ANNALS OF FACULTY ENGINEERING HUNEDOARA
- INTERNATIONAL JOURNAL OF ENGINEERING
Tome IX (Year 2011). Fascicule 3. (ISSN 1584 - 2673)

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EXPERIMENTAL DRILLING TESTS OF ABRASION RESISTANT HARDOX 500 T=f (v_c) AT CONSTANT FEED

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ABSTRACT: Materials that are heat-treated thermomechanical include but are not armored plates and abrasion HARDOX. Are the product of Oxellösund SSAB (Sweden), and used for parts that are subjected to exploitation in the process of growing demand for abrasion resistance. Therefore used for the cup tablespoons loaders, excavators, parts of the stone crushers, the hull truck dumpers for conveyors, sprockets and other. HARDOX 500 are produced by hot rolling at 900 ÷ 920 ° C with a reduction of 50 to 85% in the area of a stable austenite, and then to one minute sharply hardened in the water spray. They are rolled in thicknesses from 4 to 80 mm. Their chemical composition is indicative as follows: max 0.29% C, 0.70% Si, 1.60% Mn, 0.025% P, 0.010% S, 1.0% Cr, 0.50% Ni, 0.30% Mo, approximately 0.04% B. After quenching they followed by low temperature tempering at 200 to 300 ° C. The structure of the material is low-temperature tempered martensite, with partial residual austenite. Achieved hardness ranges from 470 to 530 HBW, i.e. about 46 to 50 HRC. Can be classified into groups intricately hard machinable hardened steel. In the process of machining these materials operate in highly abrasive cutting tool.
KEYWORDS: Wear resistant plate HARDOX 500, thermomechanical processing, microstructure, drilling

❖ INTRODUCTION

Machining of those materials with defined tool geometry, cutting wedge creates difficulties for high shear stress on the slip plane shear deformations in chips. To hardness of 50 HRC can be used even tools HSS-Co, but with low productivity and low durability. In practice, the best certified cemented carbide (HW) without coating, or better with CVD and PVD coatings (HC). Fine-grained and ultra fine grain cemented carbide structure with grain size of 0.3÷0.5 μm increases the hardness and flexural strength, and thus the cutting tool properties. Drilling can be used bits of high speed steel or cemented carbide drills from. Type used depends on the drilling machine tool, which is available as well as its stability. Whatever type of drill is necessary to minimize vibration. Drilling can be used with HSS + Co (8%), with a large helix angle (10 °) and with the heavy heart that better withstand high torque. Drills are very high and keep warm (see on Fig.2).


Fig.1: Drilling process of HARDOX 500 by HSS-HX drill on VR-2 drilling machine tool

❖ METHODOLOGY TEST DRILLING WEAR RESISTANT PLATE HARDOX 500

Material: HARDOX 500 on the dimensions of 400 x 150 mm, h = 12 mm
Machine tool: tests will be performed on VR-2 radial drilling machine, P = 2, 25 kW. Spindle speed: n = 90 - 140 - 224 - 355 - 450 - 560 - 710 - 900 - 1120 - 1800 - 2800
Feed motion: f = 0,03 - 0,05 - 0,08 - 0,12 - 0,19 - 0,30 mm
Cutting tool: drill ø 10 mm HSS-HX with taper shank (STN 22 1140), Morse 1, λ_s = 10 °, 2ε = 130 °, (chemical composition analysis according to SPEKTROLAB-Jr-CCD - Fig. 4, 5).
Workpiece clamping: in a vice, supported by washers.
Cutting fluid: drilling emulsion DASCOL 2500, 5% (ARAL) - see on Fig.1.

In the process of the experiment was monitored dependence T = f (v_c) at a constant feed f = 0.03 mm = constant. Each test was conducted at five cutting speeds: n = 90 - 140 to 224 - 355 to 560 min^{-1}, v_c = 2,827 - 4.398 to 7.037 - 11.152 to 17.592 $m.min^{-1}$

Individual measurements were repeated 3 to 4 times what we got with the average value of life, which was used to construct a T = f (v_c) dependencies. The criterion of wear was determined as destroying a transverse cutting edge showing a screeching or whistling. Wear was measured with a

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magnifying glass workshop at a magnification of 10x and the microscope MITUTOYO TM - 500 at a magnification of 30x. The size of wear on the cutting edge was measured only informative. Sharpening drill was carried out by hand in controlling the angle ε, the width of cutting edge width and transverse cutting edge. The test results were reported in the tables and transferred to graph log T = log C_T - m. log v_c. Using the least-squares constants were calculated "m" and "C_T".

