EVALUATION OF CUTTING FLUIDS FOR TAPPING CAST IRONS

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1. Introduction

Several experiments have been made in this department to select the best type of cutting fluids to be used in various machining operations about which accounts have already been given in former papers [1, 2, 3]. The present paper deals with the results of tapping experiments evaluating five various cutting fluids after having determined the best conditions for tool-life. The cutting fluids used in these tests are as follows:

a) Soluble oils at a rate of 1 : 15. The composition of the soluble oil was in accordance with the standard MSZ 19966.

b) 0—20 special spindle oil produced for the purpose of machine oiling but readily adoptable for automatons. The composition of this mineral oil was in accordance with the standard MSZ 990.

c) GS—20 sulfurized cutting oil heavy-duty cutting conditions (named "Sulfofrezol") according to the standard MSZ 4407.

d) Mixture of sulfofrezol and kerosene composed of 75 per cent of sulfofrezol and 25 per cent kerosene.

e) Chlorinated type additive, named "HDS-Konzentrat". Its peculiarity is that it can display its advantageous effect already at small cutting speed. It shows a good performance at forced chip formation. In our tests, 10 per cent of it was dissolved in "0—20" mineral oil. The composition of the "HDS-Konzentrat verstärkt" was in correspondence with the works prescriptions [4].

2. Experimental conditions

2. 1. Method of torque measurement

At cutting research it is very important to know the torque on the tool. At tapping a part of the torque comes from the chip removal i.e. from the effective cutting. But the friction between the tool and the work piece has great importance too, mostly at the core holes produced by the inferior limit where the tool may get tightly stuck.

Because the value of the real torque is wanted during the experiments and it would be a very complicated task to compute it, it is suitable to determine the prevailing cutting torque by measurement.

The apparatus used for measuring cutting torque — mentioned in technical literature — can be listed on the base of their principle of operations like this:

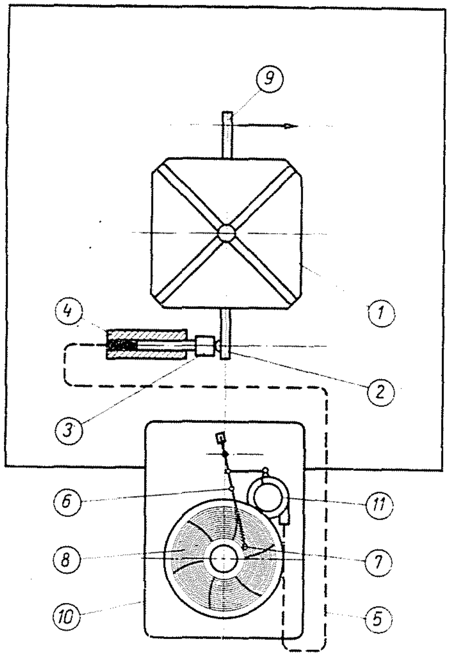

Fig. 1

a) Working with strain gauges [5, 6, 7, 8]

b) Working with electrical pick up boxes based on inductive theorem [7].

c) Working on pneumatic principle [10]

In our experiments for measuring torques we applied a hydraulic equipment built by ourselves. At great torque fluctuation on tapping the sourdine influence of the applied hydraulic system can be well seen, the instrument draws a diagram which can be readily evaluated and its accuracy of measurement is ± 5 per cent.

The setting up of the principle of the instrument is to be seen in Fig. 1. The work piece is clamped to the swing turntable (1) which having been turned by the effect of the torque dislocates the piston by means of the (2) lever. The (4) cylinder volume is joined to the (10) pressure registering equipment with a (5) pipeline. The (6) hand is moved by the (11) operating Bourdon coin pipe. The torque overchange is registered by the (7) pen arm on the revolving (8) dial plate. The instrument was calibrated by means of weight at the (9) lever.

2.2. Tools

The experiments were carried out partly with tools of tool steel marked W8 corresponding to the standard MSZ (4352), partly with tools of high speed steel marked R4 corresponding to the standard MSZ 4351. In accordance with the standard the composition of the tool steel marked W8 is the following: 1—1.2% Carbon; 0.9—1.3% Tungsten; 0.5—1% Chrome; max 0.35% Silicon; max 0.4% Manganese. In accordance with the standard the composition of the high speed steel marked R4 is the following: 0.7—0.9% Carbon; 4—5% Chrome; min. 14% Tungsten; 0.2—1.0% Molibdenum; 0.8—1.5 Vanadium; max. 0.45% Manganese; max. 0.4% Silicon. The tools of the same material were made in one series.

