Effect of Hydraulic Oil Entering the Cutting Fluid on the Tool Life and Roughness in Turning of Stainless Steel

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The use of cutting fluid should positively influence on the quality of the machined surfaces and durability of cutting tools. However, during the machining the oil from the hydraulic system of the machine often gets into the cutting fluid, which can alter the properties of the cutting fluid. In scientific literature there is no information about the effect of the hydraulic oil entering the cutting fluid on the tool life and roughness in turning. In this regard, at the laboratory of the Department of Machining and Assembly of the Technical University of Liberec, there has been conducted a study to ascertain the effects of hydraulic oil getting into different types of cutting fluids during the turning of stainless steel.

Keywords: Turning, Cutting fluid, Wear, Roughness

1 Introduction

The use of different methods of cooling the tool and the workpiece in metal cutting can increase cutting tool life and reduce the roughness of the machined surface with different types of machining [1-12]. However, often, if not always, the oil from the hydraulic system of the machine gets into the cutting fluid, which can alter the properties of the cutting fluid. In this regard, at the laboratory of the Department of Machining and Assembly of the Technical University of Liberec, there has been conducted a study to ascertain the effects of hydraulic oil getting into different types of cutting fluids during the milling of stainless steel [13]. A survey of literature has revealed that no studies have been devoted to determining the effect of the hydraulic oil entering the cutting fluid, on tool life and surface roughness in turning. Thus, the scientific interest lies in the determination of the effect of certain concentrations of hydraulic oil entering different types of cutting fluids, on tool life and surface roughness in turning.

The experiments performed at the laboratory of the Department of Machining and Assembly of the Technical University of Liberec guaranteed identical processing conditions and reliability of results.

2 Experimental procedures

In order to determine tool life when using different cutting fluids, the experiments were carried out by turning on the CNC turning machine CHEVALIER FC-2140.

The PRAMET TOOLS cutter CTAPR 2020 K16 with a cutting plate TPUN 160304 of hard alloy 8230ISO M20-35 with coating was used.

The cutter CTAPR 2020 K16 used for turning was by the company Pramet Tools l.t.d. Turning of the stainless steel X5CrNi18-10 (259 HB) was performed with the cutting inserts TPUN 160304 of hard alloy 8230 (M20 – M35) with coating by the company Pramet Tools l.t.d., at a cutting speed of v_c = 250 m/min, feed f = 0.1 mm/rot, depth of cut a_p = 1 mm.

Each cutting edge was worn on the back surface to 0.5 mm. To determine the average resistance value each experiment was repeated 5 times. Wear of the back surface was measured by using a Brinell Magnifier tool (magnification 24x, accuracy 0.05 mm).

We used three different types of cutting fluids: Hocut emulsion based on mineral oil, the synthetic cutting fluid Grindex, and the semi-synthetic cutting fluid Zubora. For all machining experiments, 5% solution of water and an emulsion concentrate was prepared. The cutting fluid concentration was controlled by the refractometer Optech Brix RLC / ATC, characterized by concentration measurement at a range of 0-18% and accuracy of 0.1%. The desired value for each fluid was calculated by the refractometer K using the following formula: K = 5/In, with 5 being the required concentration of 5%, and In being the refraction index whose value was provided by the cutting fluid manufacturer.

The hydraulic oil Paramo HM 46 was added to each cutting fluid. The mixing of 5% cutting fluids and hydraulic oil was performed in the tank of the cooling system of the turning machine CHEVALIER FC-2140 **(Fig. 1)**. Different amounts of hydraulic oil were added to the same amount of cutting fluid, thus providing different concentrations of the hydraulic oil in the cutting fluid.

Experiments were conducted with four states of the cutting fluids, namely without hydraulic oil in the cutting fluid; with hydraulic oil concentration of 13 ml per 1 l of cutting fluid; with hydraulic oil concentration of 26 ml per 1 l of cutting fluid; and with hydraulic oil concentration of 39 ml per 1 l of cutting fluid. After standing, the hydraulic oil covered the surface of the cutting fluid.

Roughness measurements were performed by a profilometer MITUTOYO Surflest SV-2000 N2. Each measurement of roughness was repeated 10 times, and based on this the average force value was determined. Roughness parameters were measured in the direction perpendicular to the cutting direction.

