BALKANTRIB'O5
5^{th} INTERNATIONAL CONFERENCE ON TRIBOLOGY
JUNE.15-18. 2005
Kragujevac, Serbia and Montenegro

THE INFLUENCE OF METALWORKING FLUIDS ON DRILLING PROCESS

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Abstract

During the drilling process, the metalworking fluid is also exposed to changes due to: chemical reactions between its substances, tool surfaces and workpiece, the presence of particles and high temperatures on contact surfaces. The changes can impair the tribological properties and increase the risks associated with tribological processes on machine tool elements. The recommendation of metalworking lubricants depends on the special application. For applications where a metalworking lubricant with better lubricating properties is needed a non-water miscible lubricant should be recommended. In other cases with high cutting velocities a water miscible lubricant is often preferred due to its better cooling properties. Any metalworking lubricant must satisfy certain fundamental requirements: removal of heat, lubrication and transport of metal removal. The aim of the study is to reduce of the failures and increase of the reliability of the machine tools. The experimental investigations of the influence of aqueous fluid for metalworking on the reliability of machine tools have been carried out on drilling machines. The lifetime of machine tool elements up to failures due to the influence of metalworking fluids mostly shows large deviations. Using the probability and the statistic methods, it is possible to determine the influence of aqueous fluid on tribological processes in relation to the lifetime and reliability of machine tools. from The following conclusions can be drawn the resultsof investigations:

- *The tribomechanical system failures were found to be affected by both coolant system and type of metalworking fluid under presented operating conditions,*
- *The metalworking microemulsion gives a longer tribomechanical systems life compared with the case of the metalworking emulsion.*

Keywords: *metalworking fluids, drilling process, coolant system*

1. INTRODUCTION

Cutting processes are primarily governed by extremely complex and inter dependant physical – chemical – mechanical, in other word tribological » phenomena » in the contact zone of the cutting tool and material causing the tool to wear, the material to be removed from the surface of the blank part and this generating the required surface geometrical configuration, accuracy and surface quality [1]. The application of advanced materials in various areas of contemporary technology can lead to improvements in the function, quality and performance of engineering components and systems [2]. The machinibility of a material may depend not only the material being machined, but also on the metal cutting process, the cutting conditions and the metalworking lubricant [3]. Friction between the tool and workpiece depends on a multitude of factors, like process parameters, cutting tool geometry and tool material, acting forces, pressure between tool and work interface, heat generating during the process, temperature of contact zone and the cutting fluid applied [4].

The cutting process is present in all kinds of metal cutting operations such as: turning, driling, milling, grinding etc., by penetrating of wedge shape cutting tool portion or grinding wheel into workpiece material. During the cutting process a certain amount of workpiece material transforms into chips (particles), which slides across the front surfaces of cutting wedge, leaving the cutting area. The nature of tribological process is very complex because of high temperatures and pressures appeared on contact surface. Transfer of particle mass, within the contact making process, in carried out from tool to workpiece material and into the coolant, from workpiece to tool and into the coolant and from coolant to tool and workpiece.

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 [5]. The effectiveness of coolants has been studied in several projects and more detailed explanations can be found in [6, 7, 8, 9, 10, 11]. Any metalworking fluid must satisfy certain fundamental requirements : removal of heat, lubrication and transport of metal removed. The coolant systems for metalworking are typical example of a tribomechanical system, where several wear mechanisms are present simultaneously. The metal particles in the coolant system have the appearance of tiny chips, grains, coils of fine wire and so on. Particulate composition varies significantly depending on the cutting process, operating conditions as well as coolant characteristics and coolant systems. During the cutting process, the metalworking fluid is also exposed to changes due to : chemical reactions between its substances, tool surfaces and workpieces, the presence of particles and high temperatures on contact surfaces. The changes can impair the tribological properties and increase the risks associated with tribological processes on machine tool elements.

2. COOLANTS FOR METAL WORKING

The recommendation of metalworkinbg fluids depends on the special application. The experimental investigations were carried out on drilling machines and the drilling 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) [12]. This detailed classification of family "M" has been established by defining the categories of products required for the main applications of this family. Each category is designated by a symbol consisting of a group of three letters, which together constitute a code. The first letter of the category (M) identifies the family of the product considered but any following letters taken separately have no significance on their own. Classifications of aqueous fluids for metalworking (family M) are shown in Table 1., where are: A - Product type and / or end use requirements, B – Symbol ISO – L. Tribomechanical system for drilling process is shown in Figure 1, where are: workpiece (1) , tool (2) and coolant (3).

