amount of hardenability elements, like Mn and Cr and special alloy elements, TP4MHH has uniform physical properties and microstructure even over 800T thickness.

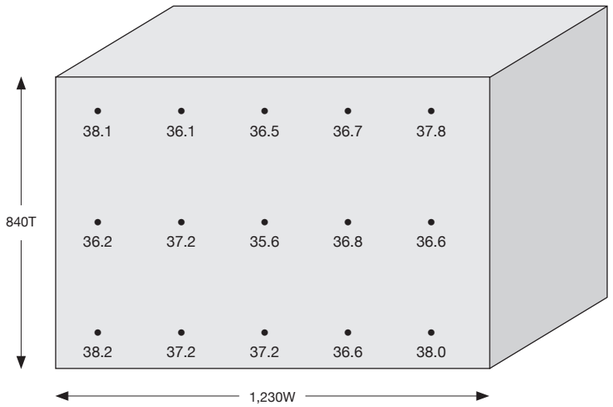
Mechanical Properties

Properties

Hardness (HRC)	Impact toughness (J/㎠)	Tensile properties			
		Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Reduction of Area (%)
37.4	30	900~1,100	1,100~1,300	>12	>30

Hardness distribution

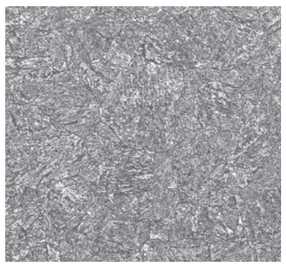
TP4MHH shows almost uniform hardness distribution even in the large cross-section material 840T×1,230W. The hardness is HRC 35.6-38.1, and the deviation from surface to core is less than HRC 3 due to forge and heat treatment technologies.



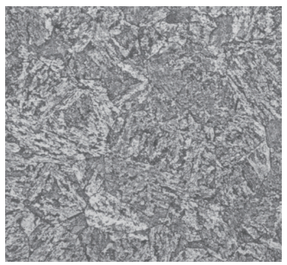
Microstructure

Microstructure of surface and core has uniform tempered martensite. However, heating and colling rate is slower in the center than in the surface so the tempered martensite lath is relatively coarse.

Surface



Core



(Magnified by 200x)

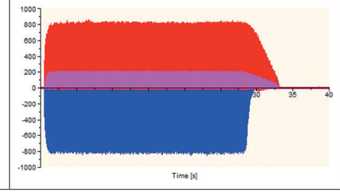
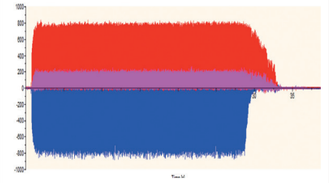
Machinability

Cutting force (in end milling)

TP4MHH has similar cutting force to TP4, SCM-type mold steel. And it has stable cutting force graph due to uniform microstructure and mechanical properties.

Cutting condition : RPM 1,320 / Depth of cut : 2mm / Feed rate : 0.7m/min / Cutting direction : Y-axis
Tool diameter : Φ15Φ / Tool material : WC (brand YG1)

(Unit : N)

Grade	TP4MHH			TP4		
Axis	X	Y	Z	X	Y	Z
Max Cutting Force	210	864	227	294	840	269
Cutting Pattern						

Despite of being harder HRC 5~8 point than TP4, maximum cutting force of Y direction of TP4MHH is similar to that of TP4.

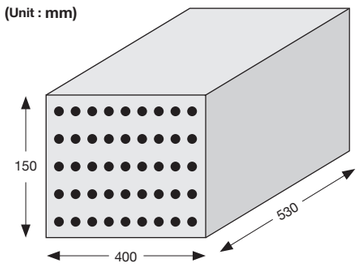
Gun drilling

When spindle speed and feed rates are high, initially the tool may fracture due to TP4MHH's enhanced hardness. The optimal operating condition is 1,440rpm, with a feed rate of 28mm/min and maximum holes machined are 28.

Drilling depth(53D) / Wet penetration work / Tool diameter : Φ10Φ
Optimum drilling condition found / Specimen size : 400x150x530

Specimen

(Unit : mm)



The results of operating conditions

Spindle Speed RPM	Feed Rate mm/min	No. of Holes	Distance machined mm
1,920	38	5	2,650
1,440	32	10	5,300
1,440	28	28	14,840

Machinability

End milling

Tool wear was measured by using various materials and diameters after machining 3-pass under the following condition. TP4MHH shows good end mill machinability.

Specimen size : 70T×120W×190L / measured tool wear after 3-pass machining
Wet condition / Tool Maker : OSG(HSS), TaeguTec(WC)

Tool		Operating Conditions			Tool Wear (μm)
Material	Diameter (mm)	Spindle Speed (mm/min)	Feed Rate (mm/min)	Depth of Cut (mm)	
HSS	Φ 16	280	45	8	0.68
WC	Φ 5	3,020	190	2.5	0.05
	Φ 16	1,090	110	8	0.13

Drilling

The table below shows how many holes were machined by tools with HSS/WC materials and several diameters until a tool breaks up. Drillability of TP4MHH with HSS was weaker but had equal or above level with WC materials.

Specimen size : 70T×120W×190L / Wet condition / Tool maker : YG1(HSS), TaeguTec(WC)
Number of holes machined before tool fracture or The depth of tool wear measured

Tool		Machining Conditions			Tool wear(μm) / No. of Holes
Material	Diameter (mm)	Spindle Speed (mm/min)	Feed Rate (mm/min)	Drilling Depth (mm)	
HSS	Φ 3	1,880	94	7D	Broken / 181
	Φ 7	730	94.9	7D	Broken / 27
WC	Φ 3	6,000	780	6D	0.09 / 851
	Φ 16	4,800	912	6D	0.05 / 322

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