IMPROVING GRINDING PERFORMANCE THROUGH OPTIMUM CUTTING FLUID APPLICATION

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Abstract : Study of chips favours judging the performance of machining and grinding Different kinds of chip formation are related to specific energy consumptions, heat produce, etc The nature of the chip forming process is extremely variable and depends upon the metallurgical aspect of the tool-work pair, un-deformed chip thickness, rake angle, cutting temperature, sharpness of the tool, etc Observation of chip formation during grinding of a specific material may facilitate determine the appropriate wheel speed, table feed and infeed for efficient grinding In this experimental study, grinding chips under different infeeds and environmental conditions have been investigated for low carbon steel specimens Good grinding performance has been achieved when water-soluble oil is used as a grinding fluid with pneumatic barrier set up

Keywords Grinding chips, surface grinding, surface quality, pneumatic barrier

1. Introduction

High specific heat generation is an inherent problem in grinding Varying grinding zone temperatures cause different types of chip formation Observation of chips leads to greater understanding of metal removal and chip formation mechanism An image processing method is employed by Tso and Wu [1] to measure the size of grinding chips, and an equivalent chip-volume parameter is proposed to compare chip sizes under various grinding conditions This chip-volume parameter is claimed to be a useful index in predicting accurately, and evaluating the grinding performance Chip formation process in grinding is extremely rapid, owing to high cutting velocity and strain rate, the process may be considered nearly adiabatic [2]

Many methods have been investigated to control the high grinding zone temperature, and to make the process environmental friendly The specific shearing energy for chip formation during grinding approaches the specific melting energy [3] It is proposed that such a large shearing energy is attained in grinding because of severe constraints due to large negative rake angles [4] on abrasive grains During the chip formation, intense rubbing generates heat, causing high temperature at the grinding zone This causes various thermal damages to the workpiece [2-5] Grinding process, employing considerably high surface speed of usually porous wheel, causes formation of a stiff air layer around the wheel periphery [6] This stiff air layer tends to restrict grinding fluid reach deep inside the grinding zone resulting in increase in wastage of lubricant, and obstructing the effective control of temperature

Types of chips produced in dry grinding of mild steel may be long, lamellar, irregular, hollow spherical chips Under flood cooling with soluble oil, short leafy chips and few spherical chips are found However, with cryogenic cooling [7-8], considerably less spherical chips are observed indicating the reduction of temperature at grinding zone Plowing and shearing becomes less, and most of the chip formation is by crushing Under cryo-cooling, steel behaves like brittle material, and, therefore, gives shorter lamellar chips, and crushed and fractured chips Application of the cryogenic fluid causes effective control of cutting zone temperature, resulting in the favourable condition for machining and grinding of steel [8-10] On the other hand, mist cooling causes [9] better penetration of the cutting fluid inside the cutting zone as finer fat molecules of the fluid can be reaching the tool-chip interface region easily through capillary action, but inhalation of a mist may be a potential health hazard. However, when soluble oil reaches deep inside the grinding zone at a high temperature, some chemical reaction is likely to occur, causing undesirable formation of spinel (such as $FeAl_2O_4$ etc.) on the wheel.

Compared to brittle fracture and shearing, plowing and rubbing actions are associated with large consumption of energy and high specific heat generation [11]. This high temperature can cause various types of thermal damages [2, 5, 7, 12, 13] to the workpiece, such as burning, phase transformation, possible surface layer rehardening, unfavourable residual tensile stress, cracks and reduced fatigue strength. Basic cause of wheel loading can be adherence of chip material to the grit, mechanical interlocking of chips in the inter-grit spaces, and chemical affinity between the grit and work material [14-16]; high grinding temperature promotes wheel loading. To control the high grinding zone temperature, and hence, to suppress thermal damage and wheel wear and loading, grinding fluid is usually applied. The function of the grinding fluid is to cool wheel and workpiece, to lubricate wheel and work-piece interface to reduce friction, to flush out chips [12, 14], to suppress wheel loading and to produce better surface finish. However, most of the grinding fluid applied is wasted due to formation of a stiff air layer around the wheel periphery.

