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INFLUENCE OF NUMBER OF PASSES ON GRINDING PERFORMANCE IN CYLINDRICAL GRINDING OF AA6061-5%TIB2 /ZRB2 IN-SITU COMPOSITES

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ABSTRACT

The present paper describes the influence of number of passes on grindability under various wheel materials and reinforcement ratio was examined. Frequent wheel dressing of grinding wheel reduce productivity. Grinding tests conducted by using the un reinforced alloy and composites under different grinding wheels like Al2O3,CBN and diamond wheel. AA6061-5%TiB2 /ZrB2 in-situ composite was preferred for the experimental work. Result of the study reveals that the grinding force, grinding temperature, specific grinding energy and surface roughness were increased by enhancing the number of pass. Diamond wheel was outperformed than the Al2O3 and CBN wheels. Specific grinding energy and grinding force for the unreinforced alloy was more than composites. On the other hand, the grinding temperature and surface roughness of the composite was more than the unreinforced alloy. The findings from the experimental work helps to utilize the grinding process for attaining the economic material removal rate without compromise the surface finish.

Key words: *In-situ Composites, Grinding, Grinding force, Grinding temperature, Specific grinding energy, Surface roughness.*

1. Introduction

Particulate reinforced aluminum based composites have good prospective to substitute the heavy and corrosive nature ferrous materials for various engineering applications. Currently, the automobile industry is seeking the material with greater strength to mass ratio in order to obtain the fuel economy [1-2]. Majority of engineering application requires the materials with diversified properties. Aluminum based composite material fulfills the aforementioned requirements. Existence of higher volume of ceramic phases in the composite restricts the applications in various fields. Reinforcing the smaller size ceramic phase with greater interfacial strength makes the composites with remarkable mechanical properties [3]. Aluminum based composites fabricated via aluminum melt and halide salt reaction was best suited for achieving such composites. TiB2, ZrB2 and TiC ceramic phases can be reinforced into aluminum matrix by using aforesaid method. Greater mechanical property of theTiB2 and supreme high temperature bearing ability of the ZrB2 develops diversified properties when it is reinforced into the aluminum alloy. TiB2 and ZrB2 ceramic phases were chosen as reinforcements. AA6061 alloy has greater corrosion resistance, fabulous machinability, supreme weldability and moderate strength [4]. Hence, this alloy was preferred as a matrix alloy. However, the extensive usage of the composites in the various engineering filed was confined due to its indigent machinability. Closer dimension control and surface quality of the component are more indispensable for assembly. Fatigue life of manufactured component relies upon the surface roughness. Grinding is an inevitable process to accomplish the smoother surface finish with reasonable rate of material removal [5]. This process was widely encouraged for machining the harder and difficult to cut materials. Grinding wheel grits become dull at short intervals. However, the dulled grits are re-sharpened by grit fracture at later stage. The grinding process consumes more specific energy for material removal thereby induces the unfavorable effects like surface damage and residual stress formation the machined surface. Cylindrical grinding process widely employed for finishing the cylindrical component. The state of the grinding wheel and its topography is

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extremely unpredictable during grinding. Hence, it is essential to be aware of the behavior of machining process and its control in grinding of in-situ composites. During grinding of the composites, the softened aluminum loaded into gap between the grit and reduces the protrusion height of the grit. This effect restricts the cutting action and deteriorates the surface. Chip deposition between the grit allows sliding action and puts a ceiling on ploughing and shearing action [6]. Grinding performance of the particulate reinforced aluminum matrix composites are extensively accounted in the literatures. Lin et al. discussed the grindability issues of the AA-7050-6%TiB2 in-situ composite made via mixed sat reaction system. The consequence of the grinding process operating parameters in addition towheel materials on grinding force, surface roughness, grinding temperature and subsurface hardness were investigated. Their study exposed that the, grinding process parameters and wheel materials are presented a remarkable consequence on the grinding performance [7]. Ronald et al., examined the significance of the grinding wheel bond material on grindability of aluminum matrix composites. Grinding force, surface roughness, acoustic emission and temperature are measured as responses. Result of the study indicates that, the resin bonded wheel outperformed than the electroplated wheel [8]. Thiagarajan et al presented an experimental study on the cylindrical grinding performance of Al/SiC composites. The result obtained from the experimental work indicates that, the fine surface roughness and damage free surfaces are obtained at lower grinding depth, greater wheel and work piece speed [9].

