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The Wearing And Durability Of Curve-Edged Auger Bits

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Abstract

Analyzing the criteria which stood behind cutting conditions optimization, the conclusion was that the most important criteria is the durability of the drill. Between many ways that can be followed to increase the tool resistance to wear, the most economic one is to improve the geometry of the drill. The paper presents the results of the experimental research, results which confirm that helicoidal drills with curved cutting edges have the well known advantage of a constant specific energetic load along the cutting edge. This property leads to a uniform distribution of the wear along the cutting edge, resulting in increased tool durability.

1. General issues

The wearing of the edged tool is a complex process of gradual removal, during cutting, of a certain amount of material from its actives surfaces, due to high pressure and temperature in the cutting area.

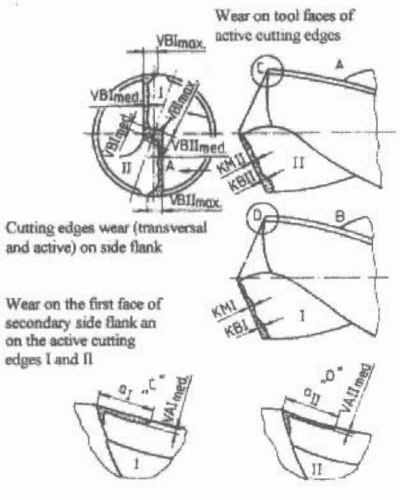


Fig. 1. Wearing types

When this happens, it causes a change in the geometry of the auger bit and the depletion of its cutting abilities. As for drills, the most frequently met wearing mechanisms are:

- wearing due to mechanical request;
- adherence wearing;
- abrasion wearing.

According to STAS 12046/1-81, we have the following wearing types in an auger bit (figure 1):

- the wearing of the back edge, (VB) criterion;
- the wearing of both back edge and front face, (KM) criterion;
- the wearing of the junction area for main and side cutting edge;
- the wearing of the cross-cut edge;
- the wearing of the main facets.

The wearing on the front face, at the drill point, causes great material losses while resharpening.

The wearing of the facets on the side back edges leads to a direct tapering which can cause the jamming of the drill into the bore and then its breaking. The wearing of the cross-cut edge leads to an incredible increase of the axial force. Some values indicated for the normal wearing of auger bits [10] and [17] can be found in table 1.

The value of the axial force, which is due 50 – 60 % to the action of the cross-cut edge, is influenced even more by its wearing, and the value of the moment of torsion is influenced more by the wearing of the main cutter's back edge, the one that leads to the shut down of drills. Experimental research have proven that, there is a linear dependence between the moment of torsion and the wearing on the back edge, something like

$$M_t = M_0 + bVB, \quad (1)$$

where:

M_0 – is the moment of torsion obtained with the newly - sharpened tool;

VB – the average wearing on the main back edge;

B – The constant which depends on the processed material.

drills. The friction coefficient was calculated according to the relation

$$\mu = 1 - tg(\varphi - \gamma_n) \quad (3)$$

where:

φ - is the yawing angles;

γ_n – the normal rake.

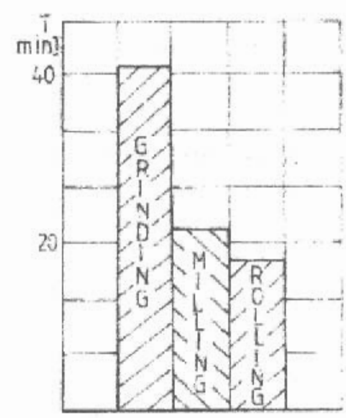
Table 1

Tool material	Processed material	The wearing criterion	Drill diameter [mm]	Admissible wearing [mm]
HSS high-speed steel	steel	On the back edge	< 20	0.4 - 0.8
			> 20	0.8 - 1.2
	cast iron	Corner wearing	< 20	0.6 - 1.8
			> 20	0.8 - 1.2

