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TOOL STEEL HTCS®-150

(07/2008 Revision)

The Tool Steel HTCS®-150 is a hot work tool steel with very high thermal conductivity (up to over 66 W/mK) combined with a high wear resistance. This tool steel has specially been designed for the hot stamping of coated sheet. This tool steel can also be employed for the hot forming of uncoated sheet, but is not as wear resistant as HTCS-170, in fact both tool steels are often used together in the same die, given that their heat conductivity at high hardness levels is similar and the thermal expansion coefficient almost identical. It can also be used for any other application requiring extreme high conductivity and wear resistance at the same time (like fibre reinforced plastic injection, strong washout areas in light alloy die casting). From all existing tool steels it is the one with the highest thermal conductivity, so the best possible candidate for any application where thermal conductivity is the most relevant property.

Characteristics

The Tool Steel HTCS®-150 is a Powder Metallurgy (PM) alloyed tool steel for hot work, it can also be used for most cold work applications. It's most remarkable property is its outstanding Thermal conductivity, but it also possesses a very good combination of mechanical properties with special mention to toughness with high levels of wear resistance. Its performance is extremely good when facing small abrasive particles (less than 5 microns) or adhesive wear, nonetheless it can also be applied when big abrasive particles are present although in such case HTCS®-170 is a better alternative (both materials can be combined together). For applications where toughness plays a major role like is the case of aluminium die casting, then HTCS®- 130 is a better alternative unless dies have an abrasive wear washout problem. It is a perfect candidate for any plastic injection moulding application where productivity is important even in the presence of fibre reinforcement.

Hardening

It is strongly recommended to directly contact ROVALMA regarding the optimized heat treatment for a given application. If the tool steel is to be used for an application where thermal fatigue is the main failure mechanism, like die casting, extrusion or forging then the heat treatment has to be done by ROVALMA. As a general guideline, for applications not requiring high toughness:

- Slowly heat up to austenitization temperature: 1080-1120 °C
- Holding time after the core has reached the temperature should be 50 to 10 minutes depending on the austenitization temperature. (if no thermocouple is available allow ½ minute for every mm of thickness)
- It is very strongly recommended to make a temperature homogenization stop at 850 ºC.
- A temperature homogenization at 650 °C is also recommendable.
- Rapid cooling is desired, specially recommendable is oil cooling (cracking risk is minimal due to high thermal conductivity, heat treatment distortions are also small due to high material stability)

Tempering

For a 42-44 HRc hardness.

- 2 h at 540 °C + 2 h at 640 °C + 2 h at 640 °C
- Afterwards adjust hardness to 42 – 44 HRc (maximum Heat conductivity: 66 W/mK).

For a 50-52 HRc hardness.

- 2 h at 540 °C + 2 h at 590 °C + 2 h at 600 °C
- Afterwards adjust hardness to 50 – 52 HRc.

Welding

Welding a working zone

- HTCS®-Rod (Welding wire) or HTCS®-RE (Refurbished Electrodes) are to be used in order to maintain the high thermal conductivity. (if HTCS®-150 is already heat treated it is recommendable to heat the piece to be weld to a temperature of 300 to 500 ºC , if HTCS®-150 is hardened at a hardness level of 50 HRc or above, heating of the pieces to be weld is mandatory.
- If the welding has been carried out on already hardened material at places between the object to be cooled and the cooling media then the whole piece has to be tempered twice after welding to fully restore the heat conductivity at the weld area.

→ Temper once during two hours (plus heating time) at a temperature of 540 to 560 °C

→ Temper once more during two hours (plus heating time) at a temperature of:

  - 620 °C (for material hardened to 40-44 HRc)
  - 590 ºC (for material hardened above 50 HRc)

Plugs

- Any welding material for hot work tool steels can be used. Welding with a high Ni containing alloy is even easier. No tempering cycles are required.

Machining

General guidelines

HTCS®-150 is easy to machine in annealed state and also in hardened state, it can be conventionally machined at all possible hardness levels, but machinability is considerably easier at 40-44 HRc.

GENERAL MACHINNING PARAMETERS

Operation	Cutting tool type	HTCS-170 condition and Hardness	Depth of cut mm	Cutting speed m/min.	Feed mm/tooth or revol. (turning)	Cooling medium
Turning	TiN coated Hard Metal	Annealed at 165 HB	$1^{+4}_{-0,9}$	76^{+30}_{-15}	$0,3^{\pm 0.2}$	Synthetic emulsion (6% dilution in water)
		Hardened and tempered to 44 HRc	$1^{+4}_{-0,8}$	$40^{\pm 10}$	$0,35^{\pm 0.25}$	
	Uncoated HSS AISI-T15	Annealed at 165 HB	$0,5^{+3,5}_{-0,4}$	$33^{\pm 12}$	$0,3^{\pm 0.2}$	
		Hardened and tempered to 44 HRc	$0,5^{+3}_{-0,3}$	$16^{\pm 4}$	$0,3^{\pm 0.2}$	
Milling	TiN coated Hard Metal inserts	Annealed at 165 HB	$2,5^{+2,5}_{-2,4}$	90^{+20}_{-10}	$0,08^{\pm 0.07}$	
		Hardened and tempered to 44 HRc	$2^{+2}_{-1,8}$	$60^{\pm 10}$	$0,07^{\pm 0.05}$	
	TiAlN coated Worm hob	Annealed at 165 HB	$2^{+3}_{-1,9}$	90^{+20}_{-10}	$0,02^{+0,13}_{-0,01}$	
		Hardened and tempered to 44 HRc	$1^{+2}_{-0,8}$	$70^{\pm 10}$	$0,02^{+0,08}_{-0,01}$	
	HSS AISI-M42 Worm hob	Annealed at 165 HB	$2^{+3}_{-1,9}$	$50^{\pm 10}$	$0,03^{+0,08}_{-0,02}$	
		Hardened and tempered to 44 HRc	$0,5^{+2}_{-0,2}$	$20^{\pm 4}$	$0,015^{+0,02}_{-0,005}$	
Drilling	TiAlN coated Hard Metal integral drill	Hardened and tempered to 44 HRc	-	$50^{\pm 10}$	$0,006^{+0,004}_{-0,003}$	
	Uncoated HSS AISI M42	Annealed at 165 HB	-	$50^{\pm 15}$	$0,005^{+0,005}_{-0,003}$	
		Hardened and tempered to 44 HRc	-	$30^{\pm 10}$	$0,01^{+0,03}_{-0,005}$	
Cutting	Bi-metallic Cutting band saw with HSS AISI M42 teeth	Annealed at 165 HB	-	$26^{\pm 3}$	$0,002^{+0,004}_{-0,001}$	
		Hardened and tempered to 44 HRc	-	$18^{\pm 2}$	$0,003^{+0,003}_{-0,002}$	
Tapping	TiN coated Hard Metal	Hardened and tempered to 44 HRc	-	$2^{\pm 1}$	-	Volatile oil
	HSS AISI M42	Annealed at 165 HB	-	$5^{\pm 2}$	-	
		Hardened and tempered to 44 HRc	-	$1^{\pm 0,5}$	-	