The tool geometry of the taps was given in accordance with the standard MSZ 3920. 50 tools "M10" of W8 and 50 tools R4 were picked out for the experiments after having measured the following characteristics: the outer diameter; the core diameter; the angle of thread; the lead; the chamfer; the rake angle γ; the relief angle α; and the error of the pitch of the flute. On determining the permissible variation in sizes of the measured values the rules of the respective standards were considered as a base. On the base of measurings the probability frequency curve characterizing the distribution of the sizes were taken in the tolerance range determined as mentioned above. The tools being between the limits $\pm 2\sigma$ for their sizes were taken as suitable for the experiments. So the final conclusions of our experiments are valid for the 95 per cent normal tools produced in the same series. $\delta = 0{,}07$ d back wear is admitted on the tools, which is 0.7 mm on the tools "M 10".

2. 3. Material to be cut

The composition of the cast iron was: 3.11% Carbon; 1.86% Silicon; 0.13% Sulfur; 0.113% Phosphorus. The tensile strength of the material was $a_B = 18.8 \sim 20.1$ kp/mm^2 its hardness was HB $= 180 \sim 210$ kp/mm^2. The structure was homogeneous according to the cast stage. In accordance with the standard MSZ 2591 the material can be classified as "Öv 22".

To decide to what rate the results of the tests are influenced by the core diameter, tests were made in core holes with diameters of 8.5, 8.4, 8.3, 8.1, mm with the above mentioned tools. The results of the tests are summarized in the following table where the percentage of the tapping torque is given in relation to the cutting torque in the 8.5 mm core hole diameter. (Coolants were not applied at the experiment.)

Cutting speed	Torque growing				
	$d_c = 8.5$	$d_c = 8.4$	$d_c = 8.3$	$d_c = 8.2$	$d_c = 8.1$
$v = 1.49$ m/min	—	31%	51%	54%	62%
$v = 11.8$ m/min	—	11%	14%	22%	24%

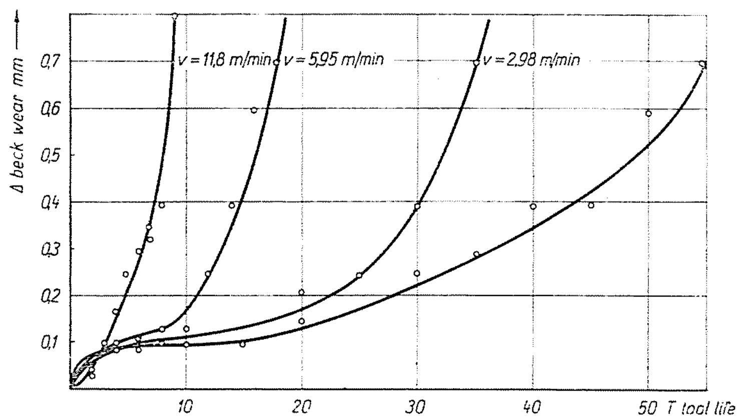

Fig. 2

It is to be seen that the decreasing of the drill hole diameter leads to the rapid incrase of the cutting moment, mostly at low cutting speeds. Taking all these into consideration, tapping was carried out in 8.5 mm diameter reamed holes. According to the data of technical literature the increasing of the drill hole diameter to such extent is permissible from the viewpoint of the strength of the screw connection [12, 13].

β. δ. *Cutting conditions*

To set up the cutting speeds to be applied at the tests tool life of the tool steel W8 was determined at v = 1.49—2.98— 5.95— and 11.8 m/min cutting speeds Fig. 2. The coolant applied at the tests was soluble oil at a rate of 1 : 15. On the base of the tool lives determined in this way the tool life cutting speed diagram was determined Fig. 3. The maximums of the cutting torques belonging to the warious cutting speeds measured at the excessive wear of the tool were plotted into the same diagram. At these tests, the thread was tapped into holes of lenght l = 33 mm. As the feed of the tool is determined by the pitch of the thread to be cut, it is possible to determine the number of the threaded holes to be cut during the time of tool life to the various cutting speeds. Plotting these data into the same diagram the following can be stated. During the tool life time belonging to the low cutting speeds a smaller number of threaded holes can be produced than at high cutting speeds in spite of the fact that the