Number of passes in the grinding operation was more dominant parameter which significantly affects the grinding performance. Life of the grinding wheel along with the successive dressing offers considerable influence on the rate of material removal. However, frequent wheel dressing may perhaps diminish the productivity. Mukhopadhyay and Kumar observed that the increasing trend of normal and tangential component of the grinding force when increasing the number of passes in grinding of Ti-61-4V alloy using Al_2O_3 wheel [10]. Ilio et al., reported that the enhancement of grinding force by increasing the number of passes. Further, the grinding force for unreinforced alloy was greater than the 20% Al_2O_3 reinforced composites under ideal grinding conditions [11]. Ilio and Paoletti emphasized the wheel surface damages after 100 grinding passes in grinding of SiC reinforced aluminum composites. The observed the clogged chips at active surface of the grinding wheel [12]. Pande and Lal found that, the grinding force was increased by increasing number grinding passes up to 20. Further, the grinding force become insensitive after 20th grinding pass [13]. State of grinding wheel and its topography are not reliable with respect to the grinding cycle and it is extremely unpredictable. The influence of number of passes on grindability calls for several additional investigation. Findings from the experimental investigation would address grindability issue and optimal use of desired number of passes in grinding of in-situ composites.

2. Materials and Methods

AA6061-TiB_2/ZrB_2 in-situ composite reinforced with 0% and 5% reinforcement ratio are used for experimental work. These composites are made by reacting K_2TiF_6, KBF_4, K_2ZrF_6 salts within the aluminum melt. The microstructure and XRD pattern of the composites are illustrated in the Fig. 1and 2.