MACHINNING WELDINGS

Operation	Welding type	Hardness HRc	Cutting tool type	Depth of cut mm	Cutting speed m/min.	feed mm/tooth	Cooling medium
Milling	Machining of the weld: 2÷3 mm. surfacing weld layer on annealed base material, the piece is hardened and tempered after the welding and prior to machining.						Synthetic emulsion (6% dilution in water)
	TIG feeding HTCS-Rod	$41^{\pm 1}$	**A**	$2^{+3}_{-1,9}$	$65^{\pm 10}$	$0,08^{+0,06}_{-0,07}$	
			B	$1,5^{+2}_{-1,4}$	$80^{\pm 10}$	$0,03^{+0,09}_{-0,02}$	
	Refurbished **ELECTRODE** HTCS-RE	$42^{\pm 1}$	**A**	$2^{+2}_{-1,9}$	$65^{\pm 10}$	$0,08^{+0,1}_{-0,02}$	
			B	$1,5^{+2}_{-1,4}$	$70^{\pm 10}$	$0,04^{+0,08}_{-0,03}$	
	Machining of the weld: Hardened and tempered base material, 2-3 mm surfacing layer, no posterior heat treatment of the weld.						
	TIG feeding HTCS-Rod	$44^{\pm 1}$	**A**	$1,5^{+3}_{-1,3}$	$40^{\pm 10}$	$0,04^{+0,02}_{-0,03}$	
			B	$1^{+3}_{-0,9}$	40^{+10}_{-15}	$0,015^{+0,02}_{-0,005}$	
	Refurbished **ELECTRODE** HTCS-RE	$53^{\pm 1}$	**A**	$1^{+4}_{-0,9}$	20^{+10}_{-5}	$0,03^{+0,02}_{-0,02}$	
			B	$0,6^{+3}_{-0,5}$	15^{+7}_{-5}	$0,015^{+0,015}_{-0,01}$	
	Machining of thick welding where base material diffusion is negligible.						
	TIG feeding HTCS-Rod	$35^{\pm 1}$	**A**	$1,5^{+2}_{-1,4}$	$50^{\pm 10}$	$0,05^{+0,07}_{-0,02}$	
			B	$1^{+2}_{-0,9}$	45^{+5}_{-10}	$0,04^{+0,04}_{-0,02}$	
	Refurbished **ELECTRODE** HTCS-RE	$41^{\pm 1}$	**A**	$1^{+2}_{-0,9}$	20^{+10}_{-5}	$0,06^{+0,04}_{-0,02}$	
			B	$1^{+2}_{-0,9}$	$18^{\pm 5}$	$0,04^{+0,03}_{-0,02}$	

A= TiN coated Hard Metal inserts

B= TiAlN coated Hard Metal Worm hob

- The values provided in the preceding tables are those optimizing the different machining operations with the machines at the disposal of ROVALMA. With different machines the optimal value can vary, but it should fall into the tolerance range provided.
- The hardness of the weld depends on the thickness of the surfacing. Below 4-5 mm the thicker the surfacing layer the lower the hardness.

The welding machining on annealed material after annealing of the weld, as well as the machining of the welding on hardened and tempered base material after tempering of the weld pose are quite similar to the machining of the base material in the same condition and thus the parameters of the corresponding table (page3) should be employe

Table 1: Physical and mechanical Properties of HTCS®-150 Tool Steel

	44 HRc			40 HRc			
Test Temperature [ºK]	300	473	673	300	473	673	Units
Physical Constants							
Linear Heat Expansion coefficient							x 10^{-6}/K
Thermal conductivity	66	61					W/mK
Specific Heat Capacity	460						J/KgK
Alfa-Gamma-Transition Temperature Ac_1-1							K
Ac_3-1							K
Density	7,97						x 10^3Kg/m^3
Specific Electric Resistivity							x 10^{-8}Ωm
Modulus of Elasticity	196						x 10^3MPa
Mechanical Properties							
Ultimate Strength							MPa
Yield Stress 2 %							MPa
Elongation in 50 mm							%
Reduction of area							%
V-notched Charpy Resilience	18						J
Unnotched Charpy Resilience [7 x 10 x 55]							J
Wear Resistance							Rovalma-Coeficient 2

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