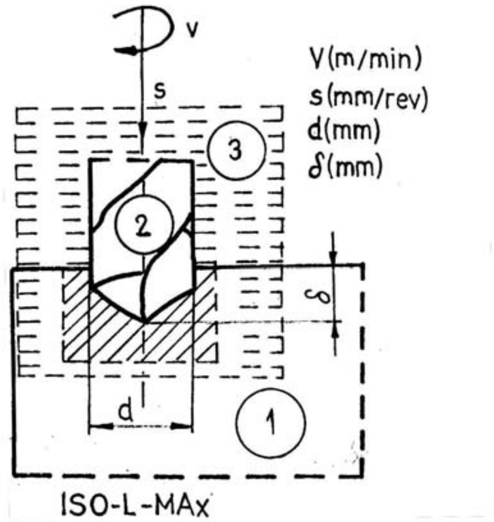

Figure 1: *Drilling process, v-cutting speed, s-feed, d-diameter of drill, δ-drilling depth*

Table 1: Classification of aqueous fluids for metalworking (Family M)

A	B
Concentrates giving, when blended with water, milky emulsions having anticorrosion properties	**MAA**
Concentrates of MAA type having friction-reducing properties	**MAB**
Concentrates of MAA type having extreme pressure (E.P) properties	**MAC**
Concentrates of MAB type having extreme pressure (E.P) properties	**MAD**
Concentrates giving, when blended with water, translucent emulsions (micro-emulsion) having anti-corrosion properties.	**MAE**
Concentrates of MAE type having friction-reducing and / or extreme pressure (E.P) properties	**MAF**
Concentrates giving, when blended with water, transparent solution having anti - corrosion properties	**MAG**
Concentrates of MAG type having friction reducing and / or extreme pressure (E.P) properties..	**MAH**
Greases and pastes applied blended with water	**MAI**

3. 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 carred out on 30 drilling 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 drilling 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 partialy centralized system was used as coolant system. In partially centralized system carried out an effective conditioning of the metalworking lubricant by means of:

- Central preparing.
- Temperature control and
- Monitoring with measurement and adjustment of concentration and flow.

The drilling conditions are given in Table 2. A medium carbon steel was selected as one of the workpiece materials, because it is one of the most common engineering metals.

Table 2.: Drilling conditions (Fig. 1)

Cutting conditions:	**min**	**max**
1. Diameter of the drill, d (mm)	6	16
2. Cutting speed, v (m / min)	16	48
3. Feed, s (mm / o)	0,12	0,32
4. Drilling depth, δ (mm)	12	48
Metalworking lubricant:		
1. Type	Emulsion ISO-L-MAB (periods I and II) Microemulsion ISO-L-MAE (periods III and IV)	
2. Concentration (%)	4	
3. Flow (l / min)	4	

4.RESULTS OF EXPERIMENTAL INVESTIGATION AND DISCUSSION

The life time of the coolant 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 coolant system elements.

Figure 2 shows the main types of failure symptom of coolant 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), p - percent of failures.