In this experimental study, grinding of low carbon steel specimens is done under dry, wet and wet with pneumatic barrier conditions with different infeeds (10, 20, and 30 microns). Pneumatic barrier set up is used to penetrate/break the stiff air layer found around the grinding wheel and to facilitate grinding fluid reach deep inside the grinding zone. Thus, grinding temperature could likely be controlled. The extent of suppression of temperature is judged by observing chips and surface characteristics.

2. Experimental Details

The experimental investigation has been carried out on a surface grinding machine using an alumina grinding wheel. Details of the experimental set-up are given in Table 1. Grinding is done in up-grinding mode on low carbon steel specimens in dry, wet and wet with pneumatic barrier conditions. Grinding operations with different infeeds of 10, 20, and 30 micron are performed. Grinding chips are collected and observed under a microscope. Ground surface also seen using a toolmakers microscope. The pneumatic barrier set up used is shown in Fig.1. in which compressed air of 400 mm water column pressure is applied to break the stiff air layer.

Table 1 : Experimental Set-up

Machine tools used	Surface Grinding Machine, Make: Maneklal & Sons. Model: 600 × 200, PARROT (India), Infeed Resolution: 10 μm, Main Motor Power: 1.5 KW
Grinding wheel	Disc type alumina wheel, Make: Carborandum Universal LimitedSpecification : AA 46/54 A5 V8, Size: ø 200 mm × 13 mm ×ø 31.75 mm
Wheel Dresser	0.5 Carat diamond tipped dresser
Job	Material: Low carbon steel, size: 120 mm x 65 mm x 6 mm
Grinding Conditions	Wheel velocity: 30 m/s, Infeed: 10, 20, 30 micron, Table feed: 7.5 m/min, Passes: 10Pneumatic barrier pressure: 400 mm of water, Grinding fluid flow rate : 1 lit/min.

3. Experimental Results and Discussions

Chips observed during surface grinding experiment under three different infeeds in dry conditions are shown in Fig.2. Fig. 3 shows chips under wet condition with 10, 20 and 30 micron infeeds whereas grinding chips found under wet with pneumatic barrier condition under three infeeds are shown in Fig. 4. Fig. 5 shows ground surfaces at three different environmental conditions with 30 micron infeed.

With 20 micron and 30 micron infeed, dry grinding gives blackish chips as shown in Fig. 2. Shear type leafy chips and few spherical chips are seen in these conditions. A number of dislodged grits, indicating self dressing are also seen. Due to high heat generation, chiploading is expected followed by self-dressing.

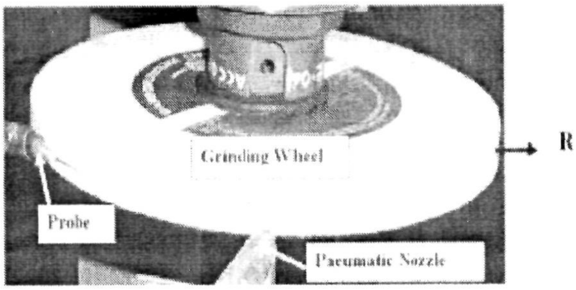
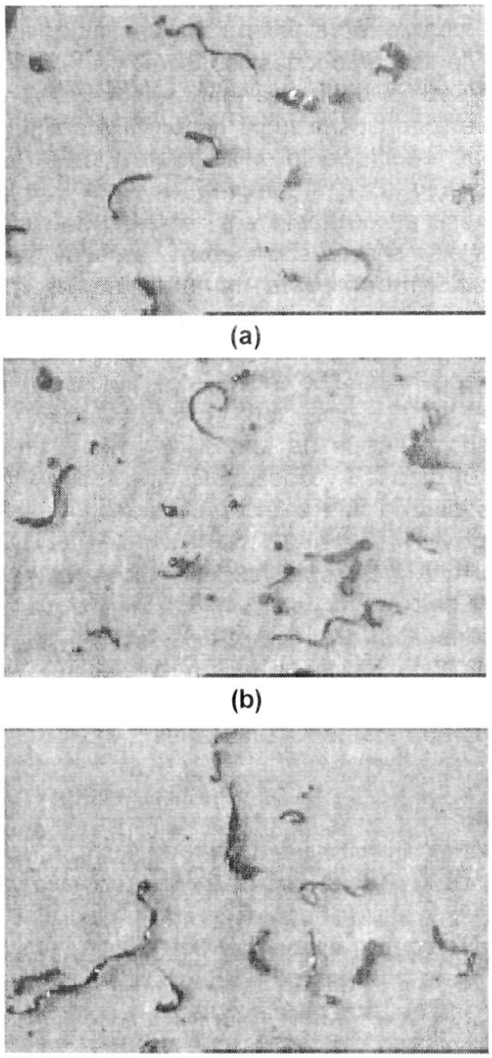


