

Methods of increasing the quality of thread pitches

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Abstract. The article considers the improvement of machining process, namely thread cutting with screw taps, improving quality and stability of roughness of the thread surfaces of high speed cutting steel tools. A scheme of magnetic abrasive polishing and a method of selecting operating conditions of screw taps machining. In the process of elaborating the conditions of the magnetic abrasive polishing process it became clear that one needs different processes for shaping major and minor cutting edges of the taper leads, the sizing parts and the lead-in sections of screw taps.

Key words: threaded joints, surface roughness, magnetic abrasive polishing, polishing conditions selection, thread quality.

INTRODUCTION

Engineering determines much of a product’s quality, especially one of the most critical components of structures: threaded joints that determine the serviceability and functional reliability of assemblies. Therefore, it is important to advance the process of machining, in particular thread cutting by screw taps, improving the quality and stability of thread surface roughness, service life and stability of thread-cutting tools made of high speed cutting steels (Grudov, 1968; Rybak et al., 1983).

It is blind holes that are mainly used in stationary engineering products. In the process of their tapping, cutting edges of taps wear severely, and sometimes chipping occurs. This results in the premature breakdown of taps and deterioration of thread surface quality. The nature of the process is caused by the following factors. When a tap stops after the thread cutting process termination, chip roots are formed in the blind hole. Under the influence of an intense heat flow generated in the process of cutting and directed mainly inside the material under processes and the cutting fluid supplied to the cutting zone, the chip roots are tempered and hardened. As the tap is unscrewed from the blind hold, each cutting edge of its taper lead must overcome the resistance of a chip root left over from the previous cutting edge. A detailed diagram of chips generation at the stages of the tap edges penetration and unscrewing is shown in Fig. 1. When the chip roots and the cut chips remaining in the cutting zone get under the form-relieved surface of the tap cutting edge, they are pinched and pressed into the processed surface, scratching the thread and distorting its profile.

As a high speed cutting tool is ground, a defective layer is formed on its working surfaces under the influence of an intense heat flow, since residential austenite and tensile stresses appear in the steel structure (Baron, 1968; Grudov, 1968). This layer

has degraded mechanical properties, it reduces the tool wear resistance and the quality of cut threads. In the process of fine and diamond grinding, the defective layer is reduced. When using taps for cutting threads in products made of high-strength steel, one needs finishing operations that improve tool surface quality and increase durability. During such tools utilisations, chips are easier removed through the flutes, cutting torque is reduced, and better quality of the thread being cut is achieved.

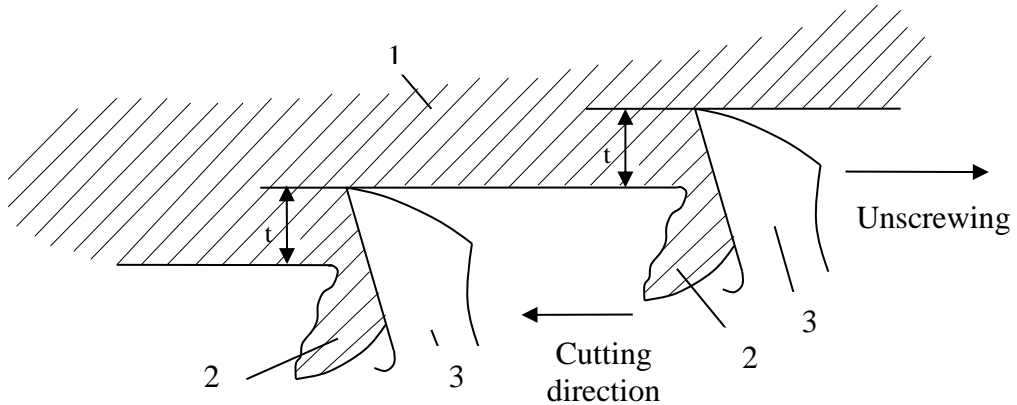


Figure 1. The diagram of chip formation at the stages of the tap teeth entrance and its unscrewing: 1 – thread surface being processed; 2 – tap tooth; 3 – residual chip root; t – cutting depth.

The analysis of existing high speed cutting steel taps finishing processes has shown that magnetic abrasive polishing (MAP) is the most acceptable and efficient option (Maksarov et al., 1987; Baron et al., 1983).

MATERIALS AND METHODS

MAP is based on mechanical removal of metal and its oxides from the surface of the tool being processed, as well as smoothing roughness by means of plastic straining with magnetic abrasive powder grains that increase their density and cling to the surface being processed.

Simultaneously with the reduction of the tool working surface roughness, MAP strengthens the subsurface layer of metal, stabilising the tool durability as a result of residential austenite breakdown and the formation of high-alloy martensite with carbide precipitates, as well as the appearance of compression stresses that do not disappear when the tool is heated up to the temperature of 500...550 °C (Grudov, 1968).