Table 1: Drilling values from test No. 1

No.	n	v_c	f	v_f	VB_{max}	pc	T (min)	øT
1	90	2,827	0,03	2,7	0,45	4	17,78	22,22
2					0,42	5	22,22	
3					0,5	5	22,22	
4					0,45	6	26,67	
1	140	4,398	0,03	4,2	0,5	10	28,57	28,56
2					0,45	9	25,7	
3					0,51	10	28,57	
4					0,47	11	31,4	
1	224	7,037	0,03	6,72	0,52	12	21,43	23,22
2					0,47	12	21,43	
3					0,48	15	26,8	
4					0,5	13	23,2	
1	355	11,152	0,03	10,65	0,49	7	7,9	6,76
2					0,51	5	5,63	
3					0,48	6	6,76	
1	560	17,592	0,03	16,8	0,48	3	2,14	2,14
2					0,5	4	2,86	
3					0,48	2	1,43	

Table 2

n	T_i	v_{ci}	log T_i	log v_{ci}	log T_i . log v_{ci}	$\log^2 v_{ci}$
1	22,22	2,827	1,347	0,4513	0,6079	0,2037
2	28,56	4,398	1,456	0,643	0,9362	0,4134
3	23,22	7,037	1,366	0,8474	1,1575	0,718
4	6,76	11,152	0,83	1,047	0,869	1,0962
5	2,14	17,592	0,33	1,2453	0,411	1,55
Σ	82,9	43	5,329	4,234	3,9816	3,9813
$\Sigma n_{3,4,5}$	32,12	35,781	2,526	3,1397	2,4375	3,3642

Fig.2: HSS-HX Drill ø10 mm with taper shank

❖ EXPERIMENTAL TESTS OF DRILLING HARDOX 500

Example 1: Drilling of abrasion resistant HARDOX 500 (h = 12mm), with ø10 mm drill HX (HSS+Co) by the constant feed motion f = 0,03 mm. Open drilling values are in Table 1. Values obtained from Table 1 were processed to determine the constants C_T and "m" for the equation (see Table 2).

$$T = \frac{C_T}{v_c^m}$$

To calculate the constants C_T and exponent "m" I apply the method of least squares. Then:

$$\sum \log T_i = n.\log C_T - m.\sum \log v_{ci} \qquad (1)$$

$$\sum (\log T_i . \log v_{ci}) = \log C_T . \sum \log v_{ci} - m.\sum \log^2 v_{ci} \qquad (2)$$

solving equations, the equation for determining the "m":

$$m = \frac{n.\sum(\log T_i . \log v_{ci}) - \sum \log T_i . \sum \log v_{ci}}{\left[\sum \log v_{ci}\right]^2 - n.\sum \log^2 . v_{ci}} \qquad (3)$$

Note: For the calculation we consider only the linear part of the dependency graph that is with points. (n $_{3,\ 4,\ 5}$)

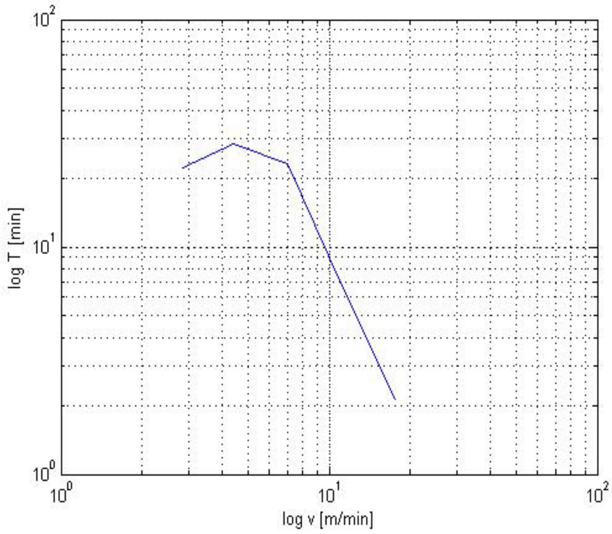

Fig.3: Graphical dependence T = f (v_c) at constant displacement 0.03 mm in two logarithmic coordinate system for the abrasion resistant sheet HARDOX 500 (h = 12 mm), with the drill ø10 mm HX (HSS + Co) STN 22 1140, the VR- 2 machine and cooling DASCOL 2500 (5%)

