EXPERIMENTAL INVESTIGATION OF SUSTAINABLE GRINDING PERFORMANCE OF NANO SiC REINFORCED Al MATRIX COMPOSITES USING MQL

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ABSTRACT

The pollution avoidance resolves in manufacturing industries to enlarge and execute various environmentally-friendly strategies. The main purpose of green machining is to hold up future generations by attaining Sustainability. Cutting fluids are discoloured with metal particles and foulness products which reduce the efficiency of cutting fluids. To minimize the unpleasant environmental effects coupled with the use of cutting fluids, the harmful components from their formulations have to be eliminated or reduced to the acceptable level. In addition, mineral-based cutting fluids are going to be replaced with vegetable-based cutting nano-MQL fluids since they are environmentally friendly. In this present work, the grinding wheel morphology is analysed using SAE20W40, Cashew nut oil and Cashew nut oil+TiO_2 as the nano MQL fluid and compared the results by SEM and AFM analysis.

Keywords: *Minimum Quantity Lubrication (MQL) , Grinding, Cashew nut shell oil.*

1. INTRODUCTION

Metal matrix nanocomposites (MMNCs) are a range of advanced materials that can be used for a wide range of applications. MMNC’s consist of a non-metallic reinforcement incorporated into a metallic matrix which can provide advantageous properties over base metal alloys [1]. These include improved thermal conductivity, abrasion resistance, creep resistance, dimensional stability, and exceptionally good stiffness to weight and strength to weight ratios [2].

They also have better high-temperature performance. Today, there is increasing use of metal matrix composites in the aerospace, automotive, nuclear, biotechnology, electronics and sporting goods industries and bio-medical industries which resulted in the abundance of literature concerned with the processing, material characterization, properties and manufacturing of these composites [3].

To grind means to abrade, to wear away by friction, or to sharpen. In manufacturing it refers to the removal of metal by a rotating abrasive wheel [4]. The cutting wheel is composed of many small grains bonded together, each one acting as a miniature cutting point. Since the dry grinding does not have a good surface finish; the application of nano-based MQL fluid is used [5].

Minimum quantity lubricant is a type of lubricant oil which is applied on the grinding wheel and on the MMNC while grinding process in order to provide the good grinding process [6]. The MQL uses less than 500ml per hour while the SQL uses more than 60000 ml per hour; the application of the MQL nanofluid is environment-friendly since the less amount of nanofluid uses less amount of the fluid for the grinding purpose [7]. In this present work, the grinding wheel morphology is analysed using SAE20W40, Cashew nut oil and Cashew nut oil+TiO_2 as the nano MQL fluid and compared the results by SEM and AFM analysis.

2. MATERIAL AND METHODS

Aluminium billets are attained from M/s Micro Fine chemicals, India and the SiC particles are purchased from M/S US Research Nanomaterials Inc, USA. The Vaccum based solidification process is used to fabricate Aluminium reinforced with SiC nanoparticles.

The gravity process begins by preheating the mould to 150–200 °C to ease the flow and reduce thermal damage to the casting. The mould cavity is then coated with a refractory material or a mould wash, which prevents the casting from sticking to the mould and prolongs the mould life. Molten metal is then poured into the mould, after solidification the mould is opened and the casting removed to reduce chances of hot tears.

3. EXPERIMENTAL WORK

The cylindrical grinding machine is a type of grinding machine used to shape the outside of an object. The cylindrical grinder can work on a variety of shapes; however, the object must have a central axis of rotation. This includes but is not limited to such shapes as a cylinder, an ellipse, a cam, or a crankshaft. The experimental setup is shown in figure 1.

Fig 1 Experimental setup

A Variable Frequency Drive (VFD) is attached to the grinding wheel motor so that the wheel is capable of changing speed. A VFD is used to change the frequency of the motor which is running in constant speed. The power used by the operation is determined, the tangential grinding force (Ft) is multiplied by wheel speed (Vs) and a constant.

Roughness is an important parameter when trying to find out whether a surface is suitable for a certain purpose. Rough surfaces often wear out more quickly than smoother surfaces. A roughness tester is used to quickly and accurately determine the surface texture or surface roughness of a material.