The layout of the installation used for the MAP of taps is shown in Fig. 2. The installation consists of a mod. 675 vertical milling machine with two magnetic coils installed on its frame. Current strength can be adjusted within the range of 0...20 A. The installation design permits the tap being processed to make three movements at the same time: to oscillate piston-wise in the axial direction, to rotate about its axis and to advance in the plane being perpendicular to the magnetic field direction.

Powders based on titanium and iron carbides (TU 6-09-03-483-88) and Ferroobraz-3 ferromagnetic abrasive (TU 065.39-82) used as magnetic abrasive powders acting as non-rigid cutting tools in the process of taps MAP had various grain size: -100...+40, -160...+100, and -320...+160.

Exploration of M6...M52 taps MAP permitted us to find out that the intensity of material removal and the processed surfaces quality are influenced by such factors as the composition of magnetic abrasive power and its grain size, the high speed cutting steel grade, the original surface roughness and the machining conditions.

Experimental research permitted us to select optimum conditions for the MAP of taps: amplitude of spindle axial oscillations $A = 2.5$ mm; spindle rotation speed $n = 630$ rpm; transverse advance of the tap along the magnetic tips $s = 82$ mm min⁻¹; magnetic induction $B = 1$ Wb (m²)⁻¹, clearance between the tap surface being processed and the magnetic tip $\delta = 1$ mm.

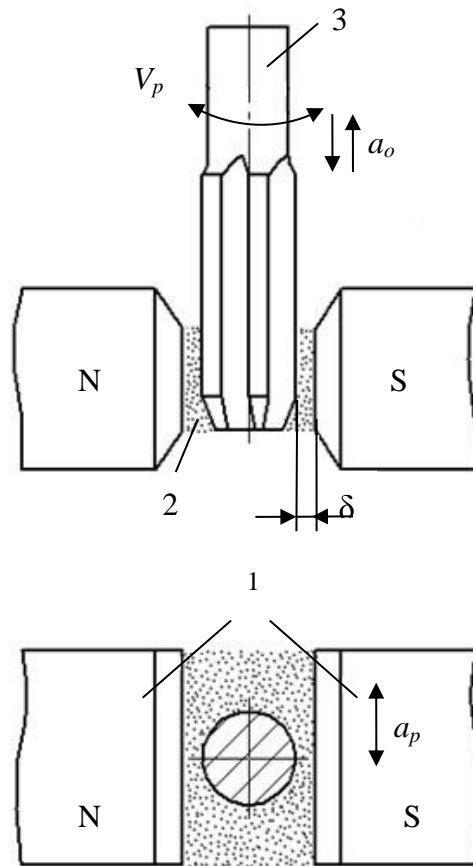


Figure 2. The diagram of taps magnetic abrasive polishing: 1 – electromagnet poles; 2 – magnetic abrasive powder; 3 – tap; a_o – oscillation amplitude, a_p – tap advance, δ – clearance between the pole and the tool.

Experimentally selected polishing conditions remained unchanged throughout the explorations. It was found out that Ferroobraz-3 powder having $-160...+100\ \mu\text{m}$ grain size is the most efficient one for processing M6...M52 taps: it ensures maximum smoothing of roughness of the tap surface being processed with minimum number of passes. Powder clinging to the complex profile of the tool is minimal as well.

EGT grade emulsion used as lubricating fluid at taps MAP stage was a coolant and also a medium for surface active agents that dissolved the ferromagnetic base of powder grains, increasing the powder service life.

The process of tap lead-in MAP in both directions of its rotation permits to round off the major and minor tap cutting edges, easing chips removal through flutes substantially, reduces cutting torque and does not deteriorate the quality of threads being cut at the unscrewing stage (Fig. 3).

In the process of analysing MAP temporal parameters it was found out that optimum conditions of taps preparation are determined to a significant extent by the type of the hole being threaded. This is caused by different conditions of chips removal and removal of the tool from the processing zone. Diagrams of taps preparations for threading open-end (a) and blind (b) holes are shown in Fig. 4. Arrows in the areas of the tap taper lead, sizing part and lead-in portion show the tool rotation directions in the process of MAP in relation to its axis and the optimum polishing time for a M36X4 tap.

