Examination of different grinding oils in the hard metal machining

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Abstract

Oils are in the fluid power as well as in the production technology crucial. In the fluid power, they are mainly used to transfer energy. Furthermore have oils a number of other tasks for example heat transport, corrosion and abrasion protection. The energy transfer via fluid power has in the production technology no more meaning.

Today, oils are mainly used as cutting and grinding oils. Except for the energy transfer the duties of the oils in the production technology are similar with the oils in the fluid power. The aim of this work was a comparison between twelve different grinding oils in the processing of hard metall. Especially the lifetime of the grinding disk and the power consumption of the grinding spindle play an essential role to grind efficiently and to conserve resources. From the comparison it can be seen that there are very different results in the grinding with different oils.

1. Introduction

When grinding hard metal the quality of the used machine tools and tools is well respected, but in contrast the grinding oil is given very little attention. It is obvious that the combination of the used grinding wheel and grinding oil is a major factor in the quality of the grinding process. During the machining have both the grinding wheel and the grinding oil direct contact with the workpiece. Therefore, the combination of different grinding wheels with different grinding oils should be investigated.

The importance of the tool during the grinding process was already demonstrated by numerous scientific studies [1, 2, 3]. Studies on the comparison of different grinding oils are up to a few publications [4], which are not comparable with the current grinding technologies, not available. Therefore together with a manufacturer of grinding oil (company oelheld[1]) the quality differences of different grinding oils during the high-performance grinding of hard metal with different grinding wheels were investigated. Were investigated twelve commercially available grinding oils from different manufacturers (the names of the oils are coded). To obtain a better bandwidth, each grinding oil was again combined with five different grinding wheels. This should show whether the properties of a grinding oil at various grinding wheels tend to be the same or different results. Furthermore, the wheels should be evaluated, which will not be discussed in this article.

2. Influencing factors of the grinding oil during the grinding process

To be able to determine the influencing factors, the tasks of the grinding oil must be investigated during the grinding process. The primary task of the grinding oil is to cool the grinding wheel and the workpiece as well as to remove the grinding abrasion. The cooling of the grinding wheel and the workpiece is essential and depends not only on how the coolant is supplied, but also on the used cooling liquid (heat capacity). Watersoluble cutting fluids will be dropped out, because the cutting speed of the grinding wheel and the resulting friction between the workpiece and grinding wheel is to high [5]. Thus, the task of the heat transport falls to the grinding oil.

As a second essential characteristic of the grinding oil is the ability to remove dirt and grinding abrasion. If the grinding abrasion will not transported out and remains in the pores of the grinding wheel (see Figure 1) the grinding process can be significantly disturbed.

[1] Oelheld GmbH, Ulmer Straße 135 – 139 70188 Stuttgart

Figure 1: Example of a porous grinding wheel

The power consumption of the grinding spindle increases because of the higher friction between the grinding wheel and the workpiece. The grinding performance decreases because the "cutting ability" of the grinding wheel is lost by the reset of the pores. As a consequence, the grinding wheel must be manually released with a binding stone from the particles. If a clog of the pores are not prevented (either by suitable selection of the machining oil, or by opening the pores), it may come to a halt of the spindle due to high power consumption.

Due to the fact how the grinding oil is introduced into the work area, there are further requirements for the grinding oil. The oil is either injected by nozzles into the gap between the grinding wheel and the workpiece, or will be transported through the grinding wheel into the contact zone. As a result the oil is very finely atomized in the work area. As a result other criteria such as aging resistance (oxidation) [6], foaming [7] and air release for the grinding oil become relevant.

By the previously described factors which have an influence on the grinding process, the following points will be examined:

- the foam behavior
- the temperature behavior
- the soiling tendency of the machine tool (a value for the oil to transport particles)
- the load on the grinding spindle (a measure of the behavior of friction-reducing additives)

3. Test rig and examined characteristics

The practical study of the twelve grinding oils was carried out on a tool grinder of the company Saacke. The various grinding oils were analyzed before and after each use in the grinding machine in the laboratory of our cooperating partner. This allows using further laboratory tests to examine the practical use of the oils. As a reference workpiece was used a

16mm end milling cutter with four grooves. The processing was done in two passes. First pregrinding with the half depth of the groove and subsequently finish grinding with the full depth of the groove. The grinding parameters were kept constant in all experiments. The temperature of the grinding wheel and the workpiece was detected by thermography (see Figure 2).