The wearing of the drill decreases its durability and influences negatively the processing accuracy. A complete relation of durability [19], depending on the parameters of the cutting process, is given by

$$T_{ef} = \frac{C_T}{\tau^{m_T} t^{x_T} s^{y_T} v_{as}^{\ z} \gamma^{-n_T} \alpha^{-n_T} \chi^{w_T} \sigma_{\varepsilon}^{\ -u_T}}, \quad (2)$$

Where σ is the fracture strength of the material to be processed in [N/mm^2], the rest of the parameters known. The quality of the material from which drills are made influences the durability of the tool. Comparative experimental research with drills made of different materials, in crude iron processing have shown that around high speed (v>40 m/min), the durability of the tool decreases rapidly for all types of steel and that there is an optimal speed which ensures maximum durability for the drill. Drills manufacture technique also influences durability. Research [6], [22] have proven that, in equal conditions, the durability of channels grinding is twice as big as that of drills with channels milling and 1.8 times bigger than the one of the drills with channels rolling with plasticity deformation (figure 2). An enhanced durability can be explained by enhancing its characteristic resistance and by improving the quality of the superficial layer of the tool's material. With grinding drills, the hardness (see table 2) measured on the facets, channel and core is much bigger than in the other situations. Since drill hardness is bigger on facets, these will have a bigger durability. Rectified drills have the smallest friction coefficient between the chip and the channel, bigger yawing angles, internal tensions in the material of smaller



(2)

Fig. 2. The value of durability for different means of creating auger channels

In Table 3, we have the values of the friction coefficient between the stall and the front face, for different means of creating auger channels for evacuating the stalls and in table 4 the durability values for 5 mm and 9 mm diameter drills respectively [6]. The creation of the chip breaking channels [11] or the finding of some means of quick stall evacuation through the drill channels, the axial vibrodrilling, reverse drilling [7] lower the temperature in the stall forming area, decrease drill wearing, thus enhancing durability.

Drill rigidity during cutting influence its durability. A big length of support from the drill point to the jig device lowers durability, especially for small-diameter drills.

Constructive geometrical parameters have been improved - as far as drill durability is concerned - for particular processing situations [7], [22].

Table 2

Drill channel creation method	Micro hardness Vickers [daN/mm^2]		
	Channel	Facet	Core
Grinding	883	856	884
Milling	846	743	900
Rolling	704	630	941

Table 3

Drill channel creation method	φ [°]	γ_n [°]	Friction coefficient μ
grinding	37°	26°	0.81
milling	27°	36°	1.16
rolling	21°	40°	1.34

Table 4

Drill channel creation method	Drill diameter (mm)	Durability (min)	The cutting axial force [daN]	Moment of torsion [daN.m]
grinding	5	66.3	82.2	11.8
milling	5	32.8	82.2	11.6
rolling	5	22.9	121.4	13.1
grinding	9	44.6	233	68.4
milling	9	12.9	257	70.4
rolling	9	6.8	324	70

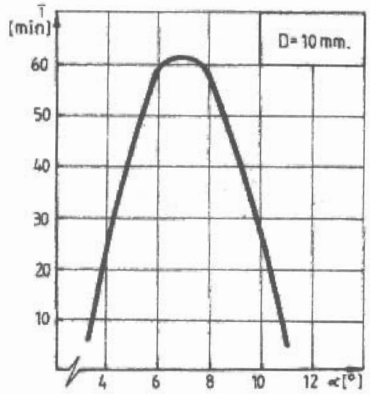


Fig. 3. The influence of the value angle of clearance on drill durability

The value of the repose angle mainly influences [5] tool durability (see figure 3). The elements of the cutting process have optimal values that ensure the tool's maximum durability for particular situations. Garina, T. I. [12] has determined the influence of the rate of cutting and of feed (figure 4) on small-diameter steel drilling durability.