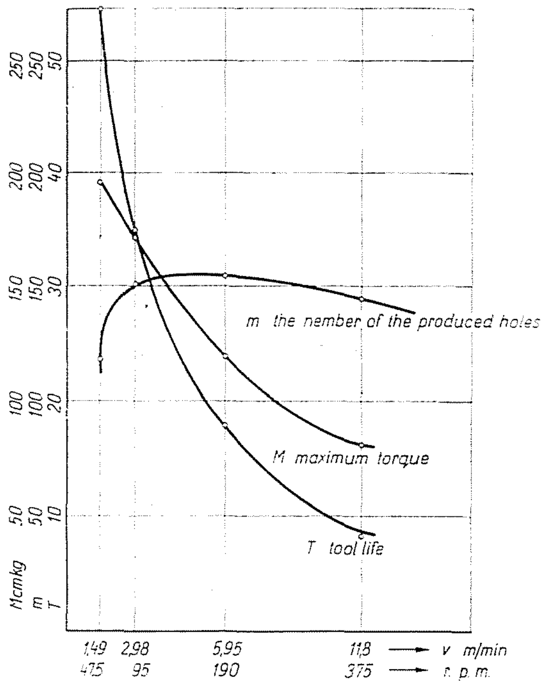

Fig. 3

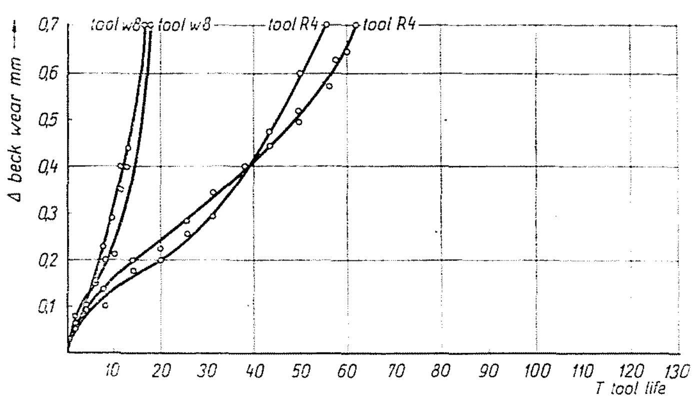

Fig. 4

tool life here is smaller. Examining the cutting torque i.e. the stress of the tool the lowest speeds are most unfavourable. On the base of this, a cutting speed of 4 m/min belonging to the 190 rev/min of the boring spindle was applied.

3. Experimental results

The tests were carried out with taps "M 10" of tool steel W8 and high speed steel R4 as was stated above. The material to be cut was cast iron "Öv. 22.". The diameters of the holes were 8.5 mm and their lenghts were 33 mm. For wear criteria 0.7 mm flank wear was chosen. Fig. 4. shows the tool life of two

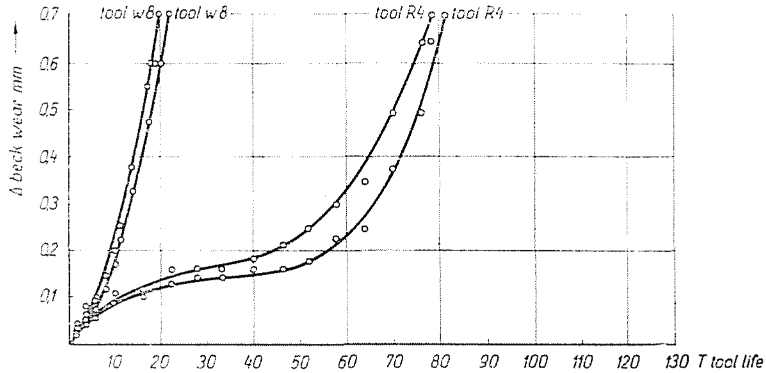

Fig. 5

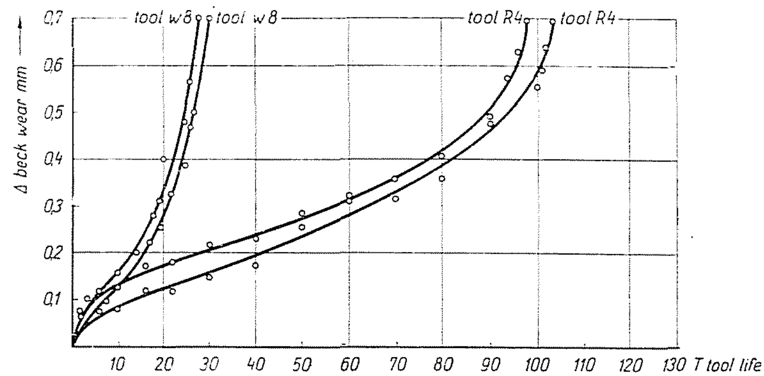

Fig. 6

taps of tool steel and of two others of high speed applied on soluble oil emulsion as coolant.