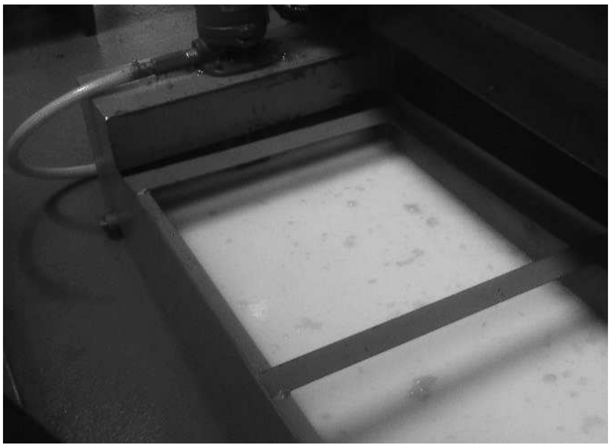

Fig. 1 Cooling system of the turning machine CHEVALIER FC-2140

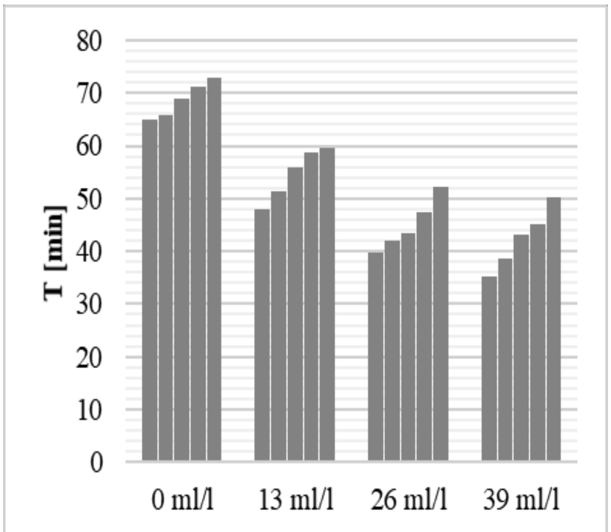

Fig. 2 The effect of hydraulic oil content (ml/l) in the Hocut emulsion on tool life T

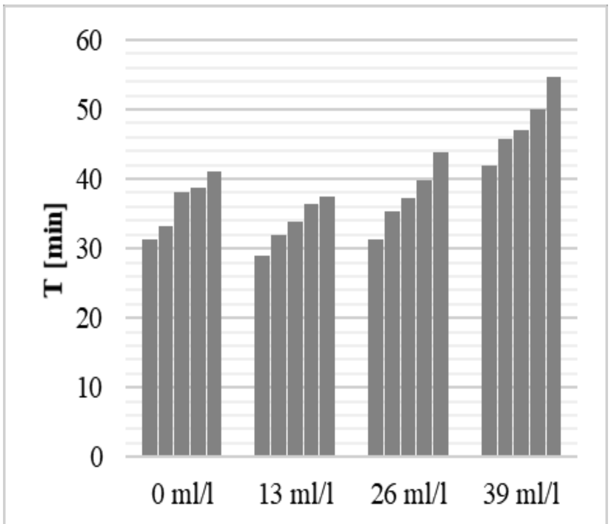

Fig. 3 The effect of hydraulic oil content (ml/l) in the synthetic Grindex cutting fluid on tool

life T

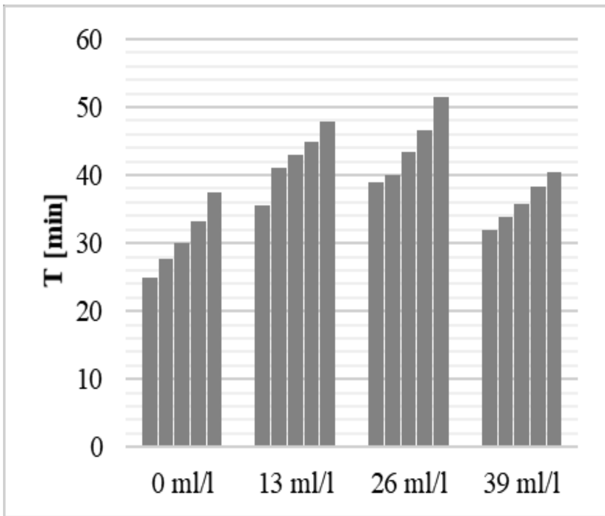

Fig. 4 The effect of hydraulic oil content (ml/l) in the semi-synthetic Zubora cutting fluid on tool life T