Another factor that influences drill durability is the depth of the processing bore (figure 5), its increase worsening conditions for the stall evacuation and cooling-lubricating of the drill's cutting edge [14].

Experimental theoretical research [13], [16] have shown that the backing-off of drill facets can determine an increase in its durability.

Cutting fluids have a great influence on the drill's durability, relieving stall evacuation and the decrease in heat transfer from stall to tool.

Many studies [10], [17] have analyzed the influence of cutting fluids on a drill's durability.

Cross-cut edge is unsatisfactorily moisture [21] and this is why certain solutions to this have been offered, such as: introducing the cutting fluid through internal channels of the drill; the value of facet height and channel width; vibration cutting; changing the section of the stall evacuation channel.

Cutting fluids decrease the intensity of facets wearing by (10 ÷ 100) times, and the edge wearing can be thus twice reduced [15].

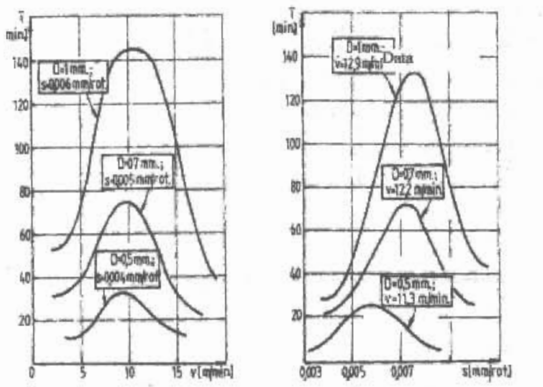


Fig. 4. The influence of the rate of cutting and of feed on durability

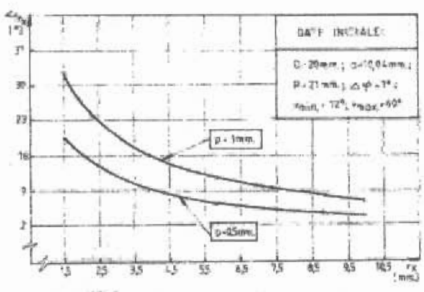


Fig. 5. The influence of the depth of the processing bore on durability

2. Methodology and experimental results

Comparative experimental research on the durability of curve-edged drills and standard drills was conducted in order to verify the hypothesis according to which the constant energetic loading of main cutting edges [10], [17] determines their usage manner and implicitly the increase of drill durability.

The durability tests have been made on curve-edged and standard, 20 mm diameter drills.

It has thus been determined the durability of drills when processing the following materials:

- OL 52, STAS 500/1-2-80 (0.18 % C, 1.43 % Mn, 0.42 % Si, 0.04 % P, 0.05 % S), with 143 HB hardness, in the shape of test rods measuring $(200 \times 200 \times 50)$ mm;
- OLC 45 STAS 880-80 (0.46 % C; 0.67 % Mn; 0.22 % Si), 195 HB hardness, in the shape of control cylinders (Φ 160×50) mm;
- FC 250 STAS 568-75 (3,1 % C; 1,5 % Si; 0,9 % Mn; 0.2 % P; 0.12 % S; 0,3 % Cr), 205 HB hardness, plate moulded $(250 \times 200 \times 35)$mm.

Since at great rates of cutting drill durability decreases substantially [12], no matter the quality of their material, the long term method has been chosen for the comparative analysis of the durability of curve-edged and standard drills. When drilling steel, the depth of the holes was of 30mm, in order to get rid of stall compaction in the drill channels, and when processing crude iron the holes were pushed through/penetrated.

For cooling they used a mixture of 5 % water emulsifying oil (STAS 2591/1-79) at a delivery of 6 l/min. The criterion for the back edge wearing V_B, was at the basis of the comparative study of the wearing resistance of curve—edged and standard drills.

