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REDUCTION OF COOLING LUBRICATIONS IN THE GRINDING PROCESS

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Abstract: *The project "Alternative cooling lubrication technologies for process optimization within the grinding process" supported by the Federal Ministry for education and research (BMBF) is focused to reduce the need of the cooling lubrication. Nevertheless, the same machining quality compared to the conventional machining is supposed to be achieved with less cooling lubrication. This goal is going to be realized on the one hand by an internal cooling lubricant supply and on the other hand by new cooling lubricants enriched with nano additives. The following work contains both the presentation of the internal cooling lubricant supply's realization and its results. For example, the process parameters of the internal cooling lubrication supply, the conventional flood lubrication and dry conditioning are pointed out on the basis of temperature and power measurements. Furthermore, surface characteristic values as well as wear characteristic values give information regarding operability of the internal cooling lubrication supply and the implementation in practice.*

Key words: Minimum quantity lubrication, dry machining, surface grinding

1. INTRODUCTION

The manufacturing process grinding is characterized by high thermal loads caused by large contact areas and a high number of grain cuts as well as negative chip angle. Beyond that high cutting velocities of up to 200 m/s define the grinding process. Here, approximately 100 % of the energy is transformed into heat. This leads inevitably to a high temperature development, which cause thermal lagging, deformation or damages in the edge zone. Therefore, efficient heat dissipation is essential by an adequate cooling lubrication technology. In various grinding processes there are used up to 500 l/min of cooling lubrication. However, the lubricants represent an exposure risk for the machine operator and its surrounding field as well as to the environment in general. Cooling lubricants can release erythema and toxic or allergic contact eczema. Likewise the bronchi and lungs can be strongly stressed by inhaled aerosol of the cooling lubricants. The exposure for humans and the environment are not the only reasons, which make the reduction of cooling lubricants that important. The used up lubricants are often hazardous waste and have to be complexly disposed, which is also very cost-intensive. The costs of the cooling lubricant disposal can amount up to 1.500 €/tonne. Additional there are costs for maintenance strategies and the power supply of the lubrication periphery, which entail a further rise of the production costs of a work piece. The specified reasons make a minimization of cooling lubrication necessary.

2. INTERNAL COOLING LUBRICATION SUPPLY

The internal cooling lubrication (Fig. 1) supply is a newly developed supply system, which can be applied to conventional grinding wheels and cubic boron nitrite grinding (CBN) wheels. The main reason to use a system like this is to reduce the quantity of the lubrication in the production considerably. Nevertheless, an efficient grinding process requires a good cooling lubrication supply system and cooling lubricant. [1]

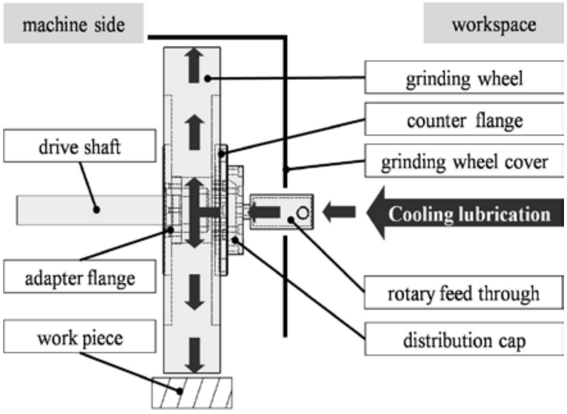

Fig. 1. Schematic diagram of the internal lubrication supply

In contrast to the conventional open jet nozzle, where the cooling lubrication is supported to the rim of the grinding wheel, the internal cooling lubrication supply transports the lubricant through the grinding wheel [2,3]. In this case the cooling lubricant flows through the pore volume of the grinding wheel (conventional grinding wheel) or the holes of the grinding wheel (CBN grinding wheel) to feed the cutting zone. This system is comparable to cutting processes with geometrically defined cutting edge [4,5]. In the case of the internal cooling lubrication supply for grinding, a modified tool holding fixture and a rotary feed through is used to transport the cooling lubricant through a distributor cap under conditions of a minimum lubrication supply. In comparison to the conventional lubrication the outstanding advantages are as follows:

- Direct supply of the cutting zone with cooling lubricant
- By-passing of the insulating air cushion
- Utilizing the centrifugal forces for lubrication
- Reduction of the thermal damages of the work piece [6]

3. TEST ENVIRONMENT

A high precision grinding machine (Fig. 2) was utilized to investigate the internal cooling lubrication supply. The grinding tools are on the one hand conventional grinding wheels with a sintered aluminum oxide mixture and on the other hand resin-bonded cubic boron nitrite grinding wheels. In addition to that, different mixtures (grain size and bond) of both types are tested. The dimension of these grinding wheels are 300x30x76 mm. The conventional grinding wheels are not modified in contrast to the CBN grinding wheels. The CBN grinding wheels are machined by drilling radial bores in order to lead the cooling lubrication through the aluminum and the abrasive layer.