Other tool life diagrams for the same four taps — two of tool steel, and two of high speed steel — can be seen with various coolants; in Fig. 5 with special spindle oil; in Fig. 6 with sulfofrezol; in Fig. 7 with sulfofrezol and kerosene and in Fig. 8 with "HDS-Konzentrat verstärkt". The data of the diagrams can be summarized in the following table:

Material of the tool	Applied cutting fluids	Tool life in min.	Percentage of the increase of the tool life %
W 8	boring oil emulsion	17—18	100
R 4	1 : 15	56—62	100
W 8	0—20 special spindle oil	20—22	114—126
R 4		78—80	132—136
W 8	75% GS—20	20—25	113—143
R 4	25% kerosene	72—82	122—149
W 8	GS—20	28—30	160—171
R 4		98—106	166—180
W 8	HDS-Konzentrat verstärkt	34	190
R 4		120—132	206—224

As it is well known the quality [1, 2] and the intensity "14" of these applied coolants greatly influences the cutting forces and the tool life of the tools.

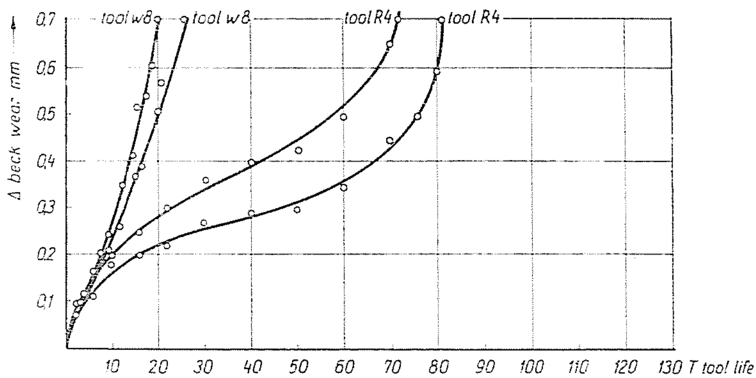

Fig. 7

Various sorts of coolants have been investigated in practice [15, 16, 17, 18]. Three important requirements are to be considered in the case of cutting fluids.

a) Cooling of the tool and the workpiece

b) decreasing the friction between the tool and the chip,

c) flushing the chips away out of the cutting zone. As it is well known, heat is developed by plastic deformation at the shearplane and that due to friction. Thus the applied coolants must carry away either the heat or lubricate the chip-tool utterface.

Water has the best cooling effect. In accordance with some data of the technical literature at high cutting speed, higher than 122 m/min, the best tool life is given on water cooling and every additive material like oils reduce the cooling effect [19]. The oil has the best lubricating effect. But due to the high temperature and the fresh metal surface produced by the cutting process the lubricating effect is not the same as can be seen at lubricating details [15, 16]. The solid being in contact with the gas and liquid can be considered as a free energy carrier, which absorbs the molecules of the agent in contact — air or oil. This way an absorption layer arises which hinders the welding joint of the particle of the tool and the chip. As the affinity of the air is greater, the coolant mixed with air can stick more strongly to the surface [20].

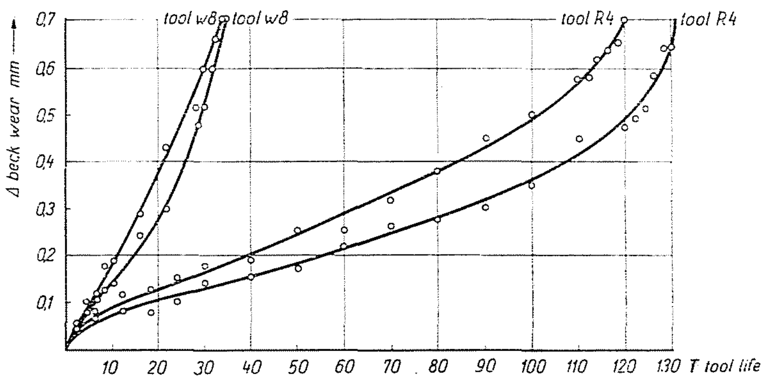

Fig. 8

The main parts of the coolants used in practice are water performing cooling and oil performing lubricating but various cutting fluids are transferred to them for protection against corrosion and for activating the above-mentioned absorption.

On the base of our tests it can be stated that the chlorine is the best additive for tapping with such conditions as mentioned above [4]. Mineral oils with artificially produced chlorine additives like "HDS-Konzentrat verstärkt" increase tool life in comparison to coolants as emulsion. The increase of tool life was 94 per cent at tools of tool steel and 106—124 per cent at tools of high speed steel i.e. the increase in tool life was about double.

4. Summary

The present paper contains the results of the experiments for finding the best auxiliary product. The technological data which are optimal from the viewpoint of tool life are determined for some given tools, and a method of measuring the cutting torque at tapping is given. From the results of the life tests made by means of native standardized tools of tool steel and high speed steel it can be seen that from the five auxiliary products applied at the experiments — each of various compositions — the one produced synthetically, containing chlorine in large quant'ty, was found to be the best.

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