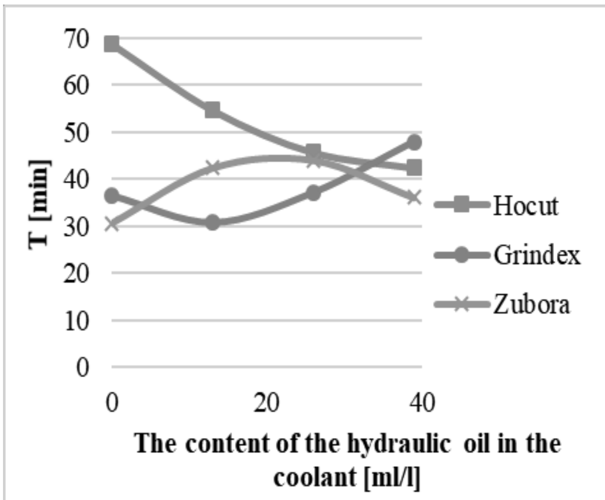

Fig. 5 The effect of hydraulic oil content in different cutting fluids on tool life T

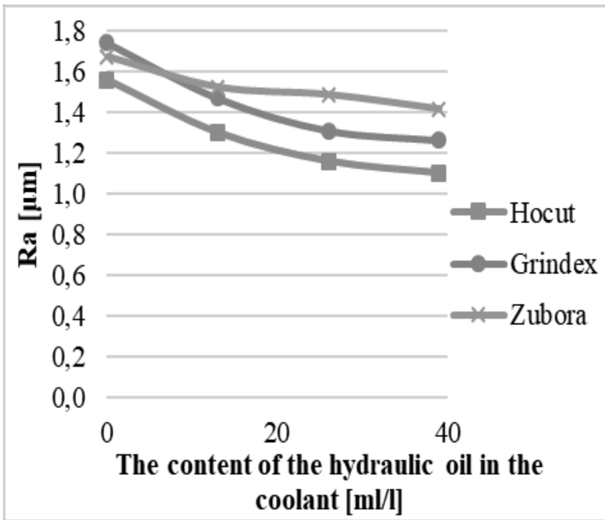

Fig. 6 The effect of hydraulic oil content in different cutting fluids on parameter Ra

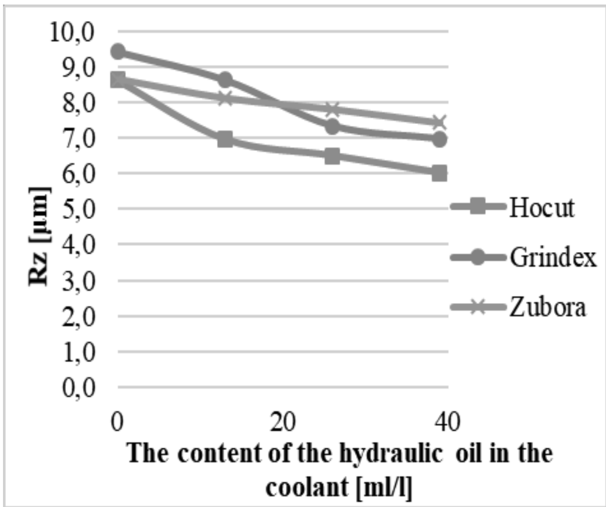

Fig. 7 *The effect of hydraulic oil content in different cutting fluids on parameter Rz*

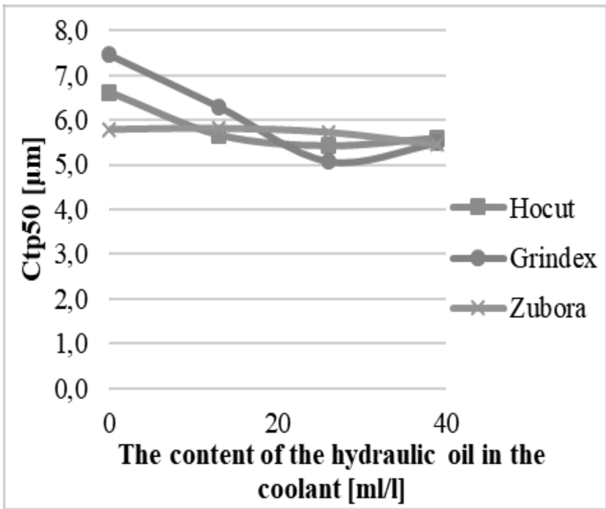

Fig. 8 *The effect of hydraulic oil content in different cutting fluids on parameter Ctp50*

3 Experimental results and analysis

The experiments have shown that the 13ml/l penetration of hydraulic oil in the Hocut emulsion 20% reduced the tool life; the 26 ml/l increase of hydraulic oil concentration resulted in a 35% tool life decrease; and the 39 ml/l of concentration resulted in a 38% tool life reduction **(Fig. 2)**. It means that the concentration of 5% is optimal for the Hocut emulsion and the growth of hydraulic oil's concentration reduces the tool life. Thus, addition of hydraulic oil in the Hocut emulsion reduces tool life, possibly, because of decreasing cooling effect of the cutting fluid.