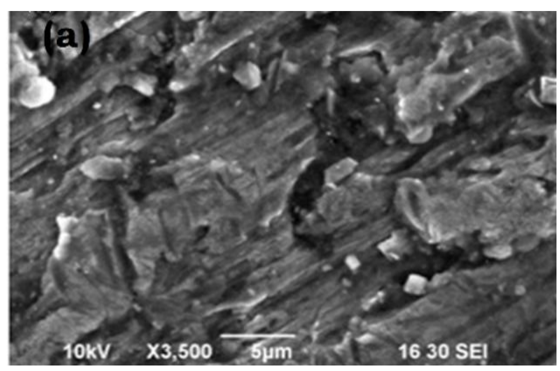

Fig. 1 SEM micro graph of 5 % composite

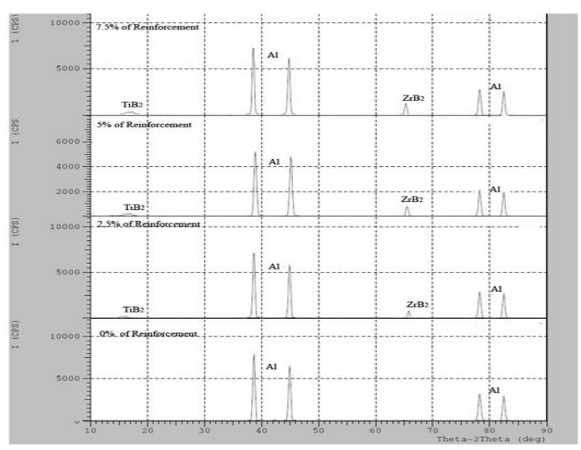

Fig. 2 XRD pattern of the composites

Smaller size (1-2μm) reinforcement particles, clean interface between particle and matrix, and uniform distribution of particle are seen in microstructure. Al, TiB_2 and ZrB_2 phases are detected in the XRD pattern. The dimension of the work piece is Φ30x300mm. Grinding experiments are conducted by using horizontal spindle cylindrical grinding machine (Heavy duty machine, Indian make). Al_2O_3 (Vitrified- bonded, grain size of 80/100, φ300 x 25mm), CBN (Resin bonded, grain size of 80/100, φ300 x 25mm) and Diamond (Resin bonded grain size of 80/100, φ300x 25mm) grinding wheels are used for the experimental work. Tangential grinding force was measured by using Variable Frequency Drive (VFD) interfaced with the grinding wheel motor [14]. Grinding temperature values were measured using Non-contact infrared thermometer and surface roughnesses were measured using by using Mituyoya surface roughness tester. All the experiments are carried out by fixing the wheel speed as 33.5m/s, work speed as 12m/min, depth of cut 20μm and feed rate 0.09m/min. The length of grinding was 250mm.Grinding force, grinding temperature, specific grinding energy and surface roughness were measured under unreinforced alloy and composites by using different grinding wheels. Influence of number of grinding pass on the aforementioned responses are measured and reported for analysis.

3. Results and Discussion

The effect of number of passes on grinding force as a function of wheel materials the grinding of AA6061 TiB_2/ ZrB_2 composites was illustrated in the Fig. 3. It is seen from the Figure 3, the grinding force was enhanced by growing the number of the pass for all the experimental conditions. The wheel clogging is more when raising the number of pass. The excessive clogging effect reduces the ploughing and cutting action in turn increase the grinding force. Further, the grinding force generated by the diamond wheel was superior to other wheels. Al_2O_3 wheel generates greater grinding force under the specified experimental conditions. The grinding forced generated by the CBN wheel lies between the diamond and CBN wheel. Extreme wear resistance and lubricating action restricts the wheel damage and allows least clogging effect. This mechanism develops lower grinding force in all experimental conditions. It can also be noted from the Fig. 3, the unreinforced alloy has more grinding force than the composite. Generally, the enhanced hardness of the composite reduce the clogging effect thereby the grinding force is reduced. The effect of number of passes on grinding temperature as a function of wheel material and reinforcement ratio of the composites was illustrated in the Fig. 4. Grinding temperature was increased by increasing the number of pass irrespective of the wheel material and reinforcement ratio of the composites. Wheel deposition was enhanced by raising the number of pass in turn hinder the ploughing and cutting action. This mechanism prolongs the sliding action and raises the temperature at the grinding interface. Greater grinding temperature was reported for Al_2O_3 wheel for both composite and unreinforced alloy. Lack of hardness and excessive wheel degradation of the Al_2O_3 wheel allows rapid clogging. Therefore, the sliding action will be extended and generates more temperature than other wheels. On the other hand, the diamond and CBN wheel produces lower temperature. It may be attributed to the least wheel degradation and sliding action at the grinding interface. It is surprise to note that, the grinding temperature of the composite was more than the unreinforced alloy irrespective of the grinding wheel. Existence of the reinforcement induces more friction at grinding interface when compared to the unreinforced alloy. The variation of number of passes on specific grinding energy as a function of wheel material and reinforcement ratio of the composites was demonstrated in the Fig. 5. Specific grinding energy was increased with the increase of number of pass. The grains are losing its cutting ability when raising the number of pass. Hence, the energy required to remove the unit volume of the material increased at higher number of pass. Greater energy was expended for grinding with Al_2O_3 wheel. The energy expenditure for diamond and CBN wheel relatively less in grinding of the unreinforced alloy and composite. Further, the specific grinding energy for unreinforced alloy is more when compared to the composite for all the grinding wheels. Wheel clogging effect was severe in grinding of unreinforced alloy and covers the cutting edge of the grains.

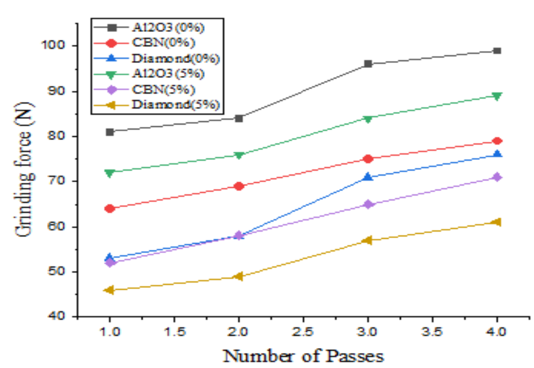

Fig.3 Variation in grinding force versus number of passes.

