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INFLUENCE OF COOLING FLUID APPLICATION ON TOOL WEAR DURING MACHINING OF HARDENED CHROME NICKEL STEEL

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ABSTRACT
Influence of cooling fluid application on the tool wear, during longitudinal turning of hardened chrome nickel steel, on the basis of experimental investigations is presented in this paper. Cutting tool wear investigation through comparation dry machining and machining by cooling fluid application, for the same other machining conditions, are conducted. Tool wear size, tool wear shape and cutting tool life are taken into account by cutting tool wear investigation. Analysis of experimental results showed inverse proportion between coolig fluid application and flank wear size, as well as significance of influence on tool wear and its characteristics, via the flank wear shape. Also, analysis of experimental results showed significance of influence coolig fluid application on increase of cutting tool life.

Key words: turning of hardened steel, tool wear size, tool wear shape, cutting tool life

1. INTRODUCTION
Machining of hardened materials, in the most cases, without cooling fluid application are performed. As for ecological aspect, it is one of the most advantage of this machining process with regard to conventional machining processes. Scientific papers that explore these issues, as well as manufacturers of cutting tools for this type of application processing, mainly favored treatment without the use of coolant . According to their opinion, the use of coolant does not give desired effect on the cutting process, and if the coolant is used, it only represents additional production costs.
Influence of cooling fluid application on the tool wear, during longitudinal turning of hardened chrome nickel steel, on the basis of experimental investigations is presented in this paper. Cutting tool wear investigation, through comparation dry machining and machining by cooling fluid application, for the same other machining conditions, are conducted. Tool wear size, tool wear shape and cutting tool life are taken into account by cutting tool wear investigatio. Analysis of experimental results showed inverse proportion between cooling fluid application and flank wear size, as well as significance influence on tool wear and its characteristics, via the flank wear shape. Also, analysis of

experimental results showed significance influence of cooling fluid application on increase of cutting tool life.

2. EXPERIMENTAL WORK

Experimental wear tests were carried out for longitudinal turning process for dry machining and machining by cooling fluid application and with appropriate repetitions. The work piece material used in this research was high alloyed tool steel X155CrVMo12. Hardness of work piece materials after heat treatment was within the boundaries 62 - 64 HRC, with austenite-martensite microstructure. The tool used in experimental tool wear tests was ceramic cutting insert CNGA 120408T, catalogue mark IN22 Al_2O_3-TiCN.

Tool flank wear curves, as a function of cutting time, during dry longitudinal turning of hardened chrome nickel steels, for three repetitions, are shown on Figure 1. Tool flank wear curves shown some deviations as a result of uncontrolled changes during machining processes. Cutting tool flank wear was within the ranges 190 (µm) - 210 (µm), while the tool life was within the ranges 12,5 (min) – 15 (min) .

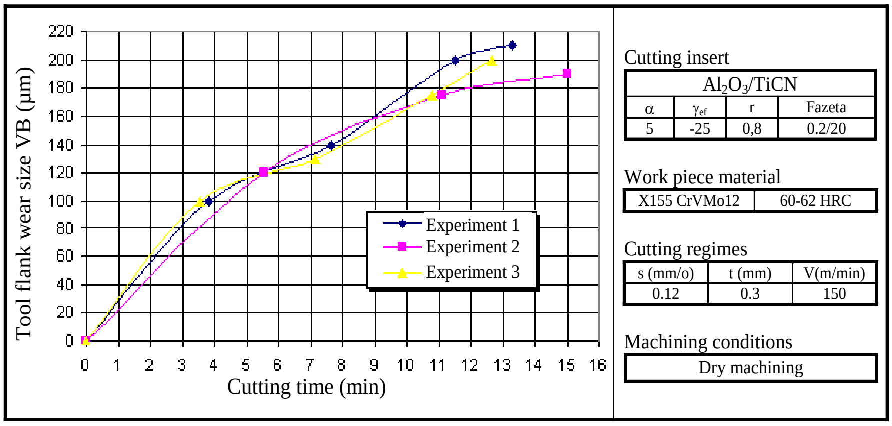

Figure 1. Tool flank wear as a function of cutting time during dry longitudinal turning

Tool flank wear curves as a function of cutting time during longitudinal turning by cooling fluid application of hardened chrome nickel steels, for three repetitions, are shown in Figure 2. Also,in this case, tool flank wear curves shown some deviations. Cutting tool flank wear was within the ranges 120 (µm) - 135 (µm), while the tool life was within the ranges 24 (min) – 30 (min).