An Infrared thermometer is used to measure the temperature of the grinding wheel at dynamic motion, by sensing the thermal radiation in the inference of workpiece and the grinding wheel. The experiments for parameter study are planned using Response Surface Method. Based on this, a total of Nine experiments, each having a combination of different levels of variables is carried out and the details are shown in Table 1.

Table 1 Experimental results

Sl No	MQL Type	Weight %	Wheel Speed rpm	Workpiece Speed rpm	Force N	Rough ness µm	Temp °C
1	SAE-20/40	1	900	80	52	1.10	48.6
2	SAE-20/40	2	1200	150	51	1.13	42.0
3	SAE-20/40	3	1500	270	36	1.11	37.4
4	Veg. Oil	1	1200	270	50	2.20	41.8

5	Veg. Oil	2	1500	80	51	1.11	47.0
6	Veg. Oil	3	900	150	50	1.98	38.9
7	Veg Oil + TiO_2	1	1500	150	36	0.82	35.7
8	Veg Oil + TiO_2	2	900	270	51	0.90	34.8
9	Veg Oil + TiO_2	3	1200	80	36	1.05	38.3

4. RESULTS AND DISCUSSION

1.1 Grinding wheel morphology

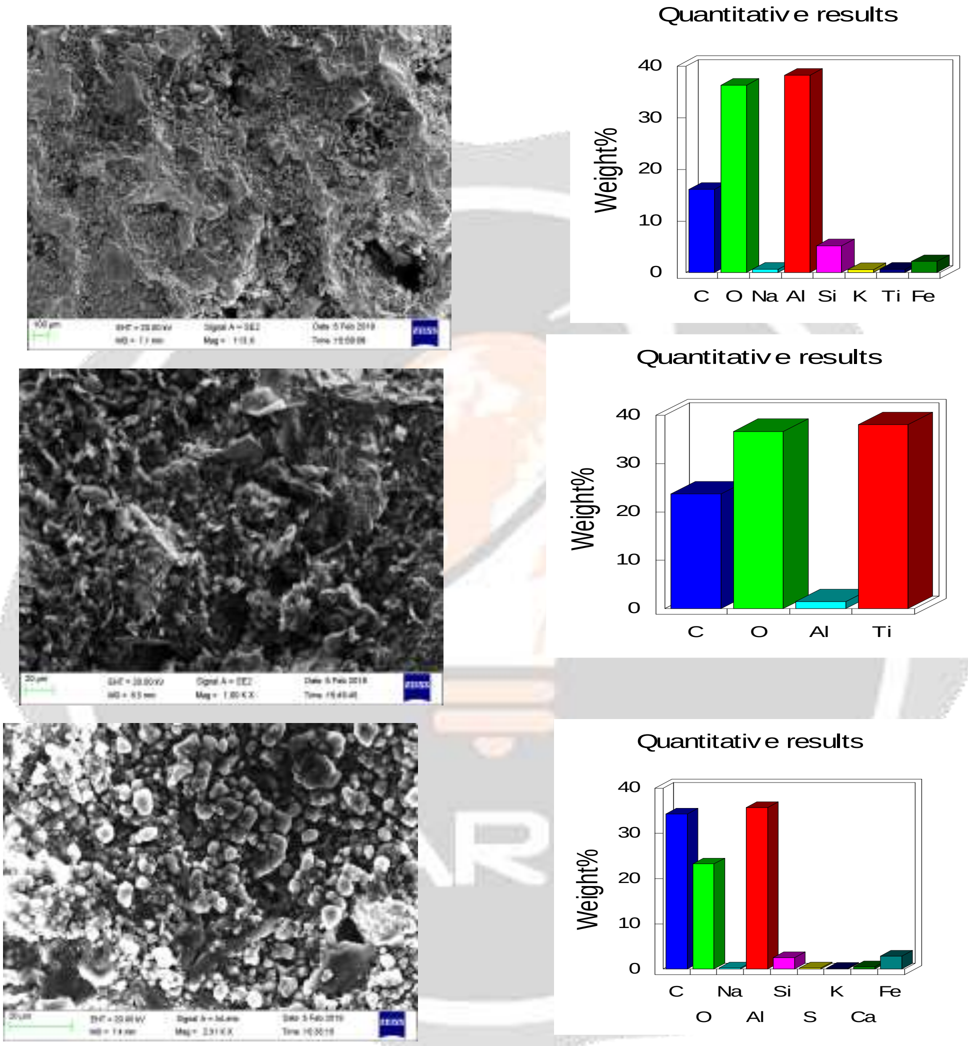

Fig 2 SEM & EDX of Grinding Wheel under SAE20W40, Veg Oil and Veg Oil +TiO_2

Nanofluids on abrasive grain surfaces can form a layer of Tio_2 nanofluid lubricating film through physical and chemical reactions; this layer can inhibit the generation of wear flats and cause them to fall off of the abrasive grains effectively [8]. More important, TiO_2 nanoparticles with a nano size and spherical appearance serve as good “bearings” in the grinding zone

As a result, the force ratio is reduced, and energy consumption and the rate of grinding wheel wear are low. SEM-EDS analysis (Figure 2) confirms the presence of elemental Ti and O in the abrasive grain surface, which proves the existence of Tio_2 nanoparticles. Tio_2 nanofluids form a lubricating film under external temperature and pressure.

4.2 AFM Analysis

Table 2 and Figure 3 shows, the average roughness value are decreased from 226.5 nm to 108.3 nm under Vegetable oil+Tio2 in MQL system. The result shows Vegetable oil+Tio2 under MQL system have smoother surface when compared to the other two MQL oils such as SAE20W40 and Vegetable oil.

