Laser Doppler Anemometry

Grinding is a fundamental manufacturing process important for achievement of low geometric tolerances and a high quality workpiece finish. However, the specific energy associated with grinding is relatively high compared with other material removal processes. Virtually all of this energy is converted to heat which is concentrated within the grinding zone. The high temperatures produced can cause various types of thermal damage to the workpiece. It can also accelerate wheel wear.

In order to limit these high temperatures and consequent thermal damage and wheel wear, a grinding fluid is applied at the grinding zone. In high-speed grinding applications, the fluid velocity with a low-pressure system may be insufficient to penetrate the boundary layer of air surrounding the wheel, thereby preventing the fluid from reaching the grinding zone.

The deleterious effect of ineffective fluid delivery raises a question concerning the magnitude of flowrate that is required to achieve ‘useful’ flow, that is, the maximum quantity of flow that can pass through the grinding contact region. To answer this question, there is a need for improved understanding of the individual factors, which affect the ‘useful’ flow. A significant factor is the flow mechanism in the contact zone between the workpiece and the wheel. This region of pre-contact in grinding presents the condition of a large diameter disk rotating at high speed, a converging gap and a pressure decrease in the flow direction and as a result there are effects of turbulent behaviour and boundary layer separation.

It is proposed to investigate the complex fluid flow and boundary layer phenomena that occur in the region of the initial contact between the wheel and workpiece using the Laser Doppler Anemometry (LDA) technique. LDA can also be used to measure the velocity profile of the boundary.

This project is one of a number of AMTReL projects concerned with fluid delivery in grinding. Outputs of the investigation will contribute to and support the current EPSRC / Industry funded project: Optimisation of Fluid Application in Grinding GR/S82350/01(P).

Aims and objectives

Aims

- Establish requirements for effective fluid penetration in the grinding contact entry region
- Investigate the problem of complex boundary layer phenomena at the periphery wheel surface
- Establish the effect of pressure and velocity on useful flowrate
- A comprehensive experimental and theoretical programme is proposed, and innovative techniques will be employed to determine the nature of complex fluid flows

in the entry to the grinding contact zone. These will help to acquire, evaluate and deliver the understanding needed to apply optimised useful fluid delivery.

Objectives

- Measure the velocity profile of the fluid in the grinding contact entry region with Laser Doppler Anemometry (LDA)
- Obtain velocity maps of fluid flow for varying: fluid type (oil, emulsion, water); delivery conditions (varying nozzle design, nozzle flowrate, nozzle position and nozzle angle); wheel speed and wheel configurations; contact conditions
- Measure the velocity profile of the boundary layer of air which develops around a high-speed rotating grinding wheel
- Obtain pressure distributions in the grinding contact entry region
- Simulate and analyse the fluid flow in the grinding contact entry region
- Develop analytical models of fluid flow in the grinding contact entry region