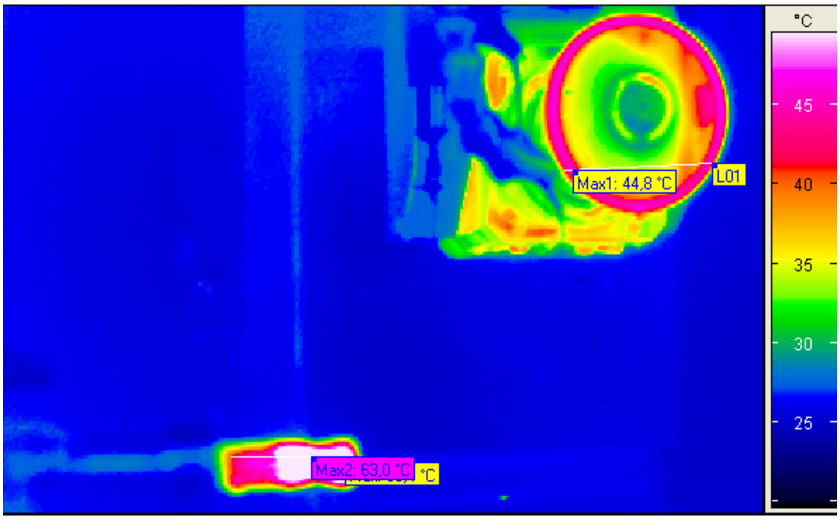

Figure 2: Thermographic image of workpiece and grinding wheel

Additionally was measured the temperature in the hard metal rod with a PT100 element. As a measurement value of the power consumption, the current consumption of the grinding spindle was determined.

The foam behavior in the practical operation was performed visually. For the evaluation a collector was placed under the processing location (see Figure 3).

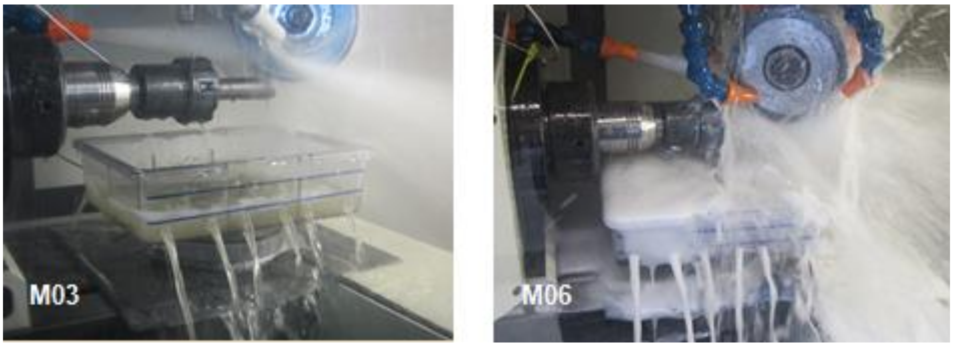

Figure 3: Differences in the foam behavior of two grinding oils (left good foam behavior, right bad foam behavior)

The collector was for the visible evaluation transparent and the medium was able to overflow the edges of the collector. Furthermore was the amount of the foam in the filter system (see Figure 4), the bellows of the working room and on the glass of the machine door documented.

Figure 4: Differences in the foam behavior of two grinding oils in the filter system

The evaluation was carried out based on the amount of foam, the bubble size and the degradation rate on a scale 1 to 10. 1 is a very good result, while 10 is an unsatisfactory result. The assessment of the amount of foam is a summary of the visual observation of the collection container and the filter system. The bubble size and degradation rate of the foam was assessed after completion the machining process inside the collection container. The result represents the arithmetic mean of these three factors.

The ability to carry away particles shows on the one hand side the current consumption of the spindle and on the other hand side the pollution of the working chamber by the deposition of particles (see Figure 5). One reason for the degree of contamination within the processing chamber represents the evaporation tendency of the medium.

Figure 5: Contamination inside the working area

The highest temperature of the medium is reached in the contact zone between grinding wheel and workpiece. The steam absorbs the dirt particles and condensed on the machine parts. The evaporation can be counteracted by "anti-fog additives". The evaluation was conducted with a grade of 1 (low pollution) to 5 (severe pollution).

4. Results

Table 1 shows the foam behavior of the tested oils. The final score is, as described in chapter 3, calculated form the arithmetic average of the individual criteria.

Table 1: Results of the foam behavior

oil code	foam behavior	bubble size	degradation rate	result
M1	4	9	5	6
M2	6	2	6	4,66
M3	2	5	2	3
M4	8	5	7	6,66
M5	7	6	7	6,66
M6	9	4	9	7,33
M7	5	5	6	5,33
M8	6	7	6	6,33
M9	5	5	6	5,33
M10	8	6	7	7
M11	5	5	7	5,66
M12	5	5	7	5,66

The contamination was evaluated as an average over all tested grinding wheels (see Table 2).

Table 2: Results of the contamination test

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
S01	3	3	2	3	3	4	3	3	3	4	3	3
S02	3	3	3	4	4	5	4	3	3	5	3	4
S03	3	2	1	3	3	4	2	3	2	4	3	3
S04	4	3	3	5	5	5	4	5	3	5	5	4
S05	4	3	3	5	5	5	4	5	3	5	5	4
evaluation	3,4	2,8	2,4	4	3,8	4,6	3,2	3,6	2,8	4,4	3,6	3,6

In addition, the foam behavior and the degree of contamination were contrasted in one diagram to compare the different oils (see Figure 6).