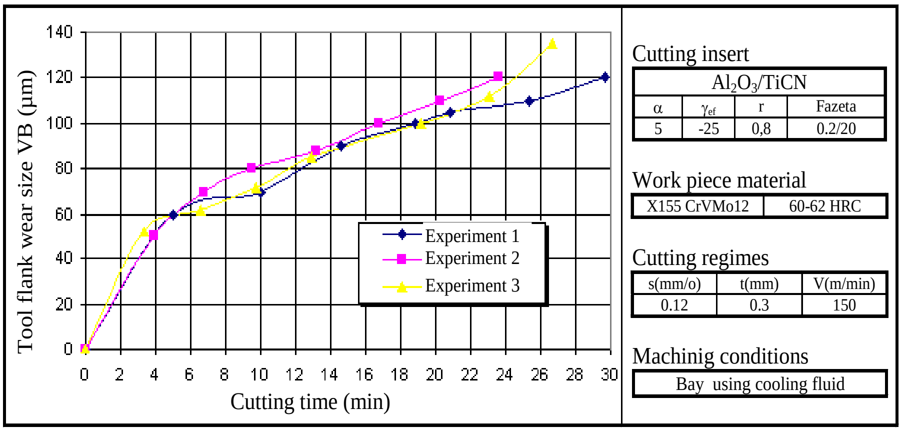

Figure 2. Tool flank wear during longitudinal turning by cooling fluid application

These variations of the curves, wich represented tool flank wear as a function of cutting time, are caused by:

- discontinuity (interruption) of the cutting process,
- irregularity in the size of dominant carbides, as well as their density in the structure of the work piece material,
- changes thermal condition on the tool-work piece interface,
- nature of uncontrolled machining factors, and so on.

However, on the basis of experimental results, it was possible with satisfactory accuracy to analysed influence cooling fluid application on the cutting tool wear. In this regard, on the Figure 3. is given comparative analyze of parameters that show intensity of tool wear and shape of tool wear as a function of cooling fluid application.

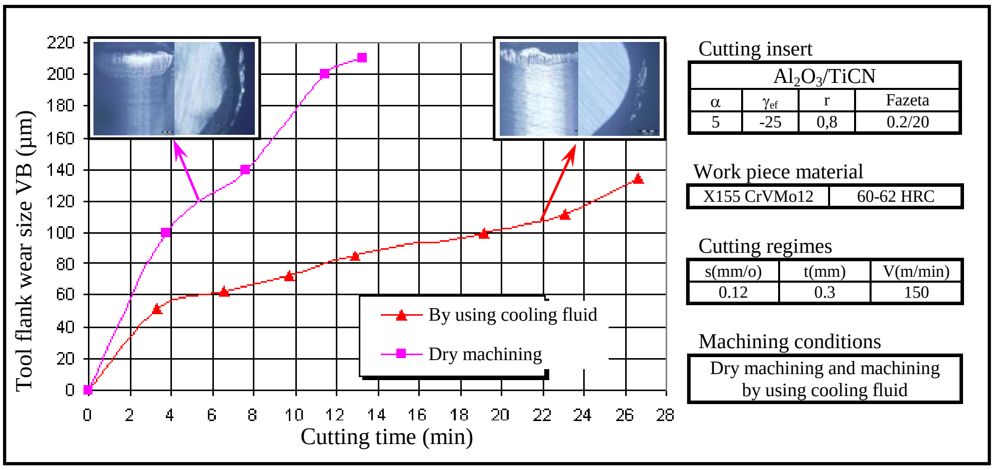

Figure 3. Comparative analysis of the tool wear in dependence on cooling fluid application

Obviously, conditions of cutting processes are different, despite a great similarity in experimental tool wear tests. The differences are presented as the cutting tool life, intensity of the tool wear, as well as the area of tool wear.

