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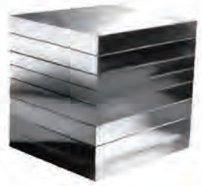
2023 Edition

HIGH-END DIE MATERIAL

中国钢研 安泰科技 HSS 河冶科技股份有限公司 HEYE SPECIAL STEEL CO.,LTD.

MANUFACTURING COST-EFFECTIVE PRODUCTS
AND PUSH THE INDUSTRIAL TECHNOLOGY FORWARDS

HDM



Material Series

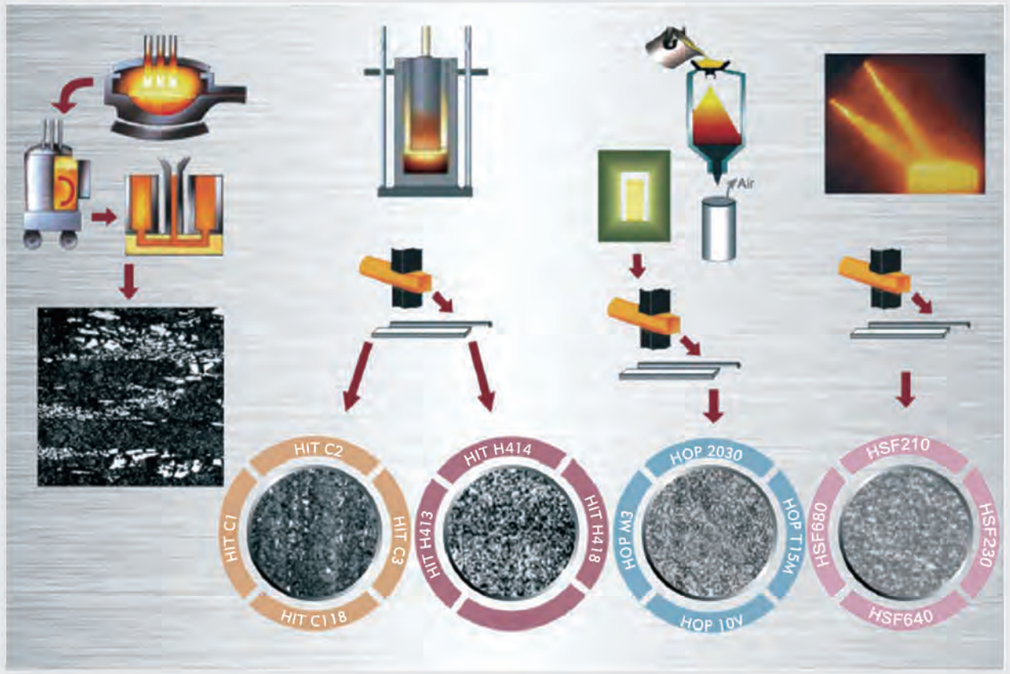
Type	Grade	Similar Grade				Chemical Composition (Wt%)							A.T.	T.T./Hardness HRC					Application
		DIN	JIS	ASTM	ISO	C	Si	Mn	Cr	Mo	V	Others		200	300	400	500	600	
Hot-work Die Material	HITH13	1.2344	SKD61	H13	X40Cr MoV5-1	0.38	1.00	0.40	5.20	1.40	0.90		1025	53	52	52	53	42	General hot work die, intermediate roll, plastic, extrusion, die casting, hot forging die, high polishing plastic die
	HITH418					0.35	0.30	0.50	5.00	2.10	0.65		1025	53	52	52	53	48	Magnesium/aluminum alloy die casting die, extrusion die, precision forging die
Cold- work Die Material	HYC1		DC53			0.95	1.00	0.40	7.80	1.95	0.40		1030	61	59	59	61	45	Punching rod, punching needle, punching die, punch, rolling wheel, etc
	HYC2					0.75	1.00	0.40	7.00	2.00	1.85		1100 -1130	530-550℃×3 57-62HRC					Blanking die, high strength plate die, powder compaction, cold forming, medium life complex forming
	HYC3					1.03	1.00	0.40	7.80	1.60	2.40	0.50Nb 1.00W	1100 -1130	530-550℃×3 60-64HRC					Powder compacting, cold-forming die, trimming die, roll, screw
	HYD2	1.2379				1.55	0.35	0.50	12.00	0.85	0.80		1080	53	52	52	53	42	Blanking die, cold-forming die, cold-drawing die, punch
	HYRD2Co					1.47	0.30	0.40	12.00	0.90	0.85	0.4Co	1025	60	59	59	60	45	Roll, cold forming, blanking, cutting roller, powder compacting, fine blanking, drawing die, wear-resistant parts
	HITC118					0.76	0.40	0.50	5.00	2.30	0.60		1025	62	61	60	61	51	Cold forming die, screw, mint impression working die, thick plate blanking, complex shape drawing die
	HITC1MOD					0.95	1.00	0.50	7.80	2.50	0.50		1030	63	60	60	63	48	Stamping die, Coining die, Cold extrusion die, Thread rolling die, screw plate
Cold and hot work steel	HITU2					0.57	0.30	0.35	4.15	2.90	0.85		1080	58	56	54	56	55	Warm stamping/warm forging die, cold stamping/cold heading die
	HITH13E	1.2345				0.49	0.95	0.35	5.40	1.35	1.05		1050 -1060	530-560℃ x 3 57-59HRC					High quality steel for shield hob
	HITH418E					0.66	0.35	0.50	5.20	2.30	1.10		1030 -1070	530-560℃ x 3 59-61HRC					