Fig.4: Overall view of the workplace spectral analysis tool material HSS-HX on the measuring device SPECTROLAB Jr-CCD

Note: n = 3 is the number of measurements of cutting speeds. Substituting from Table 1 into the equation for "m. we get:

$$m = \frac{3.2{,}4375 - 2{,}526 .3{,}1397}{(3{,}1397)^2 - 3.3{,}3642} = 2{,}633$$

$$tg\,\alpha = 2{,}633 \Rightarrow \alpha = 69°12` \approx 70°$$

C_T constant we determine when we substitute the value "m" in equation (1):

Por. cislo: 1987 Ozn. vzorky: vrtak
Meral: Ing. Lysak Pre: KO
Material STN:

No	C	Si	Mn	P	S	Cr	Mo
	%	%	%	%	%	%	%
1	1.850	0.3447	0.2343	<0.0014	<0.0011	2.832	>8.40
2	1.127	0.3659	0.1913	<0.0014	<0.0011	3.483	>8.40
3	1.252	0.4707	0.2099	<0.0014	<0.0011	3.751	>8.40

No	Ni	Al	Co	Cu	Nb	Ti	V
	%	%	%	%	%	%	%
1	0.3544	0.1411	8.88	0.1382	0.0553	0.0099	1.118
2	0.2869	0.1592	9.92	0.1356	0.0589	0.0092	1.237
3	0.3159	0.2238	9.94	0.1544	0.0617	0.0117	1.296

No	W	Pb	Sn	As	Ce	B	Fe
	%	%	%	%	%	%	%
1	1.059	0.0249	<0.0021	<0.0040	0.0798	<0.0010	<70.8
2	1.269	~0.0344	<0.0021	<0.0040	0.0762	0.0082	<70.9
3	1.394	>0.0360	<0.0021	<0.0040	0.0957	0.0074	<70.7

Fig.5: Protocol of measurements of spectral analysis of the material HSS-HX

$$\log C_T = \frac{\sum \log T_i + m.\sum \log v_{ci}}{3}$$

$$\log C_T = \frac{2{,}526 + 2{,}633.3{,}1397}{3} = 3{,}5976$$

$$C_T = 3{,}959132.10^3$$

❖ CONCLUSIONS

After realized tests to confirm the recommendations of the working drilling bit and the highest durability was achieved in the cutting speed of just under 5 m/min. With the increasing shift decreased the durability of the drill. During the process originated, as expected, a long helical cod. We also confirmed the requirement for high stiffness system Machine-Tool-Workpiece-Fixture, they were clearly significant differences in the vibrations of the machine depending on the distance from the carriage pole radial drills. After drilling approximately 50 to 70 holes there to wear a bit bevel gradually acquires a conical shape which caused considerable problems for the flow process.

This problem was solved by shortening the bit about after 50 holes of about 7 mm. Other difficulties in happened a moment just before penetration of the drill bit through the material when there is an extreme wear transverse cutting edge and disturbing sound effects. This side effect was eliminated by inserting a steel plate below the drilled material. Results of drilling tests, and graphically processed by the method of least squares for the linear part of curves, confirmed the merits of using HSS+Co even if the wear resistant plate at a lower productivity than the HW drills but only to HRC = 50.

❖ REFERENCES

[1.] BARÁNEK, I. – ŠANDORA, J.: *Výroba vybraných súčiastok špeciálnej techniky,* Trenčín. ISBN 80 – 8075 – 017 – 3, TnUAD 2004, s. 81, 82.

[2.] ŠANDORA, J. – VAVRUŠ, M.: *Obrábanie oteruvzdorných a vysokopevných plechov HARDOX,* In: Zborník prednášok 6. medzinárodná vedecká konferencia,TRANSFER 2004, 2. diel, TnUAD – FŠT Trenčín, s. 477 - 481

[3.] VAVRUŠ, M.: *Vŕtanie oteruvzdorných plechov HARDOX vrtákmi z rýchlorezných kobaltových ocelí HSS-HX.* Diplomová práca FŠT TnUAD Trenčín, 2005, 58 s.

[4.] JAMBOR, M.: *Vŕtanie TMS plechov vrtákmi z HSS+Co bez povlakov a s povlakmi TiN, rezanie závitov závitníkmi,* Diplomová práca, TnUAD FŠT, Trenčín 2004

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