THE INFLUENCE OF COOLANTS FOR METAL WORKING ON GRINDING PROCESS

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SUMMARY
Like the blood of human being, the coolant for metal working contains a lot of information about the tribological processes where it circulates. Any metal working coolant must satisfy certain fundamental requirements: removal of heat, lubrication and transport of metal removed. During the grinding process, coolant is also exposed to the changes, due to the chemical reactions between its substances, weel surfaces and workpiece, the presence of particles and the high temperatures on contact surfaces.

The aim of the study is to reduce of the failures and increase of the reliability of the machine tools. The experimental investigations were carried out on 28 grinding machines and the grinding conditions were determined using water based coolant.

Keywords: Coolants, reliability, grinding process, failure

1 INTRODUCTION
In practical industry, grinding is usually used as a final processing by which the required workpiece quality should be reached. In grinding processing, the form error of workpiece is affected by elastic and thermal deformation of machine tool and workpiece, the wear of grinding wheel and motion error of machine tool [1].

The progress made by tribology during the past twenty-five years is indeed impressive, both in technological achievement include: improved understanding of the role of lubricants and of atmospheric environment in cutting and abrasive machining processes [2]. The effectiveness of coolants has been studied in several projects and more detailed explanations can be found in [3, 4, 5, 6].

2 COOLANTS FOR METAL WORKING
The main functions of the coolants for metalworking are as follows:
- to reduce frictional heat by lubrications,
- to divert the generated heat from the workpiece and tool in an adequate flow of coolant and
- to remove the chips produced in the process initially from the cutting tool.

The recommendation of metal working coolants depends on the special application. For applications where a metalworking fluid with better lubricating properties is needed a non-water-miscible product should be recommended. In other cases with high cutting velocities a water-miscible product is often preferred due to its better cooling properties. From the maintenance point of view no-water-miscible cutting oils cause relatively few problems. They undergo a relatively slow deterioration and the only necessary maintenance is filtering. Water based coolants are liable to undergo a number of changes during the use with respect to their composition and properties which can impair the functional properties and increase the risks associated with abrasion, erosion and corrosion of tribomechanical system elements. The main influential factors in the coolant system are: particles, temperature, fluid composition and flow.

The presence of particles has a negative influence on surface quality, machine life, tool life, coolant life and for the health aspect. The temperatures rise in coolants can be quite considerable, if the machine is of the type where the coolant sump forms an integral part of the machine frame-work. An increased temperature as compared to the normal 18 - 20 °C will result in a very considerable increase in bacterial growth and problem with tolerances.

The experimental investigations were carried out on grinding machines and the grinding conditions were determined using water based coolant.

International Standard ISO 6743 / 7 establishes the detailed classification of family M (metalworking) which belongs to the class L (Lubricants, Industrial Oils and related products ) [7].

There are decentralized and centralized systems. In the first case, each machine has own coolant system which consists of: a tank, a pump, distribution plumbing and swarf tray.

Centralized systems are those in which the coolant is returned to a central unit in which it undergoes a reconditioning of some form or another before being recirculated to the individual machine tools.

3 GRINDING PROCESS
The shape and dimension of cuts on the surface are a random value and depend on the grinding wheel specification, the wear of cutting edges and cutting surface, also on the chip removal space, on the manner
and condition of grinding, as well as the ground material, the coolant, the rigidity of the grinding system and the period of the grinding contact. The grinding process efficiency depends on the chip removal space of grinding-wheel cutting surface which represents maximum volume of the removed material. The space between the cutting edges and grains, includes pores gives chip removal space. Metal removal rate is one of the most important parameter for selecting optimum condition for grinding.

Microscopic examination of grinding swarf shows the individual chips to closely resemble those formed in conventional metal cutting operations. The grinding wheel actually consists of a myriad of randomly oriented single point cutting tools.

4 EXPERIMENTAL INVESTIGATION

The experimental investigations of effect of the selection of the metalworking fluids on tribological processes of tribomechanical system elements have been carried out at a metalworking factory. The investigations were carried out on 28 grinding machines in four periods of time (I, II, III, IV), each being 2000 working hours.

In period I and III of the investigation, decentralized systems were used as coolant systems on these grinding machines. Maintenance consists only of a course individual filtering and sedimentation, in which only great chips are retained. In period II and IV of the investigation, a partially centralized system was used as coolant system. In partially centralized system carried out an effective conditioning of the metalworking lubricant by means of:

- Fine filtering, i.e. removal of particulates.
- Removal of tramp oil.
- Temperature control and
- Monitoring with measurement and adjustment of concentration and flow.

Removal of particulates, i.e. fine filtering carried out by passing the metalworking lubricant through a magnetic field whereby the particles are retained and then removed by scraping. Removal of tramp oil, i.e. free oil, carried out by means of sedimentation followed by a removal of the oil by adhesion (tramp oil skimmer). Controlling the concentration is carried out by measuring with a refractometer and blending by means of a battery of ejector mixers.