Note: HIT: high isotropic and toughness
HY: Traditional die steel

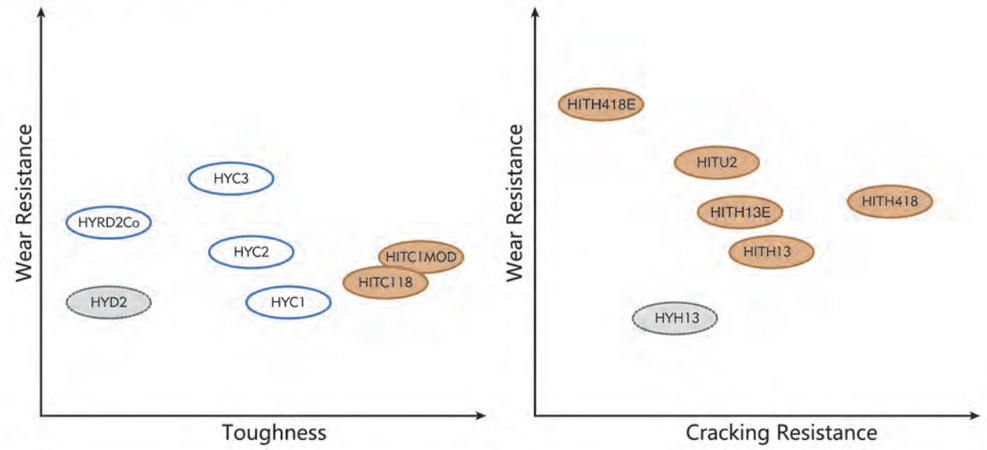
Product Form

Form Supplied	Size(mm)	Surface Condition
Bar	Φ12-30	Black
	Φ30- 410	Roughly Turned
Bright Material	Φ5. 0-14. 5	Ground
	Φ12-410	Peeled
Profiled Bar	7. 2X7. 2-27X27	Black
	(3. 5-40) X (13-100)	Black/Shot Blast
	(20-200) X (40 -400)	Black/Milling
Wire Rod	Φ5. 5-17	Black/Ground
Wire	Φ0. 8-14	Black/Ground
Prehardened Bar	Φ1. 0-15. 0	Black
Strip Material	(33-65) X (1. 5-3. 0)	Black
	(25-55) X (0. 65-1. 80)	Polished
Sheet Material	(1.0-10.0) X (500-850)	Black
Forged Product	Round Φ (50-350) X (10-300)	Black/Machined
	Rectangle (20-200) X (5-80)	
Forged Flat Steel	(100-300) X (200-400)	Black/Machined

Process



Characteristics



Reference for Cold Work Die Steel Selection

HEYE Grade	Hardness	Wear Resistance		Toughness	
		Abrasive Wear Resistance	Abhesive Wear Resistance	Chipping Resistance	Cracking Resistance
HYRD2Co					
HYD2					
HYCI					
HYC2					
HYC3					
HITC118					
HITC1MOD					

Reference for Hot-Work Die Steel Selection

HEYE Grade	Indentation Resistance	Wear Resistance	Heat checking Resistance	Cracking Resistance
HITH13				
HITH418				
HITU2				
HITH13E				
HITH418E				

HIT H13

Summary

HIT H13 is a Cr-Mo-V hot work die material of premium high quality. HIT H13 is featured for its high ductility and toughness under high temperature, frequent hot and cold cycles conditions.

Vacuum degassing and electroslag remelting, together with advanced homogenization processing, strict forging process control and grain refining processing ensures the very fine and uniform micro-structure and finally contributes to the excellent hot wear resistance , thermal fatigue cracking resistance and anti-cracking ability in all directions.

HIT H13 is applied to the precision Al/Mg die casting moulds, Al extrusion dies with complex section and precision forging dies.

Chemical Composition

Typical Analysis %	C	Si	Mn	Cr	Mo	V
	0.38	1.00	0.40	5.20	1.40	0.90
Standard Specification	Premium high quality H13/1.2344/SKD61					
Delivery Condition	Soft annealed to about 180HB					

Properties

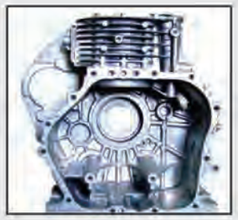
- Excellent toughness and ductility in all directions
- Excellent thermal fatigue resistance
- High hot strength
- Excellent hardenability

Good dimension stability during heat treatmentHIT H13 is produced through electric-slag-refining, high temperature homogenization, and microdizing, etc, which ensures the cleanliness with little non-metallic inclusion.and improves the hot strength, toughness, thermal fatigue resistance and polishability.

HITH13 meets speification of (NADCA #207-2003 for *Premium High Quality H13 Die Steel.*

Applications

Al, Mg and Zn Die Casting Moulds



Regardless of the dominant failure mechanism (e.g.,heat checking, gross cracking, hot wear or plastic deformation) HITH13 offers the potential for significant improvements in die life.

Others

- Dies for Al, Cu alloy extrusions
- Precision forging dies
- Plastic injection moulds with high polishing requirements.
- Thermosetting plastic injection moulds
- Thermoforming dies for automotive partsAll kinds of mechanical parts with high toughness requirements

Hardness Recommendations

Al Die-casting Dies	44~50HRC
Mg Die-casting Dies	48~52HRC

Heat Treatment

Soft Annealing

Protect the steel and heat through to 850°C. Then cool in the furnace at 10°C per hour to 650°C, then freely in air.

Stress Relieving

If the machine-off amount is remarkable at the process of die manufacturing, or the shape of dies is extremely asymmetrical, stress relieving should be conducted in between rough machining and semi-fine machining aiming at reducing size changes and distortion during subsequent heat treatment process.

Stress Relieving:

After rough machining, the tool should be heated through to 650°C, holding time 2 hours. Cool slowly to 500°C, then freely in air.

Hardening

Preheating temperature:

The first stage : 600~650℃

The second stage : 820~850℃

The third stage : 900~950℃

(Simple and small dies can be preheated at the two stages at 650 ℃, 850 ℃ respectively)

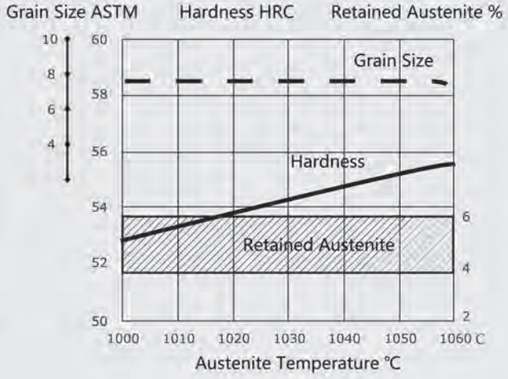
Austenitizing temperature : 1000~1050℃

Recommended autenitizing temperature : 1000~1030℃

Note: Protect the dies against decarburization and oxidation during hardening.