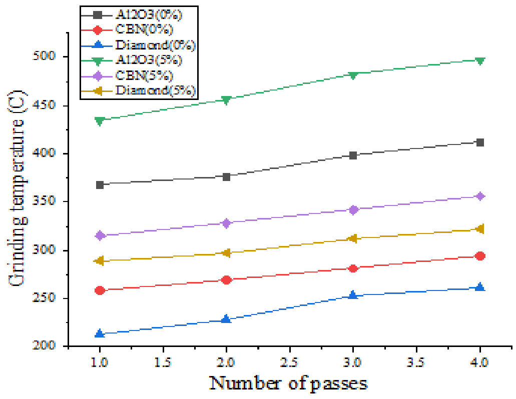

Fig.4 Variation in grinding temprature versus number of passes.

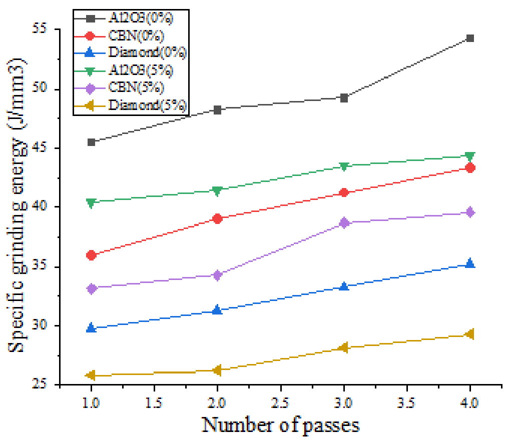

Fig.5 Variation in specific grinding energy versus number of passes.

The variation of number of passes on surface roughness as a function of wheel material and reinforcement ratio of the composites was exhibited in the Fig. 6. It was noticeable from the Fig. 6, the surface roughness was in increasing trend with the increase of the number of pass. Excessive clogging effect facilitates extended sliding action at greater number pass spoils the surface. Diamond wheel was outperformed in terms of minimal surface than the other wheel. Al_2O_3 wheel yields poor surface roughness for the identical grinding conditions. Surface roughness of the composite was more than un reinforced alloy for all the grinding wheel. Existence of ceramic content in the composite capitalizes on the surface roughness.

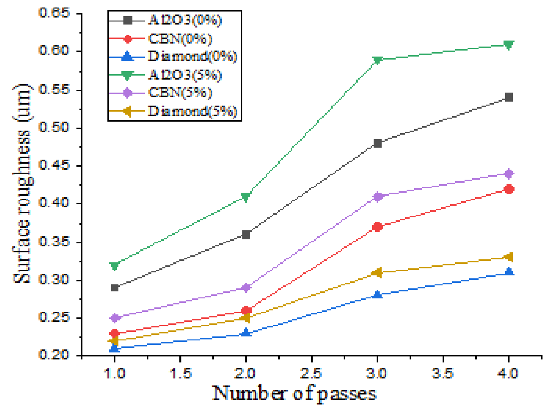

Fig.6 Variation in surface roughness versus number of passes.

4. Conclusion

The influence of number of passes on grindability under various wheel material and reinforcement ratio was investigated and the subsequent conclusions are obtained. The grinding force, grinding temperature, specific grinding energy and surface roughness were increased by enhancing the number of pass. Wheel degradation and clogging effect are major mechanism for grindability behavior of the composite and unreinforced alloy. Clogging effect was more severe in grinding of the unreinforced alloy. Generation of grater temperature fuse alloy and fused aluminum was deposited at the gap between the grits. This deposition dilutes the sharpness of the cutting tools and portion of the deposition dragged over the surface and raises the grinding force, temperature, specific energy and surface roughness. This mechanism enhances the sliding action and declines the ploughing and cutting action. On the other hand, the ceramic phase existing in the composite degrades the wheel and forms the pours. Fused aluminum occupies these pores and reduces the grinding performance. This effect was more severe on the Al2O3 wheel. Diamond and CBN wheels have good thermal conductivity and wear resistance in addition to the lubricating agent. These properties are diminishing friction and temperature at the grinding interface in turn improves the grinding performance. Findings from the experimental investigation would address grindability issue and optimal use of grinding process to acquire the desired machining rate without negotiation of the surface finish.

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