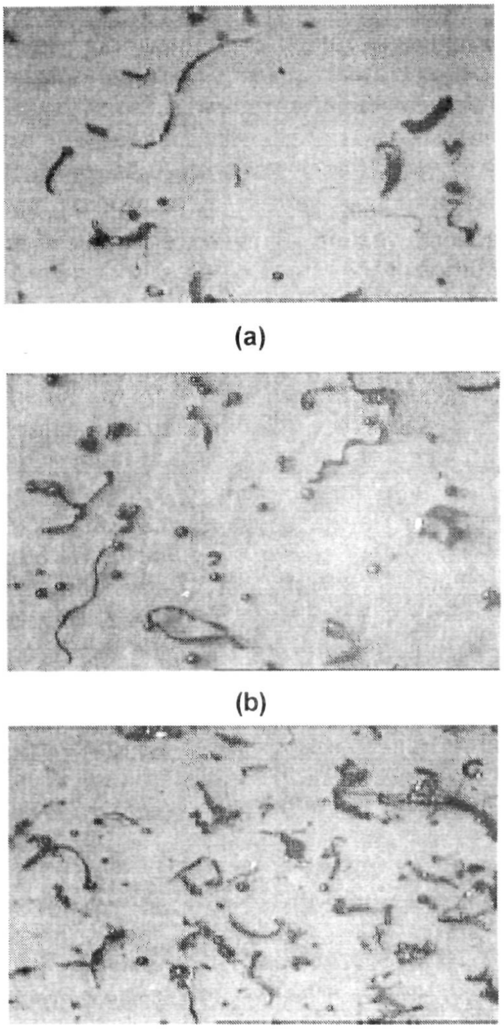
Fig. 1. The pneumatic barrier set up


(a)

(b)

(c)

Fig. 2 : Photographic view of grinding chips of low carbon steel specimens under dry conditions with (a) 10 micron infeed, (b) 20 micron infeed, and (c) 30 micron infeed.

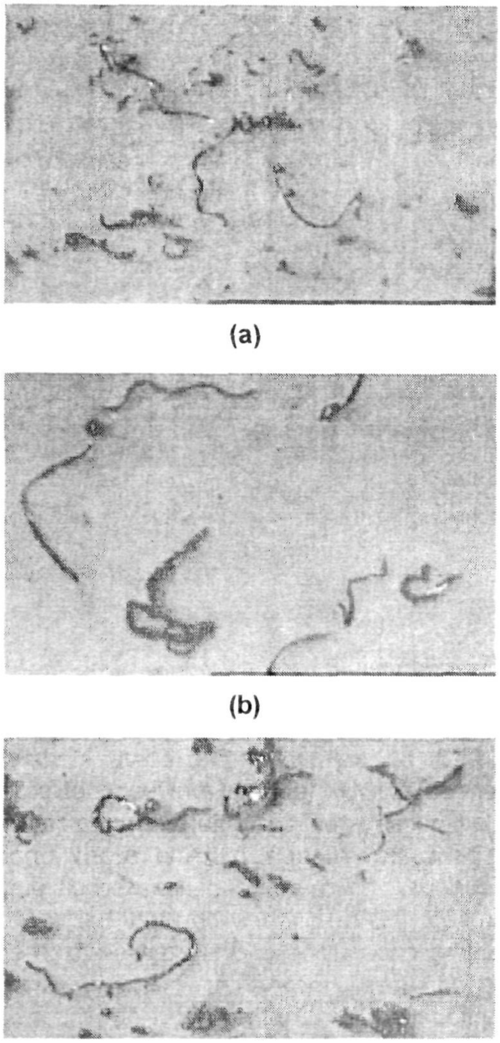

(a)

(b)

(c)

Fig. 3 : Photographic view of grinding chips of low carbon steel specimens under wet conditions with (a) 10 micron infeed, (b) 20 micron infeed, and (c) 30 micron infeed.