Soaking time at austenizing temperature is 30 minutes, the time start to count from when the dies center reaches the austenitizing temperature.

Hardness, Grain size, Retained Austenite at different Autenizing Temperature



In the terms of microstructure and properties of the dies, the quenching speed should be as fast as possible. This helps to improve the toughness and resistance against crack propagation.

Cooling Medium

- Oil (for dies with simple geometry) ;
- High-pressure, high-speed inert gas ;
- Martempering, is beneficial to control the deformation and crack.

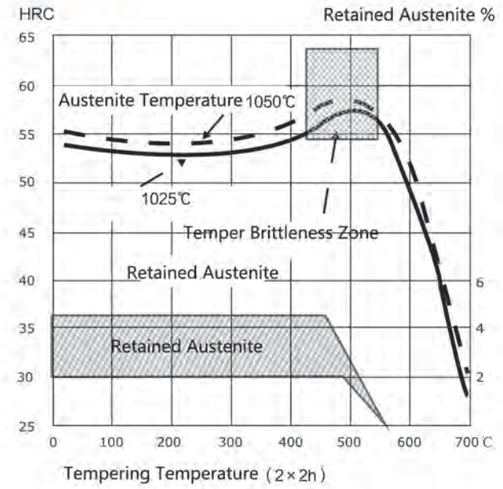
Note: Temper the dies as soon as its surface temperature reaches 50–70°C.

Tempering

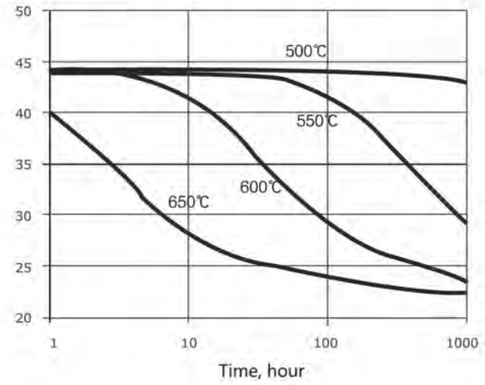
Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper is at least twice , and after the first tempering, the mould needs to cool to room temperature, and then the second tempering. It is recommended to temper the die casting mould three times, and the forging and aluminum extrusion mould twice.The lowest tempering temperature which should be used is 250°C. The minimum holding time at tempering temperature is 2 hours.

To avoid ' temper brittleness' , do not temper in the range 500–550°C, see graph.

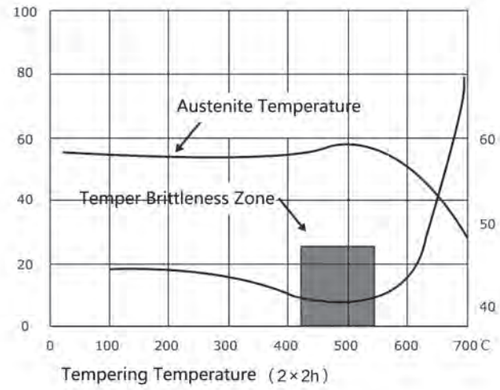
Tempering



Temper Back Resistance



Influence of tempering temperature on impact toughness(thickness direction)



HIT H418

Summary

HIT H418 is a newly development of Cr-Mo-V hot work die steel. It is especially featured for its high ductility and toughness under high temperature, frequent hot and cold cycles conditions.

Optimized chemical composition, closely controlled melting process, high temperature homogenizing, and three direction forging ensure the very fine and uniform micro-structure and finally contributes to the excellent hot wear resistance , thermal fatigue cracking resistance and anti-cracking ability in all directions.

HIT H418 is especially suitable to be selected as the tooling material of dies for Al/Mg diecasting, big and intricate Al extrusion and precision forging dies. When choosing HIT H418 for the die material, it is very likely that tool life or the total tooling economy will be improved substantially.

The quality of HIT H418 meets the specification of NADCA # 207-2003.

Chemical Composition

Typical Analysis %	C	Si	Mn	Cr	Mo	V
	0. 35	0. 30	0. 50	5. 00	2. 10	0. 65
Delivery Condition	Soft annealed to about 200HB					

Hardness Recommendations

Al die-casting dies	44~50HRC
Mg die-casting molds	48~52HRC
Aluminum extrusion dies	48~52HRC
Copper alloy extrusion dies	46~50HRC
Plastic mold injection or thermoset plastic molds	48~52HRC
Forging dies	44~48HRC
Molds for AHSS hot forming	45~50HRC

Heat Treatment

Soft Annealing

Protect the steel against oxidation and heat through to 850 ℃, then cool in the furnace at 10°C per hour to 650°C, then freely in air.

Stress Relieving

If the machine-off amount is remarkable at the process of die manufacturing, or the shape of dies is extremely asymmetrical, stress relieving should be conducted in between rough machining and semi-fine machining aiming at reducing size changes and distortion during subsequent heat treatment.Stress relieving : the dies should be heated through to 650℃ and held for 1~2 hours. Cool slowly to 500°C then freely in air.

Hardening

Preheating temperature:

The first stage : 600~650℃

The second stage : 820~850℃

The third stage : 900~950℃

(Simple and small dies can be preheated at the two stages at 650 ℃, 850 ℃ respectively)

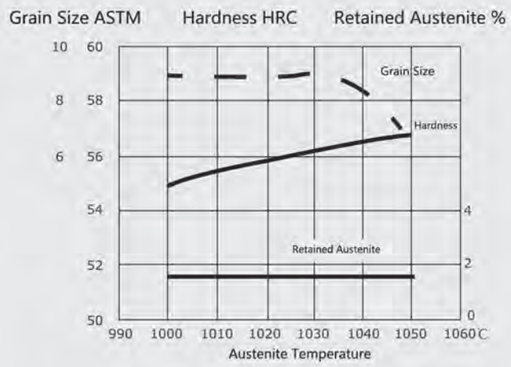
Austenitizing temperature : 1000~1050℃

Recommended autenitizing temperature : 1000~1030℃

Note: Protect the dies against decarburization and oxidation during hardening.

