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Simulation-based Optimization of Fluid Distribution for Enhanced Grinding Performance

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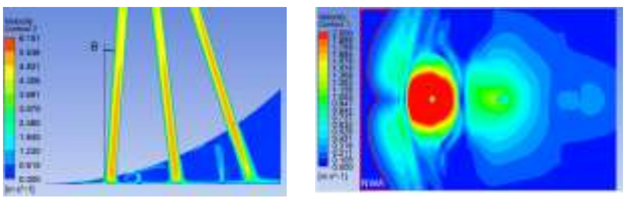
1. Introduction

Grinding fluids play a crucial role in removing heat and debris during grinding processes. Their distribution directly affects the grinding results, particularly in reaching the contact zone between the wheel and workpiece [1]. Our study introduces a novel approach utilizing wheels with internal channels to distribute grinding fluid from the center of the wheel to the workpiece, aiming to reduce the air barrier phenomenon [2] and to control heat generation in the grinding zone. Through computational simulations, the fluid's distribution and spreading were evaluated through different internal cooling channel configurations. The findings offer valuable insights into enhancing fluid distribution strategies for optimizing cooling systems design in grinding operations.

2. Materials and methods

The ANSYS Workbench software was utilized to construct the geometric and mesh models of the channel structure, which were later imported into the FLUENT software to conduct simulations. Four structures were studied, with different channel diameters (Ø = 1 or 1.5 mm), number of channels (32 or 22) and orientations (θ = 0° or 15°, figure 1a). The area of the region immediately before the contact zone (with fluid velocity <0.1 m/s; non-wetted area - NWA) were measured to assess the fluid's efficacy in reaching the work zone (Figure 1b). A smaller NWA signifies a greater ability of the fluid to reach the work zone effectively.



(a) (b)

Figure 1 Fluid velocity profile obtained at the medium plane of channels (a) and workpiece interface (b).

3. Results and discussion

Figure 1a and 1b visually depicts the phenomenon of neighboring channel interference in the fluid spreading process from the closest channel to the contact zone. It is evident from the illustration that only the immediate neighboring channel manifests interference, while other neighboring channels do not have a noticeable impact on the fluid flow and spreading behavior.

Figure 2 presents the NWA evolution varying the outflow per channel. In general, an exponential growing trend in NWA is observed as flow rate decreases. The findings reveal that configurations with higher number of channels, smaller diameter and oriented channel reduces the NWA. Under reduced flow rate grinding, a reduction of ~40% in the NWA was observed from the "22 channels, Ø = 1.5 mm, θ = 0°" configuration when compared to the "32 channels, Ø = 1 mm, θ = 15°" setup. Furthermore, as the flow rate surpasses 0.3 L/min, the maximum lubricated areas tend to stabilize.

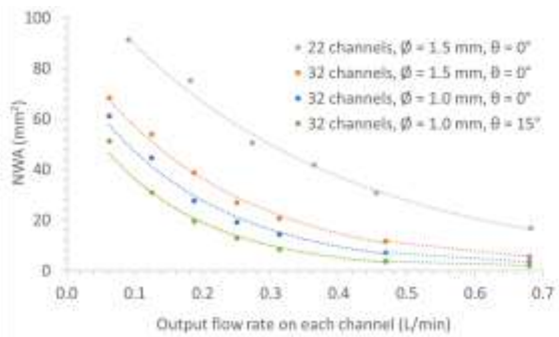


Figure 2 Non-wetted area as a function of outflow per channel.

4. References

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