Abstract: This paper describes the development of a concept for implementing an internal lubrication supply for grinding processes. An appropriate lubrication is mandatory in the grinding process. Compared to cutting processes using a geometrically defined cutting edge there are higher demands on the heat dissipation when grinding due to the higher cutting speeds, negative rake angles as well as higher friction predominating the grinding process. The minimum quantity lubrication and moreover dry machining, which is often used in milling, turning or drilling operations, is also being considered for the grinding process. This paper focuses on the development of an internal lubricant supply for the grinding process, at least to reduce expensive coolant costs.

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

1. INTRODUCTION

The grinding process is characterised by strong plastic deformation work as well as friction work, which leads to an extreme development of heat. These conditions highly influence the grinding process and the workpiece quality is consequently affected. In order to counteract the thermal influence on the grinding process the use of an effective lubrication is essential. The application of cooling lubricants in grinding still occurs without consideration of its effectiveness. In many cases the reason is a minor knowledge of the conditions prevailing in the grinding process, the cooling lubricant itself or the possibilities of their supplies.

In this context, it is necessary to reduce the cooling lubricant due to ecological as well as economic aspects. Finally, the high costs also motivate to search for new lubrication alternatives. In some grinding applications the costs of cooling lubrication exceed even the tool costs.

2. INTERNAL LUBRICANT SUPPLY

Within the presented research project the above-mentioned internal cooling lubricant supply has been developed. The internal system aims to reduce the quantity of the lubricant considerably (Fig. 1).

![Fig. 1. Internal lubricant supply](image)
minimum lubrication supply. Thereby, the cooling lubricant is conducted into the bore of the grinding wheel and, supported by centrifugal forces, is transported directly to the cutting zone. 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
- Utilising the centrifugal forces for lubrication
- Reduction of the thermal damages of the workpiece

3. EXPERIMENTAL CONDITIONS

The investigations are accomplished on a precision grinding machine using the equipped internal lubricant supply. For testing the internal lubricant supply conventional grinding wheels were used. The sintered aluminium oxide mixture of the grinding wheel (300x30x76 mm), medium grain size and a vitreous bond was not modified due to the special tool holding fixture. The grinding tests with internal lubricant supply were compared to grinding with a conventional open jet nozzle supply and by dry machining conditions. Workpieces of X45NiCrMo4 were utilised for these tests. Besides wear measurements, temperature as well as force measurements were carried out. In the presented paper all process conditions were held constantly. Only the specific stock removal rate \( V_{w}' \) was continuously increased.

4. RESULTS

The results, which are based on the radial wear measurements of the grinding wheel \( \Delta r_s \), show that the internal lubrication supply has a steady increasing course (Fig. 2). In comparison with the conventional flood lubrication it is apparent, that the internal lubricant supply leads to a better wear behaviour in spite of a lowering the cooling lubricant quantity of about 99%. This result can be explained by a direct supply of the cutting zone from inside the grinding wheel.

![Fig. 2. Radial wear of the grinding wheel using different lubricant supply systems](image-url)

By other investigations it is reported that using an external jet nozzle 91% of the cooling lubricant does not reach the cutting zone [2]. Comparing grinding with internal cooling lubricant supply and under dry machining conditions it can be said, that the internal cooling lubricant system fulfils its purpose. The studies show that in both cases the wear of the dry machining is about 200% higher after a spec. stock removal rate of 3,600 mm³/mm.

Another aspect of this investigation is the quality of the machined workpieces. The results reflect similar tendencies as in the previous studies (Fig. 3). The dry machined workpieces show the worst average surface roughness \( R_a \). Furthermore, the internal cooling lubricant system indicates the best results up to 3,600 mm³/mm. At higher values for the stock removal the surface quality of workpiece using the internal supply are worse than those using the external supply.
After this point the course constantly continues. The results of the internal lubricant supply are about 10 - 20 % higher than by using external lubricant supply.

<table>
<thead>
<tr>
<th>workpiece:</th>
<th>X45NiCrMo4 (1.2767)</th>
</tr>
</thead>
<tbody>
<tr>
<td>grinding wheel:</td>
<td>300x30x76 mm</td>
</tr>
<tr>
<td>grinding operation:</td>
<td>surface grinding</td>
</tr>
<tr>
<td>parameters:</td>
<td>a_p = 15.855 mm, a_e = 30 µm/stroke</td>
</tr>
<tr>
<td></td>
<td>V_c = 30 m/s, v_f = 20 m/min</td>
</tr>
</tbody>
</table>

Fig. 3. Average surface roughness R_a [µm] of the workpiece by different lubricant supplies

By visual comparison of the different surfaces first marks of overheating with the dry machining is indicated. Thus, this result confirms the surfaces-covering cooling function of the internal lubricant supply.

5. CONCLUSION

On the one hand, the presented results show that an internal cooling lubricant supply for grinding processes is realisable. On the other hand, the quantity of the cooling lubricant can be significantly reduced by using the internal cooling lubrication concept. The reason for this can be attributed to the direct supply of the cutting zone with cooling lubricant. Furthermore, costs for peripheral equipment can be reduced, which is attributed to the decreased coolant quantity when using the internal lubrication. In addition to that the tool life of the grinding wheel can be extended. In general, the total costs of the grinding process can be reduced. Future investigations will focus on the practical application of this technology.

Acknowledgement: The authors would like to thank the German Federal Ministry of Education and Research (BMBF), the Geibel & Hotz GmbH and the ALAN Lubrication GmbH for supporting the presented investigations.

6. REFERENCES


7. ADDITIONAL DATA ABOUT AUHORS

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