Soaking time at austenizing temperature is 30 minutes, the time start to count from when the dies center reaches the austenitizing temperature.

Hardness, Grain size, Retained Austenite at Different Autenizing Temperature



In terms of microstructure and properties of the dies heat treated, the quenching speed should be as fast as possible. This helps to improve the toughness and resistance against crack propagation. However, too fast quenching can lead to severe distortion and cracking.

Cooling Medium

- Oil (for dies with simple geometry)
- High-pressure, high-speed inert gas
- Martempering, is beneficial to control the distortion and size changest

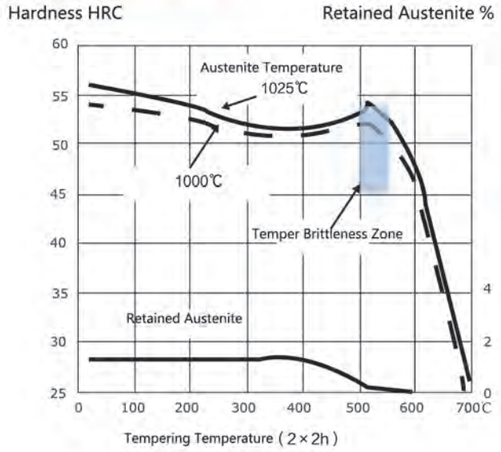
Note: Temper the dies as soon as its surface temperature reaches 50–70°C.

Tempering

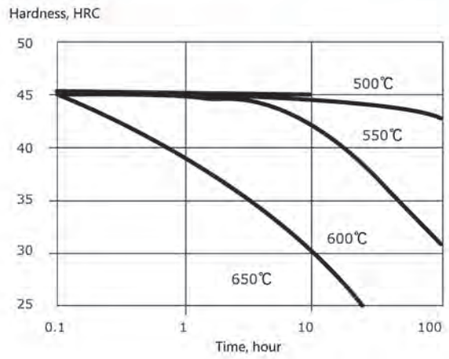
Choose the tempering temperature according to the tempering graph. Temper is at least twice , and after the first tempering, the mold needs to cool to room temperature, and then the second tempering. It is recommended to temper the die casting mold three times, and the forging and aluminum extrusion mold twice.The lowest tempering temperature which should be used is 250°C. The minimum holding time at tempering temperature is 2 hours.

To avoid 'temper brittleness' , do not temper in the range 500–550°C.

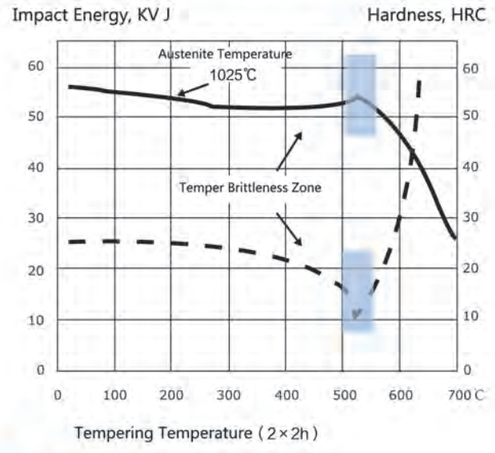
Tempering Graph



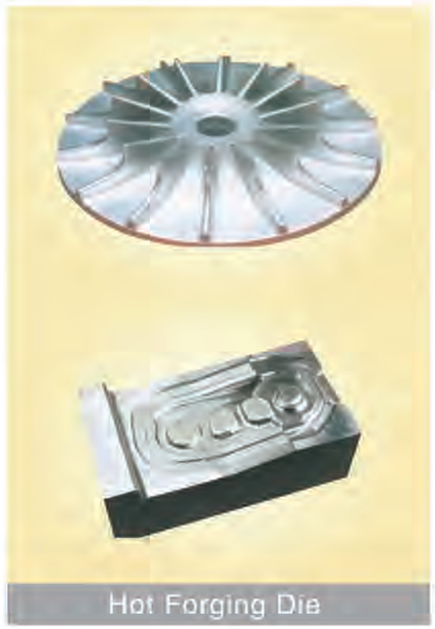
Temper Back Resistance



Influence of tempering temperature on impact toughness(thickness direction)



Product Application



HIT C118

Summary

HIT C118 is newly development of Cr-Mo-V cold work tool steel. The material is produced through ESR process to ensure fine carbide and homogeneous microstructure. Its excellent ductility and toughness is suitable for dies prone to chipping and cracking failure. Its main features are as follows:

- Excellent ductility and toughness, effectively against cracking generation and extension
- High hardness after high temperature tempering in normal austenizing temperature
- Excellent through-hardening properties
- Good resistance to tempering softening
- Excellent polishability
- Good wear resistance

Chemical Composition

Typical Analysis %	C	Si	Mn	Cr	Mo	V
	0.76	0.40	0.60	5.20	2.30	0.60
Delivery Condition	Soft annealed to about 220HB					

Characteristics

HIT C118 is suitable for dies with high compressive strength and whose major failure modes are chipping and cracking. Because of its uniform matrix structure and low carbide content, it can effectively improve the life of the dies when it is prone to adhesive wear. At the same time, the material is tempered at high temperature to obtain high hardness, which is beneficial for subsequent EDM and wire cutting.

Applications

- Moulds for cold forging, cold heading
- Precision roller, screw
- Moulds for automotive high strength plate forming
- Moulds for stainless steel punching and forming
- Moulds for thermosetting plastic molding
- Working dies for mint industry

Properties

Samples were taken from Φ120mm bars and 80X240mm sheets. All specimens has been hardened at 1025 ℃, and tempered twice at 530 ℃ with two hours each tempering. The hardness is 60 -62 HRC.