3. Interpreting the results

In Fig. 6 ... 8, we see the experimentally determined relation wearing-time, for Φ 20 mm drills and the materials OL 52, 40 Cr 10 and Fc 250. Analysing the relations wearing-time, we notice that, for a V_B = 0,2 mm wearing criterion, the durability of curve-edged drills sharpened according to the established methods is (6÷10) times bigger than the durability of standard drills, as a result of the specific method in which the main, curvilinear cutting edge detects stalls and precisely small peripheral stalls.

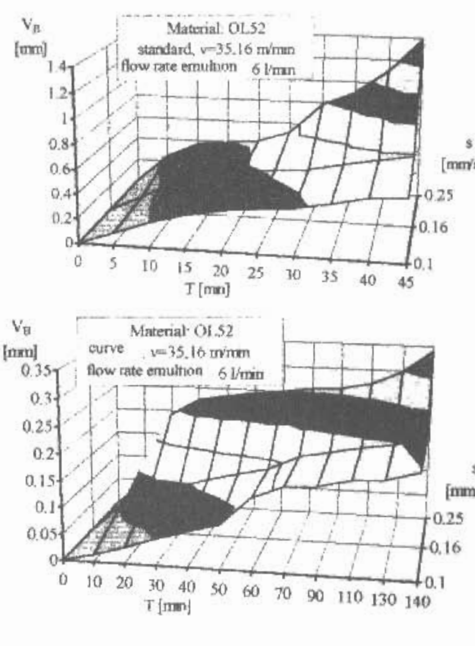


Fig. 6. The relation between wearing (V_B criterion) and time for steel drilling OL 52

The wearing of the main cutting edge is more obvious towards the axis of the drill because there the width of the stall increases and the cooling process is unsatisfactory.

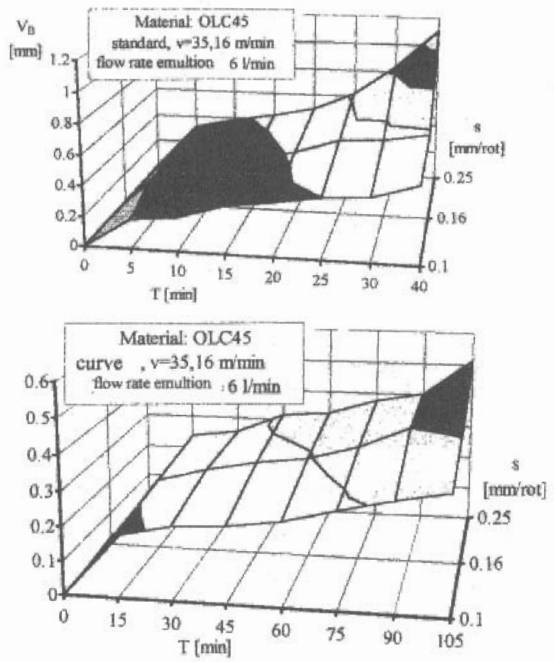


Fig. 7. The relation between wearing (V_B criterion) and time for steel drilling OLC 45

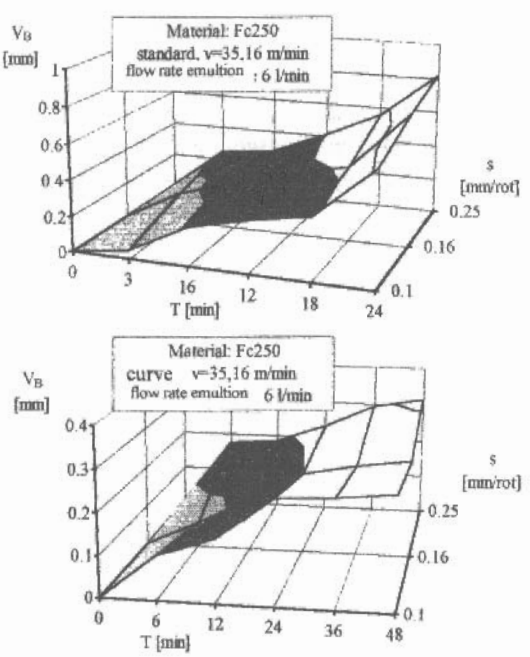


Fig. 8. The relation between wearing (V_B criterion) and time for crude iron drilling Fc 250

The increase of the feed determines the increase of the width of the stall detached from the peripheral drill points and, consequently, the reduction of the difference between the durability of curve-edged and standard drills (see figure 9).