Fig. 2. Precision grinding machine FS 840 Z CB, Geibel & Hotz GmbH

The results of the internal cooling lubrication supply are compared to the conventional open jet nozzle supply as well as to the dry machining. Work pieces of X45NiCrMo4, Ck45, HS6-5-2C and X153CrMoV12 are applied for the tests. Additional to wear measurements both temperature (Fig. 3) and force measurements are carried out. Furthermore, the process conditions (for example cutting speed, feed rate) are varied. Thus, there are several measurements recorded and compared to the results of the conventional cooling lubrication supply. These test results give a good overview about the practicability of the internal cooling lubrication supply

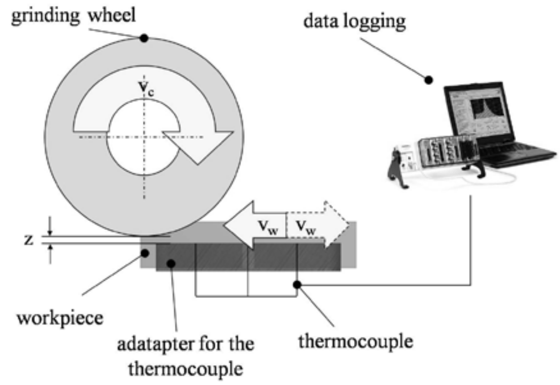

Fig. 3 Test set-up of the temperature measurements

4. TEST RESULTS

In Fig. 4 the temperature profile of the open jet nozzle and the internal cooling lubrication supply with varying volume flow is shown. The temperature is attached to the distance z, where z is the distance between the grinding wheel to the thermocouple.

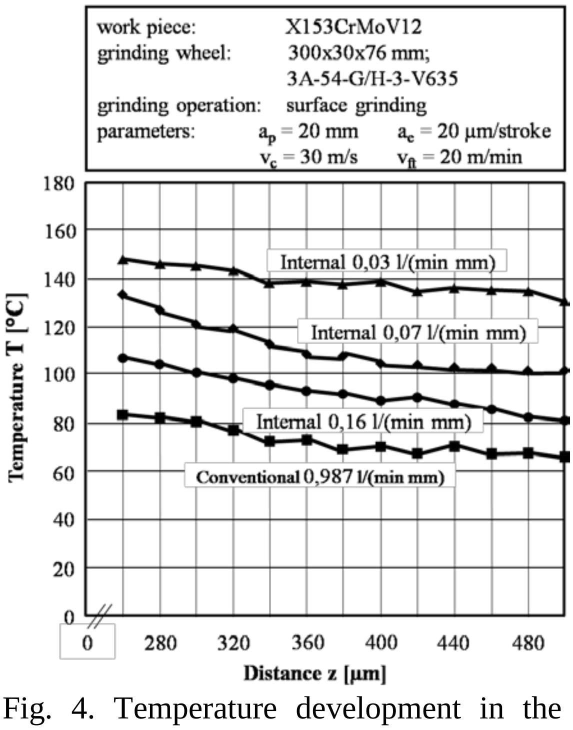

Fig. 4. Temperature development in the work piece

The higher temperature profile of the internal cooling lubrication is attributed to the stronger developed secondary cooling effect of the conventional open jet nozzle (Fig. 5). Although 91 % of the cooling lubricant is not used for the primary cooling it still cools down the work piece by the open jet nozzle operation. [7]

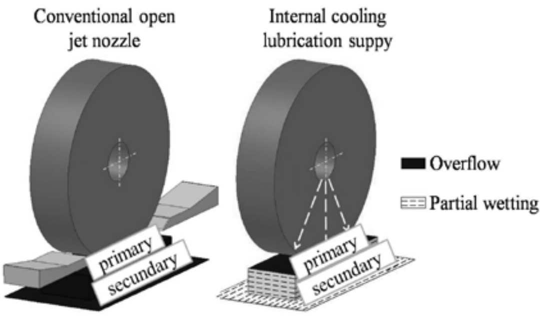

Fig. 5. Effect of the secondary cooling system by using the conventional open jet nozzle and the internal lubrication supply

Fig. 6 and Fig. 7 show the dependency of the specific tangential force against the feed rate and the cutting speed. In general the forces of the internal cooling lubrication and the open jet nozzle are nearly at the same level. However, dry machining possesses the highest specific tangential forces as expected.