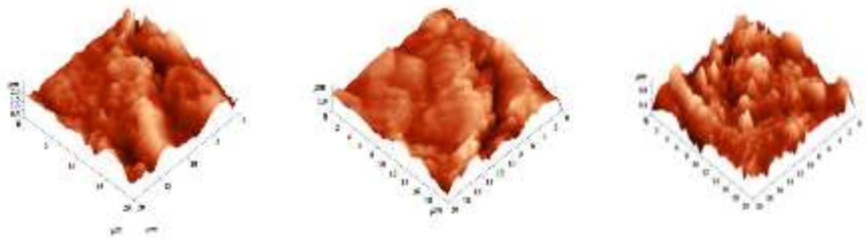

Fig 3 AFM analysis of finished Job under SAE20W40, Veg Oil and Veg Oil +TiO_2.

Table 2 Roughness analysis

MQL Type	SAE20W40	Veg Oil	Veg Oil+TiO_2
Peak-to-peak	2356.42 nm	1888.78 nm	1042.46 nm
Ten point height	1208.22 nm	970.096 nm	523.265 nm
Average Roughness	226.562 nm	156.591 nm	108.342 nm

5. CONCLUSION

Based on the results of the present experimental investigation, the following conclusions for MQL grinding of MMNC can be drawn.

- The large apertures are a feature of good cutting capability and show that nanofluids are reserved on the grinding wheel surface. The fissure networks on the grinding wheel are like micro-reservoirs that can accumulate nanofluids for the time being. This property guarantees that micro-reservoirs can carry Tio_2 nanoparticles into the grinding zone.
- Nanofluids on abrasive grain surfaces can form a layer of Tio_2 nanofluid lubricating film through physical and chemical reactions; this layer can inhibit the generation of wear flats and cause them to fall off of the abrasive grains effectively.
- The TiO_2 nanoparticles with a nano size and spherical appearance serve as good “bearings” in the grinding zone.
- TiO_2 nanoparticles prevent direct contact in the friction pair, change the sliding friction between the abrasive grains and the workpiece into rolling friction, and reduce the wear flats of grains by narrowing the contact area between them and the workpiece.
- As a result, the force ratio is reduced, and energy consumption and the rate of grinding wheel wear are low.SEM and EDAX analysis confirm the presence of elemental Ti and O in the abrasive grain surface, which proves the existence of Tio_2 nanoparticles. Tio_2 nanofluids form a lubricating film under external temperature and pressure.

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