Physical Properties

Hardened and tempered to 60-62 HRC

TemperatuTemperature	20℃	200℃	400℃
Density, kg/m3	7850	-	-
Elasticity modulu, MPa	215 000	192000	181 000
Coefficient thermal expansion, /℃, 20 ℃ to	-	$11.6x10^{-6}$	$12.4 x 10^{-6}$
Thermal conductivity, W/(m℃)	-	24	28
Specific heat, J/kg°Cre	460		

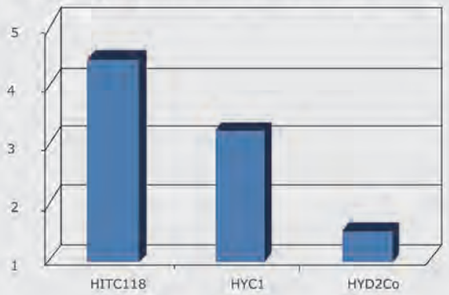
Compressive Strength

At the room temperature

Hardness, HRC	Compressive Strength, Rc0.2(MPa)
58	2240
60	2350
61	2440

Chipping Resistance

Compare chipping resistance with HYD2Co and HYC1



Heat Treatment

Soft Annealing

Protect the steel and heat through to 820℃ wait for equalization of the temperature.Then cool in the furnace at 10℃ per hour to 650 ℃, then freely in air to room temperature.

Stress Relieving

If the machine-off amount is remarkable at the process of tool manufacturing, or the shape of dies is extremely asymmetrical, stress relieving should be conducted in between rough machining and semi-fine machining aiming at reducing size changes and distortion during subsequent heat

treatment process. Stress relieving: the dies should be heated through to 650℃ and held for 1-2 hours. Cool slowly to 500℃ then freely in air.

Hardening

- The first stage : 600~650℃
- The second stage : 820~850℃
- The third stage : 900~950℃

(Small dies or dies with simple geometry can use 650℃and 850 ℃ two stage preheating)

Austenizing temperature : 1000~1025℃

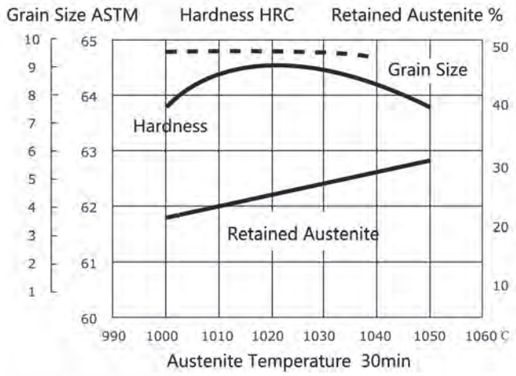
Recommended temperature : 1000~1030℃

Note: Protect the dies against decarburization and oxidation during hardening.

Soaking time at austenizing temperature is 30 minutes, the time start to count from when the dies center reaches the austenitizing temperature.

Hardness, Grain Size and Retained Austenite at Different Austenitizing Temperature

In terms of microstructure and properties of the dies heat treated, the quenching speed should be as fast as possible. This helps to improve the toughness and resistance against crack propagation. However, too fast quenching can lead to severe distortion and cracking.



Cooling Medium

- Oil (geometry simple tool).
- High-pressure, high-speed inert gas.

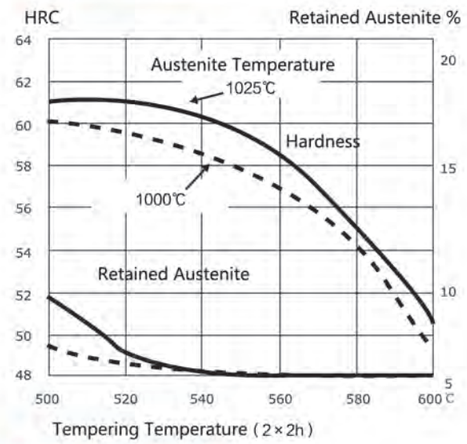
Martempering, 500-550 ℃ or 200-350 ℃ can be chosen for step quenching, which is extremely beneficial to control the distortion and size changes

Note: Temper the dies as soon as its surface temperature reaches 50–70°C.

Tempering

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper is at least twice , and after the first tempering, the mold needs to cool to room temperature, and then the second tempering. The lowest tempering temperature which should be used is 525°C. The minimum holding time at tempering temperature is 2 hours.

Tempering Graph



Product Application

Stamping die

Precision forging die

HIT C1MOD

Summary

HITC1MOD is a chromium-molybdenum-vanadium alloy tool material which is characterised by:

- Good wear resistance and chipping resistance
- High compressive strength
- High hardness (>63 HRC) after high temperature tempering
- Good through-hardening properties
- Good dimensional stability during hardening
- Good resistance to tempering softening and WEDM properties
- Good machinability and grindability

Chemical Composition

Typical Analysis %	C	Si	Mn	Cr	Mo	V
	0.95	1.00	0.50	7.80	2.50	0.50
Delivery Condition	Soft annealed to approx. 235 HB					

Applications

HITC1MOD is a multi-purpose cold work material. It has good resistance properties against abrasive-adhensive mixed wear and chipping. Furthermore, a high hardness (>63HRC) can be obtained after high temperature tempering. This means that surface treatments such as nitriding or PVD can be made on a high strength substrate. It also means that big blocks and complicated shapes with >60 HRC hardness can be wire EDM' d with reduced risk of cracking.

HITC1MOD is recommended for medium productivity dies, where a resistance to abrasive and adhensive mixed wear and a good resistance to chipping are required.