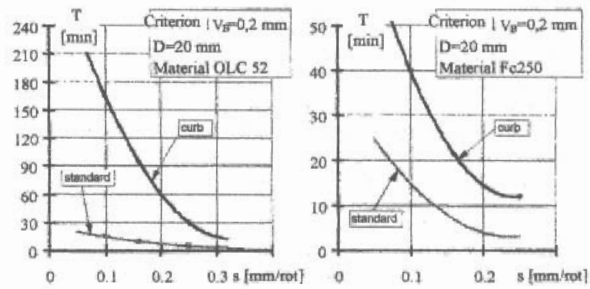


Fig. 9. The relation durability-feed for OL 52 steel, V_B = 0.2 mm criterion

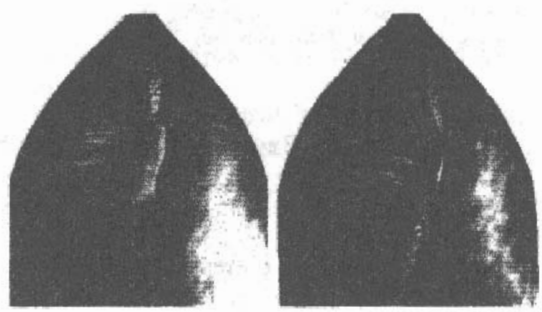


Fig. 10. Worn drills (20 mm diameter, processed material – OLC 45)

In figure 10 we can see curve-edged auger bits, with a 20 mm diameter, worn, when processing OLC 45 steel.

4. Conclusions

Comparative experimental research on curve-edged and standard drill durability has allowed the highlighting of the following aspects:

- the durability of curve-edged drills is much bigger than that of standard drills, when processing both steel and crude iron;
- the wearing of the cross-cut edge is the one that shuts down the curve-edged drills;
- the increase of feed value determines a decrease in the durability of curve-edged drills.

The results of the experimental research conducted for curve-edged drills according to the methods established confirm the results obtained by previous research [4], [10] and [17].

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Uzura şi durabilitatea burghielor cu tăişuri curbe

Rezumat

Analizând criteriile care au stat la baza optimizării regimurilor de lucru, a rezultat că cel mai important criteriu este durabilitatea burghiului, iar dintre căile care pot fi urmate pentru mărirea rezistenţei la uzură a sculei, cea mai economică este îmbunătăţirea geometriei burghiului. Lucrarea prezinta rezultatele cercetarilor experimentale care atesta faptul ca burghiele elicoidale cu tăişuri curbe prezintă avantajul cunoscut al unei încărcări energetice unitare constante în lungul tăişului, lucru ce favorizează dezvoltarea unei uzuri uniforme în lungul acestuia, conducând, pe această cale, la creşterea durabilităţii.

Le port et la longévité du peu courbe-bordé de foreuse

Abstrait

L'analyse des critères qui se sont tenus derrière le découpage conditionne l'optimisation, la conclusion était que les critères les plus importants est la longévité du foret. Entre beaucoup de manières qui peuvent être suivies pour augmenter la résistance d'outil à l'usage, le plus économique doit améliorer la géométrie du foret.

Le papier présente les résultats de la recherche expérimentale, les résultats qui confirment que les exercices hélicoïdaux avec les tranchants incurvés ont l'avantage bien connu d'une charge énergique spécifique constante le long du tranchant. Cette propriété mène à une distribution uniforme de l'usage le long du tranchant, ayant pour résultat la longévité accrue d'outil.