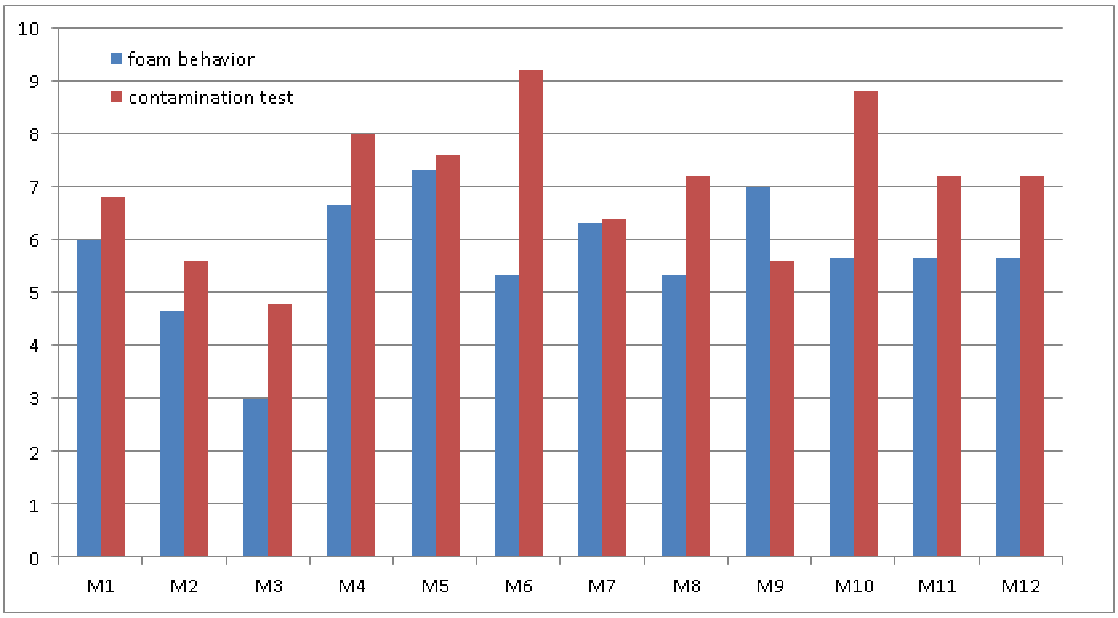

Figure 6: Contrast between the foam behavior and the degree of contamination

Table 3: Table of the maximum temperature and machining energy of different oils

	max. temperature [°C]	machining energy [Ws]
M1	99,248	6300
M2	96,594	6950
M3	117,983	6900
M4	101,862	5300

In Table 3 the maximum temperature (in the hard metal rod) and the cutting energy (energy that is necessary to machine a workpiece) are shown in extracts of four different oils. It can be seen, that a high temperature in the workpiece is not connected to a high cutting energy. But clearly visible is the variation of the cutting energy which caused on the friction-reducing additives and the ability to transport dirt.

5. Conclusion

The half of the oils shows nearly the same behavior between the foaming properties and the ability to transport dirt. In absolute terms one oil can be named as very good, two oils as good and the rest of the oils were average to poor. The cutting energy, that is necessary for processing of the workpieces, varies not only with the different grinding wheels, but also for the various oils.

In summary it can be said that grinding oils show different behavior in practice use. It is possible to save by suitable selection of the grinding oil not only energy and resources it can also save costs. In further consequence a correlation between laboratory test and practice test should be found, to replace the expensive practice tests by cheaper laboratory test.

6. References

[1] Zhang, Z.; Zhang, J.; Gao, S.; Lu, C.; Zheng, C.: Experimental study on relation between wear and grinding force for sharping diamond tools; Advanced Materials Research (2010), Nr.97-101; page 1925 – 1928

[2] Ptashnikof, V. S.: Mechanism of elbor tool wear in high-speed grinding; Soviet engineering research (1982), Nr.2; Issue 11; page 45 – 47

[3] Uhlmann, E.; Hochschild, L.: Tool optimization for high speed grinding; Production engineering (2013); Nr.7; Issue 2-3; page 185 – 193

[4] Sugarda, A. A. Grigor`er, V. M.; Zakharov, V. P.: Effect of cooling on the wear resistance of a diamond tool in machining grinding wheels; Soviet journal of superhard materials (1988); Nr.10; Issue 6; pages 46 – 50

[5] Storr, M.; Ott, H.: Das 1x1 des Öl- Schleifens". Räse u. Haigis Offsetdruck, 2002.

[6] Hochleitner, H.: Skriptum Fluidtechnik 1; 2010, IFT TU-Graz

[7] Klüber Lubrication München AG: Schaumverhalten von Getriebeölen; 2004

[8] Goritschnig, M. P.: Schleifprozessuntersuchung zur Energie- und Ressourcenoptimierung beim Werkzeugschleifen; 2013; Diplomarbeit