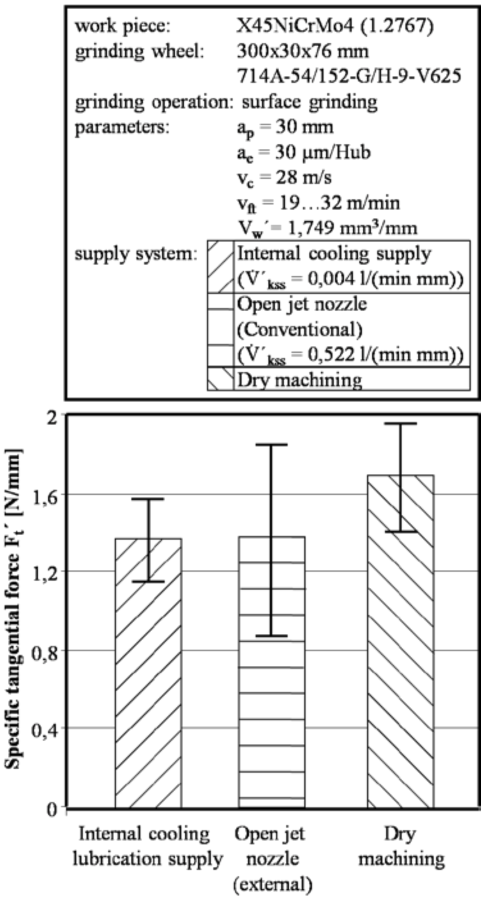

Fig. 6. Dependency of the specific tangential force against the feed rate

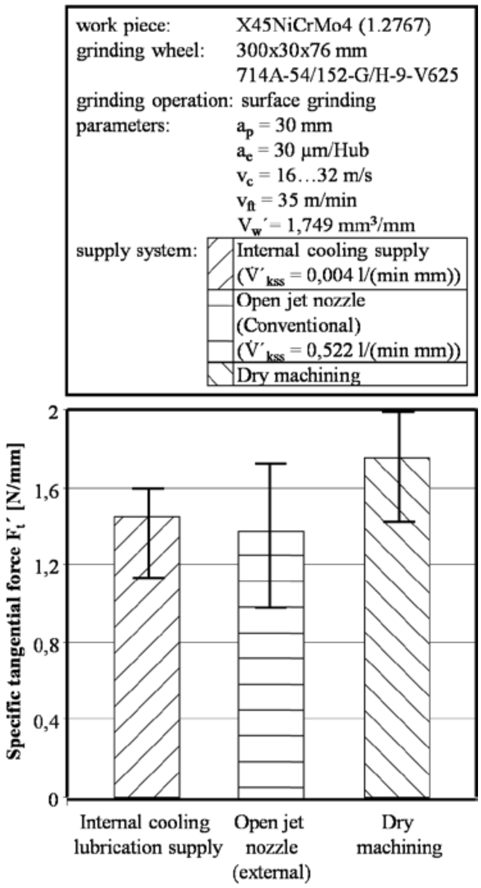

Fig. 7. Dependency of the specific tangential force against the cutting speed

5. CONCLUSION

It can be shown, that an internal cooling lubrication supply for grinding processes is realizable. The results indicate that the internal cooling lubrication supply for conventional grinding wheel and a CBN grinding wheel are comparable. However, the CBN grinding wheel has to be modified in order to obtain an internal cooling lubrication supply. The temperature measurements result in about 20 % - 30 % higher temperatures of the internal cooling lubrication supply compared to the conventional open jet nozzle. First of all, in future there will be adjustments of the grinding wheel cover to reuse the wasted cooling lubrication in the form of a secondary cooling of the work piece. Secondly a computational fluid dynamics simulation is supposed to optimize the position of the bores of the CBN grinding wheel. Further investigations should demonstrate the potential of the internal cooling lubrication supply. In addition to that the internal lubrication supply will be tested in the environment of a company under working conditions.

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