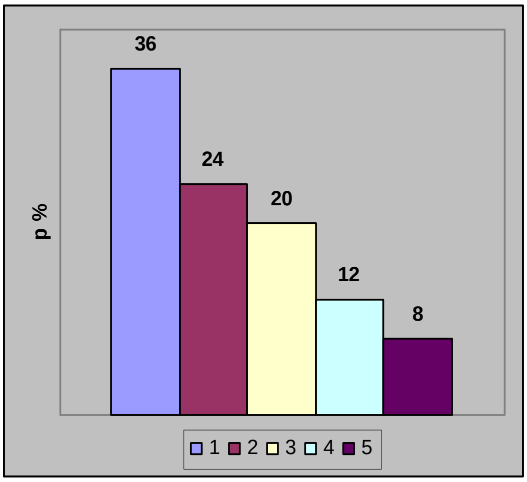

Figure 2: *Analysis of symptoms of coolant system failure*

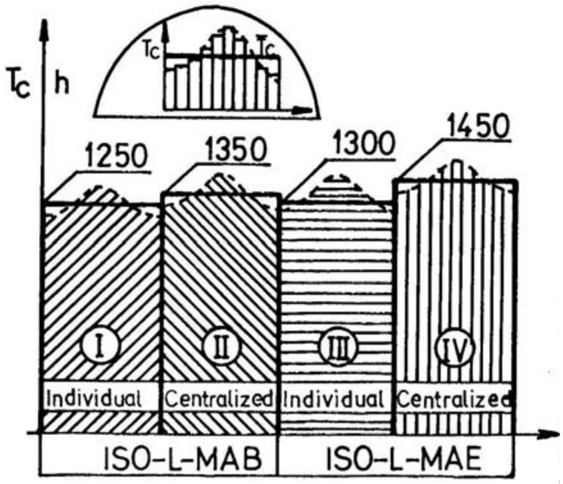

Figure 3: *Analysis of average life of coolant system elements* $\overline{T_c}$

Analysis of the results showed that the most common single symptom of element failures was contamination with particles, that is to say about 36%. 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 drilling machine failures are taken into the account.

The author discussed three major measures of reliability effectiveness of coolant system elements:

- **f**ailure rate – λ
- average life - $\overline{T_c}$
- reliability curve – R(T)

Average life is mean time between or to failure of critical coolant system elements. Critical coolant system elements are those which the first and mostly breakdown, damage and premature failure happened. The results of the average life $\overline{T_c}$ of critical elements of drilling machine in function of types of metalworking fluid and types of coolant system in periods I, II, III and IV of investigations, are shown in Figure 3.

As it is evident from Figure 3, the average life $\overline{T_c}$ (h) of critical elements after used decentralized coolant systems is lower (average 1300 h / ISO-L-MAE, i.e. 1250 h / ISO-L-MAB) than that of critical elements (average 1450 h / ISO-L-MAE, i.e. 1350 h / ISO-L-MAB) after used partially centralized coolant system.

Figure 4 shows the curves of reliability of critical coolant system elements versus time on these drilling machines in function of tribological properties of metalworking fluid and coolant system for metalworking in periods: I, II, III and IV of investigations.

Using a probability and statistic methods it was possible to find the reliability distribution from data.

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 4, the least reliable are tribomechanical system elements in I period of investigation, i.e. for emulsion ISO-L-MAB from individual systems (the greatest incline of the curve R(T)). They are the most reliable in IV period of investigation, i.e. for micro - emulsion ISO-L-MAE from partially centralized system (the least incline of the curve R(T)).

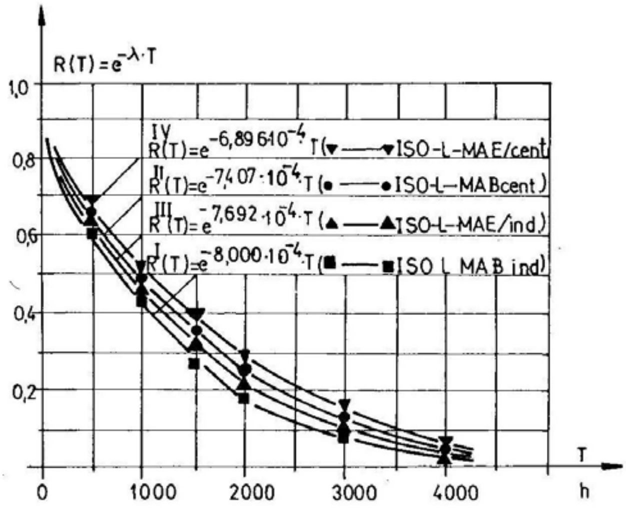

Figure 4: *Curves of coolant system reliability, R(T) - reliability, T - time (h)*

5. CONCLUSIONS

The data were arranged to different types of metalworking fluid of same coolant system, different coolant systems of same type of metalworking fluid to identify the influence of metalworking fluid type, coolant system type on the drilling process. 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-MAE gives a longer tribomehanical system life compared with the case ISO-L-MAB.
- The partially centralized coolant system gives a longer tribomechanical system life compared with the case decentralized coolant systems.

The paper presents the following:

- The analysis of the symptoms of failure to critical coolant system elements.
- The analysis of the average life of critical coolant system elements in function of the effect of the metalworking fluids,
- The curve of reliability of critical tribomechanical system elements of drilling machines in function of the effect of coolants for metalworking and maintenance of coolant system under presented operating conditions of investigation.

The obtained results have proved that the right choice of coolants, by monitoring and maintenance of the coolant systems for metalworking maximum reliability of machine tools could be achieved and coolant system elements could be protected from damage and premature failure.

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