Spherical chips are produced through oxidation and unequal thermal expansion. More spherical chips are found in grinding with 30 micron infeed under wet conditions (Fig.3c) as compared to that at 10 and 20 micron infeeds (Fig.3a, Fig.3b). This is likely to be due to higher energy requirement at higher infeed of 30μm than that with 10μm and 20μm. Grinding in wet condition with pneumatic barrier set up gives sizeable leafy chips (Fig.4) due to less heat generation. Photographs of ground surfaces with 30 micron infeed under dry and wet conditions are



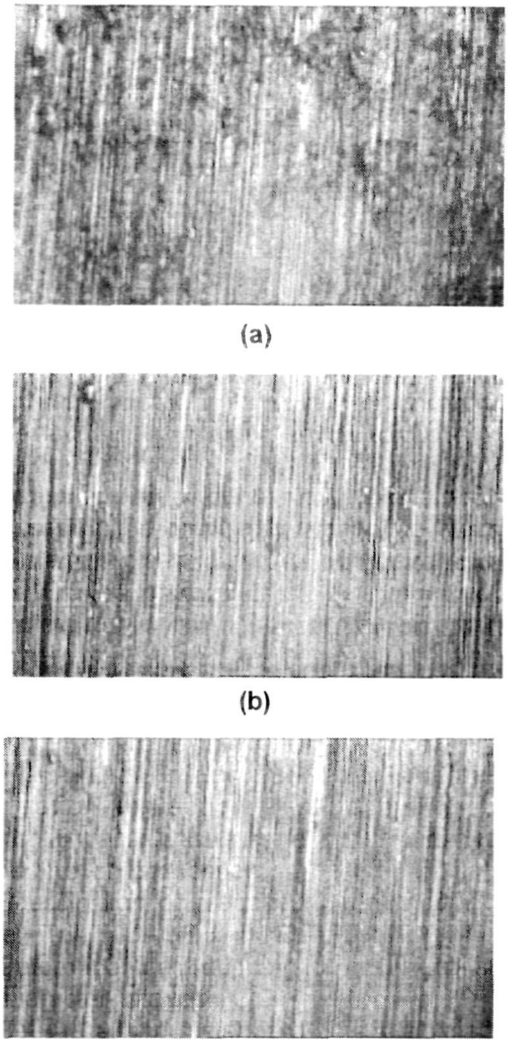
(a)

(b)

(c)

Fig. 4 : Photographic view of grinding chips of low carbon steel specimens under wet condition with pneumatic barrier set up with (a) infeed of 10 micron, (b) infeed of 20 micron, and (c) infeed of 30 micron.

shown in Fig. 5. In dry conditions, redeposited chip particles through melting is seen (Fig. 5a). In wet conditions, ground surface is better as compared to that of dry condition. However, occasional redeposited chips particle are observed in wet condition as shown in Fig. 5b. Grinding with wet condition with pneumatic barrier set up (Fig. 5c) shows a good surface with longitudinal shear lay marks and without redeposited chips particles indicating good temperature control through significant amount of shearing action for chip formation.



(a)

(b)

(c)

Fig. 5 : Photographs of ground surfaces of low carbon steel specimens with 30 micron infeed under (a) dry condition,(b) wet condition, and (c) wet conditions with pneumatic barrier set up.

4. Conclusions

Based on the experimental results obtained in surface grinding with different environmental conditions and infeeds, following conclusions may be drawn;

i) Effective flow of fluid in the grinding zone is possible by using proper pneumatic barrier to reduce temperature and to prevent wastage of lubricant.

ii) Wet condition with pneumatic barrier with low infeed gives good quality of surface and favourable chips, and hence, shall its applicability

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Education begins a gentleman, conversation completes him