Typical Applications

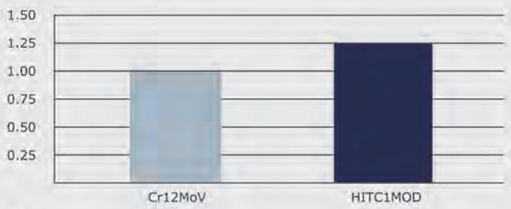
- Blanking and fine blanking
- Shearing
- Forming
- Coining
- Cold forging
- Cold extrusion
- Thread rolling
- Drawing and deep drawing

Typical Applications

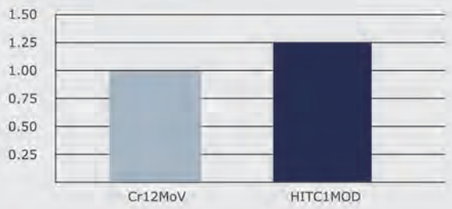
Temperature	20℃	200℃	400℃
Density, kg/m³	7730	7680	7620
Elasticity modulus, MPa	205 000	190 000	180 000
Thermal expansion coefficient, /℃ --Low tempered* per ℃ from 20℃ --high tempered* per ℃ from 20℃	-	$12.7x10^{-6}$ $11.6x10^{-6}$	12.4×10^{-6}
Thermal conductivity, W/m℃	-	24	28
Specific heat, J/kg℃	460	-	-

Low tempering temperature is ~200℃
high tempering temperature is ~550℃

Compressive Strength



Chipping Resistance



Heat Treatment

Soft Annealing

Protect the steel and heat through to 850°C. Then cool in the furnace at 10°C per hour to 650°C, then freely in air.

Stress Relieving

After rough machining, the tool should be heated through to 650°C and held for 2 hours. Cool slowly to 500°C, then freely in air.

Hardening

Preheating temperature: 650-750℃

Austenitising temperature: 950–1080°C, Normally:1030–1050℃.

Holding time: 30 minutes

Protect the dies against decarburisation and oxidation duringhardening.

Cooling Medium

Forced circulating gas or air in vacuum furnace (high speed gas with sufficient overpressure)

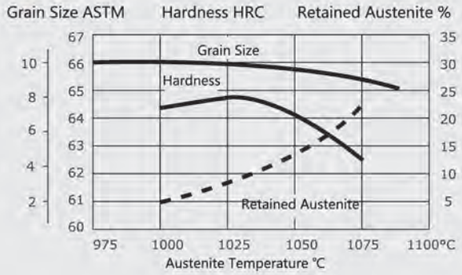
Martempering at 500–550℃ in salt bath furnace or flow furnace

Martempering at 200–350℃ in salt bath furnace or flow furnace

Warm oil, approx. 80°C (only very simple geometries)

Note: Temper the dies as soon as its temperature reaches 50–70 ℃.

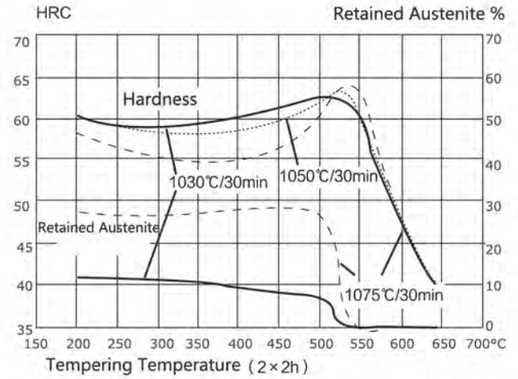
Hardness, Grain Size and Retained Austenite at Different Austenitizing Temperature



Tempering Graph

Choose the tempering temperature according to the hardness required by referring to the tempering graph.

Temper at least twice and air cool to room temperature between tempers. The lowest tempering temperature is 180°C. 2 hours minimum each temper.

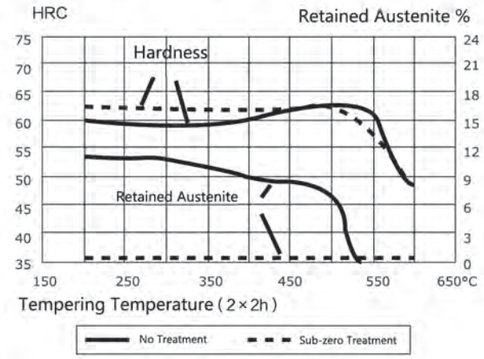


Subzero Treatment

The workpiece with high dimensional stability requirements should be subzero treated. Subzero treatment reduces the amount of retained austenite and changes the hardness as shown in the diagram below.

Austenitising: 1030°C /30 min

Tempering: 2 x 2 h at various temperatures



Product Application

HIT U2

Summary

HITU2 has a unique alloying design, and it is produced byelectroslag remelting smelting, high temperature homogenization and multi-directional forging. It is a new type of tool material for both cold work and hot work, with a hardness of 56~61HRC. It has outstanding high toughness, high strength, wear resistance, thermal stability and thermal fatigue resistance, and has a wide range of heat treatment. Elements with a strong affinity to nitrogen, good nitriding performance. Wear resistance and durable corrosion resistance could be further increased by nitriding. It is mainly used for hot extrusion punch, hot extrusion die, hot stamping die, precision forging die, hot heading die and cold stamping die of standard parts, cold heading die, mechanical cutting straight blade for medium and thick plate.

Characteristics

- High hardness
- High toughness
- High resistance to tempering softening
- Can be used for cold work and hot work tool
- Suitable for coating surface treatment
- High toughness, strength and high isotropic

Chemical Composition

Typical Analysis %	C	Si	Mo	Cr	W	V
	0.57	0.30	2.90	4.15	–	0.85
Delivery Condition	Soft annealed to about 220HB					

Application

- Hot extrusion punch
- Hot extrusion die
- Hot stamping die
- Precision forging die, hot heading forging die
- Cold forging die and cold heading die for standard parts
- Mechanical cutting straight blade for medium and thick plates

Properties

The specimen was taken from Φ19mm bars. It has been hardened at 1080 ℃ and tempered twice at 550 ℃ with two hours each tempering.The hardness is 59.5 HRC.

Physical Properties

Hardened and tempered to 58-61HRC.