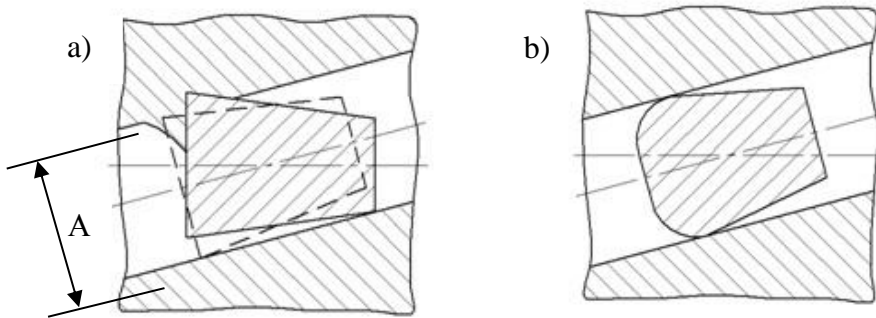


Figure 3. Influence of the shape of the tap drive portion teeth on undercutting the hole thread in the process of lateral backing-off. a – unilateral (direct), A – the size of the tooth profile; b – bilateral with the help of magnetic abrasive polishing

RESULTS AND DISCUSSION

Comparative tests were performed on a 2B660F1 model milling machine with the utilisation of a standard set of taps made of R6M5 grade steel and one finishing tap prepared in accordance with the technique described above. The tap processed by MAP had the following geometric parameters: $\alpha = 6^\circ$, $\gamma = 5^\circ$, $\omega = 0^\circ$, $\varphi = 13^\circ$ and clearance $\delta = 0.26\ \text{mm}$. The reverse taper of the tap amounted to 0.10 mm per 100 mm of length. The roughness of the surface of the tap working part measured with the help of a Surktronik-3 instrument manufactured by Rank-Jaulor-Hobson (UK) amounted to $Ra = 0.5\ \mu\text{m}$.

M36x4-7H thread was cut in 336 blind holes of a pressure compensator lower housing with the tool rotation speed $n = 27$ rpm and coolant supply under pressure of 4 MPa. Test results have demonstrated that the utilisation of an experimental tap processed with MAP reduces thread surface roughness by 1.6...2.5 μm as compared to a standard set of three taps. Subsequent burnishing ensures obtaining roughness within the range of 0.8...1.25 μm , i.e. meeting the limits of specifications. Besides, experimental taps utilisation increases cutting tools durability 2...3 times, saves considerable amounts of high speed cutting steel, reduces labour intensity, and improves threaded joints quality.

CONCLUSIONS

It is feasible to use magnetic abrasive polishing of taps intended for cutting thread in heavy-duty materials.

It was found out that Ferroobraz-3 powder having -160...+100 μm grain size is the most efficient one for processing M6...M52 taps, ensuring maximum smoothing of roughness of the tap surface being processed with minimum number of passes. Powder clinging to the complex profile of the tool remains minimal as well.

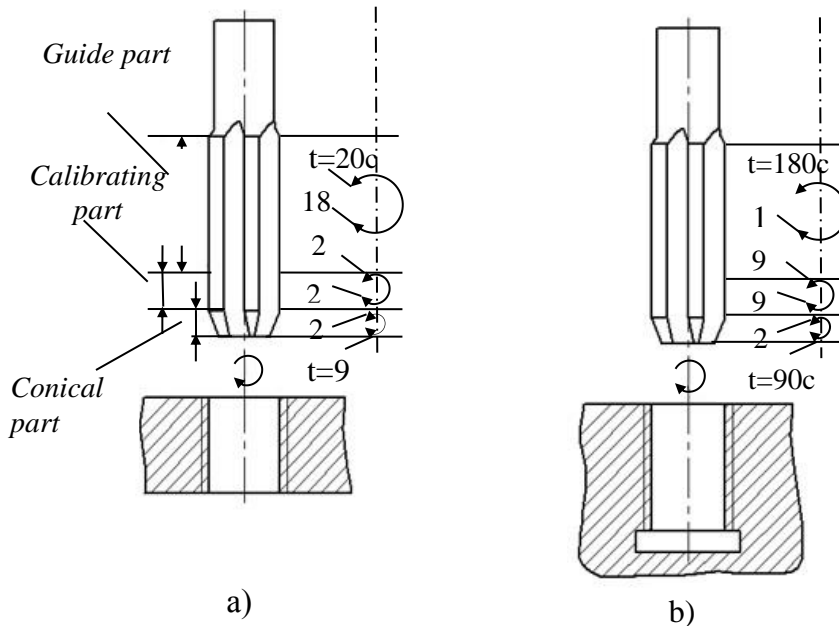


Figure 4. The procedure of taps preparation for threading open-end (a) and blind (b) holes.

The techniques of magnetic abrasive polishing of the taper lead, sizing part and lead-in section of taps must be different.

The process of taps lead-in MAP in both directions of their rotation permits to round off major and minor tap cutting edges, easing chips removal through flutes substantially, reduces cutting torque and does not deteriorate the quality of threads being cut at the unscrewing stage (Fig. 3).

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