Figure 1 shows tribomechanical system on grinding process, where are: workpiece (element 1), grinding wheel (element 2) and coolant (element 3).

The grinding conditions are given in Table 1, where are: A - ISO-L-MAE for periods I and II, B – ISO-L-MAG for periods III and IV. A medium carbon steel was selected as one of the workpiece material because it is one of the most common engineering metals (YU steel Č 1730). They are commonly used to manufacture machine parts and tools.

<table>
<thead>
<tr>
<th>Machine tool</th>
<th>Surface grinding machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel:</td>
<td></td>
</tr>
<tr>
<td>- speed, nw</td>
<td>840 – 2520 rpm</td>
</tr>
<tr>
<td>- diameter, Dw</td>
<td>300 – 400 mm</td>
</tr>
<tr>
<td>- width, bw</td>
<td>10 – 50 mm</td>
</tr>
<tr>
<td>- specification</td>
<td>YU</td>
</tr>
<tr>
<td>Workpiece:</td>
<td></td>
</tr>
<tr>
<td>- feed rate, Vp</td>
<td>100 – 500 mm/ min</td>
</tr>
<tr>
<td>- width, bp</td>
<td>50 – 500 mm</td>
</tr>
<tr>
<td>- length, lp</td>
<td>100 – 1000 mm</td>
</tr>
<tr>
<td>- material</td>
<td>steel (YU)</td>
</tr>
<tr>
<td>- depth of grinding, ag</td>
<td>0,04 – 0,2 mm</td>
</tr>
<tr>
<td>Coolant:</td>
<td></td>
</tr>
<tr>
<td>- type</td>
<td>- micro emulsion A</td>
</tr>
<tr>
<td>- concentration, k</td>
<td>3 %</td>
</tr>
<tr>
<td>- quantity (flow), Qc</td>
<td>15 – 20 l/ min</td>
</tr>
<tr>
<td>- pressure, pc</td>
<td>0,1 – 0,3 MPa</td>
</tr>
</tbody>
</table>

Table 1: Grinding conditions

The relevant parameters of test procedure on the experimental grinding process are shown in Table 2.

5 RESULTS OF EXPERIMENTAL INVESTIGATION AND DISCUSSION

The life time of the tribomechanical system elements up to the failures due to the influence of coolant mostly shows large deviations. By the aid of probability and statistic method, it is possible to determine the influence of coolants for metalworking on tribological processes in relationship to the life time and reliability of operation of tribomechanical system elements.
Symptoms of failure | Relevant parameters
--- | ---
Max values before failure | 
Contamination with particles | $K_p$, particle concentration
$K_p > K_{p_{max}}$
$K_{p_{max}} = 30\%W_t$
Corrosion | Corrosion due to decreasing of concentration
$K < K_{min}$
$K_{min} = 3(2)\%$
Increase of coolant temperature | $t > t_{max}$
$t_{max} = 35^\circ C$
Decrease of machining accuracy | $\tau > \tau_{max}$ of grinding operation

Table 2: Relevant parameters of test procedure

Figure 2 shows the main types of failure symptom of tribomechanical system elements, where are: 1 - contamination with particles, 2 - corrosion, 3 - increase of temperature, 4 - decrease of machining accuracy due to tribological processes, 5 - other symptoms (composition, flow and so on ), 6 - percent of failures.

Analysis of the results showed that the most common single symptom of element failures was contamination with particles that is to say about 45%. Contamination leading progressively to decreased of machining accuracy. There were also a number of failures initiated by corrosion and increase of temperature and some of these would have been prevented by more attention to maintenance of coolants. The proportion of failures initiated by the other causes (composition and flow) is relatively small but not insignificant, specially when the high costs of grinding machine failures are taken into the account.

Based on statistical goodness - of - fit test to these data, it can be concluded, that reliability curves are approximately exponentially distributed. As it is evident from Figure 3, the least reliable are tribomechanical system elements in I period of investigation, i.e. for micro-emulsion ISO-L-MAE from individual systems (the greatest incline of the curve R(T)). They are the most reliable in IV period of investigation, i.e. for sinthetic concentrate ISO-L-MAG from partially centralized system (the least incline of the curve R(T)).

6 CONCLUSION

The following conclusions can be drawn from the results presented above:

- The tribomechanical systems failures were found to be affected by both coolant systems and type of metalworking fluids under presented operating conditions.
- The metalworking fluid ISO-L-MAG gives a longer tribomechanical system life compared with the case ISO-L-MAE.
- The partially centralized coolant system gives a longer tribomechanical system life compared with the case decentralized coolant systems.
- The paper presents the following:
- The distribution of the symptoms of failure to critical elements.
The curves of reliability of critical tribomechanical system elements of grinding machines in function of the effect of coolants for metalworking and maintenance of coolant system under presented operating conditions of investigation.

REFERENCES