Temperature	20℃	200℃	400℃
Density, kg/m3	7800	–	-
Elasticity modulus, MPa	210 400	198 000	17 000
Thermal expansion coefficient, /℃ , from 20℃	–	11.02×10^{-6}	12.42×10^{-6}
Thermal conductivity, W/m℃	32.5	31.8	3.2
Specific heat, J/kg℃	572	580	650

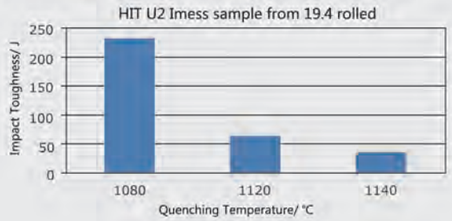
Compressive Strength

At the room temperature

Hardness, HRC	Compressive Strength, Rc0.2(MPa)
60	2800

Impact Toughness

Impact toughness test with un-notched specimen 7×10×55



Heat Treatment

Soft Annealing

Protect the steel and heat through to 880°C. Then cool in the furnace at 10°C per hour to 650°C, then freely in air.

Stress Relieving

If the machine-off amount is remarkable at the process of tool manufacturing, or the shape of dies is extremely asymmetrical, stress relieving should be conducted in between rough machining and semi-fine machining aiming at reducing size changes and distortion during subsequent heat treatment process .

Stress relieving : the dies should be heated through to 650℃ and held for 2 hours. Cool slowly to 500°C then freely in air.

Hardening

Preheating temperature :

The first stage : 600~650℃

The second stage : 820~850℃

The third stage : 900~950℃

(Simple and small molds can be 650 ℃, 850 ℃ two step preheating)

Austenitizing temperature : 1030~1150℃, normally: 1080℃.

Protect the tool against decarburization and oxidation during austenitizing.

Soaking time at austenizing temperature is 30 minutes, the time start to count from when the dies center reaches the austenitizing temperature.

HITU2 Quenching Hardness, Carbide and Retained Austenite Quantities Data

Austenitizing Temperature ℃	1060	1090	1120	1150
Hardness HRC	60	61	62	62.5
Carbide Vol.%	5.6	5.3	2.3	1.8
Retained Austenite Vol.%	–	20.8	28	29
Tempering temperature ≥520 ℃, the residual austenite content ≤2%.				

In the terms of microstructure and properties of the dies heat treated, the quenching speed should be as fast as possible. This helps to improve the toughness and resistance against crack propagation. However, too fast quenching can lead to severe distortion and cracking.

Cooling Medium

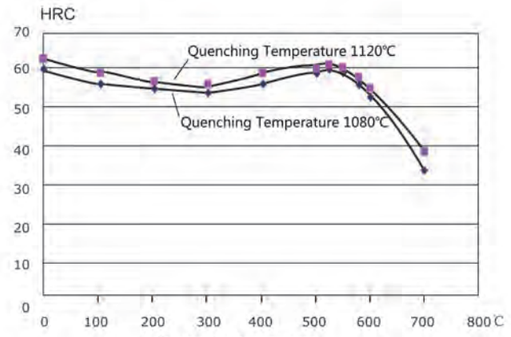
- Oil (Dies with simple geometry)
- High-pressure, high-speed inert gas
- Step quenching, choose 500-550 ℃ or 200-350 ℃ for step quenching, which is extremely beneficial to control the deformation and cracking

Note: Temper the dies as soon as its surface temperature reaches 50–70°C.

Tempering Graph

Recommended tempering temperature is 540 ~ 600 ℃.

Choose the tempering temperature according to the hardness required by referring to the tempering graph, Temper three times,and after the first tempering, the dies need to cool to room temperature. The minimum holding time at tempering temperature is 2 hours.



Product Application

Hob Cutter Ring Material—H13E

Summary

The shield tunnelling machine can complete the excavation and form the tunnel simultaneously on the terrain with different complex conditions. The cutterhead is equipped with a variety of tools. The hob is used to crush hard rock stratum, sandy gravel strata, weathered rock formation, the stratum with rock and soil interleaved frequently. The requirements for disc cutters life and safety are very high, and disc cutters material is the key.

HYH13E, developed jointly by Heye and users, is a kind of ideal hob cutter ring material with high toughness and high hardness. It adopts electroslag remelting smelting, saturation control, fast forging and precision forging-cogging, counterboring-three directions deformation, CNC machining into near-final disk hob billet. Heat treatment hardness can reach 57 ~ 59HRC, and toughness is above 18J.

HITH13E adopts high temperature homogenization, three directions forging and fine crystallization processing technology, and its toughness can reach more than 25J. It is a kind of hob cutter ring material with ultra-high toughness and high isotropic, suitable for excavation in extremely harsh and complex geological environment.

Properties

- High hardness can reach 57 ~ 59HRC
- HYH13E toughness can reach more than 18 J
- HITH13E toughness can reach more than 25 J
- Good fracture resistance and cracking resistance
- Good resistance to tempering back

Hob

Disc cutter ring

shape of cross-section in hob blank

Chemical Composition

Typical Analysis %	C	Si	Mo	Cr	W	V
	0.49	0.95	1.35	5.40	-	1.05
Delivery Condition	Soft annealed to about 220HB					

Cutter head of shield tunneling machine

Model No.	Typical size				
	ϕ1	ϕ2	ϕ3	h1	h2
14					
17	432	318.38	283	78	23
	432	325	283	80	24
	432	317	283	78	24
	432	316	284.6	78	24
	432	314	284	78	30
	432	314	285.8	76	22
	447	320	284.4	59	28
18	457	316	ϕ285.8	76	30
	457.2	322.32	283	78	24
	457.2	321.48	282	79	24
19	482.6	362.6	326.5	90.8	20

Physical Properties

Hardened and tempered to 56-59HRC.