It has been established that the penetration of hydraulic oil in the synthetic cutting fluid Grindex with a concentration of 39 ml/l showed result in a significant 31% tool life gain **(Fig. 3)**. It can be assumed that the synthetic cutting fluid Grindex don't provide high lubricating properties and the growth of hydraulic oil's concentration does increase of these properties and of the tool life. It means that it is possible to get better lubricating properties of the synthetic cutting fluid Grindex by increasing of the hydraulic oil's concentration.

The experiments have shown that the penetration of hydraulic oil in the semi-synthetic cutting fluid Zubora with a concentration of 13ml/l resulted in a 38% tool life gain; the increase in hydraulic oil concentration to 26 ml/l resulted in a 43% tool life gain; and the increase of concentration to 39 ml/l gave 18% tool life gain **(Fig. 4)**. It means that it is possible to increase the lubricating properties of the semi-synthetic cutting fluid Zubora by increasing of the hydraulic oil's concentration (13-26ml/l), possibly, because of increasing lubricating effect of the cutting fluid. Addition more hydraulic oil (39 ml/l) reduces tool life, possibly, because of decreasing cooling effect of the cutting fluid.

The comparative analysis has shown that when the oil from the hydraulic system of the machine is not present in the cutting fluid, the greatest tool life is provided by Hocut emulsion. The use of the synthetic cutting fluid Grindex leads to a 47% reduction in tool life, and the use of the semi-synthetic cutting fluid *Zubora* reduces tool life for 55%. For the 39 ml/l concentration of hydraulic oil in the cutting fluid the best results in cutting tool life showed synthetic cutting fluid Grindex. The use of the Hocut emulsion resulted in a 11% tool life decrease while when using the semi-synthetic Zubora cutting fluid the tool life is reduced by 25% **(Fig. 5)**.

It has been established that when the oil from the hydraulic system of the machine is not present in the cutting fluid, the lowest roughness parameter *Ra* is provided using the Hocut emulsion cutting fluid. The use of the synthetic Grindex cutting fluid increases the roughness parameter *Ra* by 12%, and the use of the semi-synthetic Zubora cutting fluid increases the roughness parameter *Ra* by 7%. For the 39 ml/l concentration of hydraulic oil in the cutting fluid, the use of the Hocut emulsion produce the best roughness parameter *Ra.* Use of the synthetic cutting fluid Grindex increases the roughness parameter by the 15%, while the use of the semi-synthetic Zubora cutting fluid increases the roughness parameter by 28% **(Fig. 6)**.

The studies have shown that when there is no oil in the cutting fluid, the use of the semi-synthetic cutting fluid Zubora and the Hocut emulsion cutting fluid produces approximately the same roughness parameter *Rz*, while the use of the synthetic Grindex fluid increases the roughness parameter by 10%. For the 39 ml/l concentration of hydraulic oil in the cutting fluid, the lowest roughness parameter *Rz* is provided using the Hocut emulsion. The use of the synthetic Grindex cutting fluid increases the roughness parameter *Rz* by 16%, and the use of the semi-synthetic Zubora cutting fluid increases the roughness parameter *Rz* by 23% **(Fig. 7)**.

The comparative analysis has shown that when the oil from the hydraulic system of the machine is not present in the cutting fluid, the lowest roughness parameter *Ctp50* is provided using the semi-synthetic Zubora cutting fluid. The use of the Hocut emulsion increases the roughness parameter *Ctp50* by 14%, and the use of the synthetic Grindex cutting fluid increases the roughness parameter *Ctp50* by 29%. For the 39 ml/l concentration of hydraulic oil all cutting fluids produces approximately the same roughness parameter c_{tp50} **(Fig. 8)**.

4 Conclusion

The studies have shown that the penetration of the oil from the hydraulic system of the machine in the synthetic cutting fluid and semi-synthetic cutting fluid does not cause deterioration of the cutting tool life, and does not increase the roughness parameters of the machined surface.

It has been established that the penetration of the oil from the hydraulic system of the machine in the emulsion reduces the cutting tool life, and does not increase the roughness parameters of the machined surface.

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