3. RESULTS AND DISCUSSION

It can be concluded that application of cooling fluid, during hardened steel cutting, significantly increases tool life (Figure 4.). In addition to intensity and tool wear size, application of cooling fluid causes changes of dominant wear mechanism and tool wear regions. This trends can be observed in micrographs (Figure 4.), as well as in the profiles of worn cutting tools contours.

In the case of dry machining, tool wear manifests through wider tool flank wear (right profile Figure 4.). On the other side, in the case of machining using cooling fluid, tool wear manifests through increased depth of crater and increased width crater on primary rake tool surface (left profile Figure 4.).

Analyzing of micrographs of worn cutting tools, which are presented in the figure 4, it can be observed widening of crater from primary to secondary rake tool surface, in the case of dry machining. Crater propagation from primary to secondary rake tool surface, in addition to ability to indicate deterioration of dimensional accuracy, it also indicates increased intensity of tool wear, in this region, which is followed by tool fracture, in the very short time. Traces of increased temperature on secondary rake tool surface, locates possible tool fracture regions, in the case of dry machining (regions **A**, Figure 4.).

These trends are not visible in the case of machining using cooling fluid. In this case, there is no visible crater widening tendency from primary to secondary rake tool surface. Also, chip removing from cutting zone is significantly improved, while influence of temperature on cutting tool is reduced. During experimental investigation, in the case of dry machining, it was noticed that accumulation of chip in the vicinity of tool/work peace interface take place after tool wear size reaches certain value. In this way, tool/work peace interface is insulated by chip, affecting on decreasing of heat dissipation from cutting zone to environment. At the same time, heat transfer through tool and work piece were raised. All this causes increasing of tool insert temperature, work piece temperature and so on, as well as intensifying of different wear tool mechanisms and reduction of dimensional accuracy.

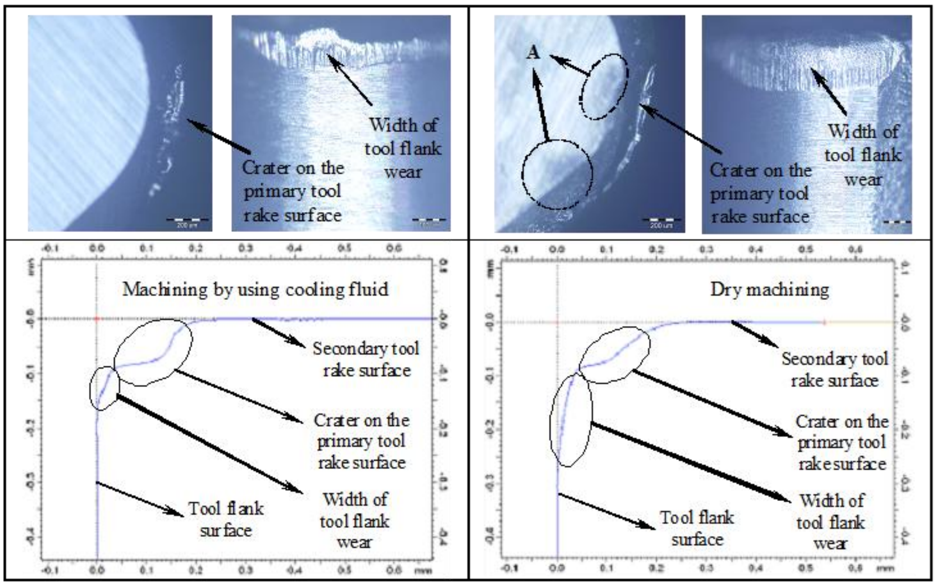

Figure 4. Micrographs and profiles of worn cutting tools in dependence on cooling fluid *application*

4. CONCLUSIONS

- Analysis of experimental results showed inverse proportion between cooling fluid application and flank wear size, as well as significance influence on tool wear and its characteristics, via the flank wear shape.
- Application of cooling fluid, during cutting of hardened steel, significantly increases tool life as well as causes changes of dominant wear mechanism and tool wear regions.
- In the case of machining using cooling fluid, tool wear manifests through increased depth of crater and increased width of crater on primary rake tool surface.
- In the case of dry machining, it can be observed widening of crater from primary to secondary rake tool surface. Crater propagation from primary to secondary rake tool surface indicates increased intensity of tool wear, in this region, which is followed by tool fracture, in the very short time.

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