Temperature	20℃	200℃	400℃
Density Kg/m³	7790	-	-
Modulus of Elasticity MPa	215 000	184000	148 000
Coefficient of thermal expansion per °C from 20°C	-	12.50x 10^{-6}	13.4 x 10^{-6}
Thermal conductivity W/m°C	27	29	30

Compressive strength
At room temperature

Hardness, HRC	Compressive Strength, Rc0.2(MPa)
56	2950
58	3180
59	3320

Heat Treatment

- **Soft Annealing**

Protect the steel and heat through to 880℃ ,wait for equalization of the temperature. Then cool in the furnace at 10℃ per hour to 650℃, then freely in air to room temperature.

- **Stress relieving**

If the machine-off amount is remarkable at the process of tool manufacturing, or the shape of dies is extremely asymmetrical, stress relieving should be conducted in between rough machining and semi-fine machining aiming at reducing size changes and distortion during subsequent heat treatment process .

Stress relieving : the dies should be heated through to 650℃ and held for 2 hours. Cool slowly to 500°C then freely in air.

- **Hardening**

Preheating temperature:
The first stage : 600~650℃
The second stage : 820~850℃
The third stage : 900~950℃
(Small dies or dies with simple geometry can use 650℃and 850℃ two stage preheating)

Austenitizing temperature : 1040~1070℃, normally: 1050~1060℃.

Note:Protect the tool against decarburization and oxidation during austenitizing.

Soaking time at austenizing temperature is 30 minutes, the time start to count from when the dies center reaches the austenitizing temperature.

In terms of microstructure and properties of the dies heat treated, the quenching speed should be as fast as possible. This helps to improve the toughness and resistance against crack propagation. However, too fast quenching can lead to severe distortion and cracking.

- **Cooling Medium**

Oil (geometry simple tool)
High-pressure, high-speed inert gas
Martempering, choose 500-550 ℃ or 200-350 ℃ for step quenching, which is extremely beneficial to control the deformation and cracking

Note: Temper the dies as soon as its surface temperature reaches 50–70°C.

- **Tempering**

Recommended tempering temperature is 530 - 560 ℃. Choose the tempering temperature according to the hardness required, tempering three time with 2 hours soaking time after the center of the dies reached the tempering temperature.

Hob Cutter Ring Material—HITH418E

Summary

In the process of design the new material of hob cutter ring in shield machine ,ensuring the sufficient toughness is the first element ,and then increase the strength and hardness as far as possible for improing the cutter ring life. The new type of die steel --HITH418E ,which is modified from the best toughness and ductility of all hot working die steels , has the more excellent strength and hardnees by increasing the content of carbon and vanadium, and micro-adjusting other alloy elements.

Chemical Composition

HEYE Grade	Chemical Composition (wt%)					
	C	Cr	Mo	V	Si	Mn
HIT H418E	0.66	5.2	2.3	1.1	0.35	0.5

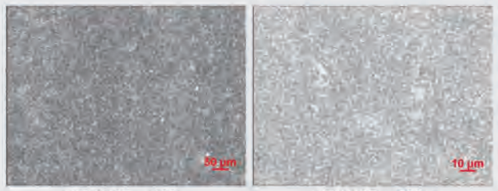
Metallurgical Process

HIT H418E production process :
Quality raw materials selection→Mid-frequency furnace →Ladle refining→Electroslag remelting→Homogenization → Forging deformation and roll molding→Spheroidizing annealing

Properties

- High hardness and resistance to plastic deformation
- High wear resistance
- Good impact toughness

Annealed Structure



HITH418E 100× HITH418E 500×

Heat Treatment

• Soft Annealing

Protect the steel and heat through to 880℃ ,wait for equalization of the temperature. Then cool in the furnace at 10℃ per hour to 650℃, then freely in air to room temperature.

• Stress relieving

If the machine-off amount is remarkable at the process of tool manufacturing, or the shape of dies is extremely asymmetrical, stress relieving should be conducted in between rough machining and semi-fine machining aiming at reducing size changes and distortion during subsequent heat treatment process.

Stress relieving : the dies should be heated through to 650℃ and held for 2 hours. Cool slowly to 500℃ then freely in air.

• Hardening

Preheating temperature:
The first stage : 600~650℃
The second stage : 820~850℃
The third stage : 900~950℃
(Small dies or dies with simple geometry can use 650℃ and 850℃two stage preheating)

Austenitizing temperature: 1030–1070°C

Note: Protect the tool against decarburization and oxidation during austenitizing.

Soaking time at austenizing temperature is 30 minutes, the time start to count from when the dies center reaches the austenitizing temperature.

In terms of microstructure and properties of the dies heat treated, the quenching speed should be as fast as possible. This helps to improve the toughness and resistance against crack propagation. However, too fast quenching can lead to severe distortion and cracking.

• Cooling Medium

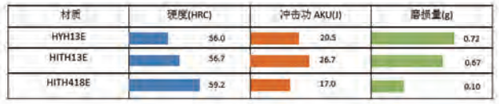
Oil (geometry simple tool)
High-pressure, high-speed inert gas
Martempering,

Note: Temper the dies as soon as its surface temperature reaches 50–70°C.

• Tempering

Recommended tempering temperature is 530 - 560 ℃. Choose the tempering temperature according to the hardness required, tempering three time with 2 hours soaking time after the center of the dies reached the tempering temperature.

Heat treatment hardness, impact toughness, wear resistance

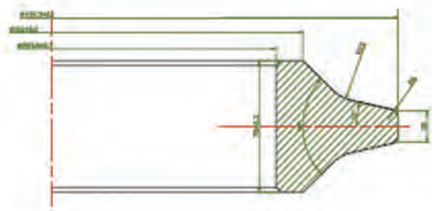


HITH418E and conventional H13 hob cutter rings are applied to different geological condition. HITH418E has higher wear resistance and plastic deformation resistance than conventional H13, and it is mainly used in hard rock ground with small impact .

Supply Type

- Supply condition: pre-processed annealed state, hardness ≤235HB

- Size(mm)



Model No.	Typical size (mm)				
	Φ1	Φ2	Φ3	h1	h2
14					
17	432	318.38	283	78	23
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19	482.6	362.6	326.5	90.8	20