Experimental investigation on machining parameters of Al6061-Mgo

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KEYWORDS

Al6061,
Merchant Circle,
Machinability,
Rake Angle.

ABSTRACT

The objective of the current paper is, to investigate the machinability on Al 6061-Mgo metal matrix considering machinability parameters like speed, feed, depth of cut. Aluminum is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. It is widely used for high performance applications such as automotive, military, electricity and aerospace industries because of their improved physical and mechanical properties such as light weight, high strength, good corrosion resistance, malleability, etc. Al metal matrix is the material. In the present work aluminium is used as the matrix and several reinforced materials are embedded into the matrix. Al 6061 aluminum alloy is reinforced with 1.0 weight percentage of Magnesium Oxide (MgO) particles through stir casting. In the present work, the influence of alloying elements in Al 6061 alloy have been investigated Casting of specimen having mentioned composition were prepared using stir casting method. Experiments were performed machining parameters like speed, feed, depth of cut during the turning operation with rake angle 15^o per various trials, by changing the machinability parameters and calculated for all trials resultant force and frictional force with the help of merchant cycle and identified optimized machinability parameters.

1. Introduction (Al 6061-MgO)

Important Non-ferrous metals include Aluminum, Copper, Lead, Nickel, Chromium, Manganese, Magnesium, Titanium and Zinc, and alloys such as brass. Precious metals such as gold, silver and platinum are also non-ferrous. They are usually obtained through minerals such as sulfides, carbonates, and silicates. Non-ferrous metals are usually refined through electrolysis. Alloying additions improve the properties when added in appropriate quantity. Al 6061-MgO material was produced by stir-casting methods using Al6061 aluminum alloy as the matrix material and MgO particles as the reinforcement materials. In this process, Researchers are introduced a two-step and electromagnetic assisted stir cast process to achieve better mechanical properties of fabricated. In which material matrix composite (MMC) is to be heated above its melting point, where it reaches in liquidus form after that molten metal is cooled to the stage where it becomes semi solid. Particles that are preheated added and mixed through stirring mechanism. Slurry formed is heated again till liquid state is being achieved.

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1.1 Mechanics of forces in orthogonal Machining.

For establishing the relationship between measurable and actual forces Merchant's circle diagram will be used. Merchant circle diagram is used to analyze the forces acting in metal cutting. The analysis of three forces system, which balance each other for cutting to occur. Each system is a triangle of forces.

Assumptions made in drawing Merchant's circle:

1. Shear surface is a plane extending upwards from the cutting edge. The tool is perfectly sharp and there is no contact along the clearance force.
2. The cutting edge is a straight line extending perpendicular to the direction of motion and generates a plane surface as the work moves past it.

3. The chip doesn't flow to either side, that is chip width is constant. The depth of cut remains constant. Width of the too, is greater than that of the work.
4. Work moves with uniform velocity relative tool tip.
5. No built-up edge is formed.

2. Preparation of Al 6061-Mgo alloy

2.1 Stir casting

Stir casting is the economical, effortless and most commercially adopted technique and it is known as 'vortex technique'. In this process, Researchers are introduced a two-step and electromagnetic assisted stir cast process to achieve better mechanical properties of fabricated. In which material matrix composite (MMC) is to be heated above its melting point, where it reaches in liquidus form after that molten metal is cooled to the stage where it becomes semi solid. Particles that are preheated added and mixed through stirring mechanism. Slurry formed is heated again till liquid state is being achieved. Stir casting is an economical process for the fabrication of aluminum matrix composites stircasting is a liquid state method for the fabrication of composite materials, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir Casting is the simplest and the most cost effective method of liquid state fabrication. Melting is carried out by adding the required metals according to the compositions. The molten material is poured into the cylindrical mould and allowed to solidify.

Pouring: Molten composition was poured into a die by using a crucible.

Solidification: Aluminium alloy was allowed to solidify inside the die. Once solidified, the casting was removed from die by opening the ejector.

Cleaning: All operations such as the removal of sand, scale and excess metal from the casting, burned-on sand and scale are removed to improve the surface appearance of the casting. Excess metal, in the form of fins, wires, parting line fins and gates are removed. Visual inspection of the casting for defects and general quality test is performed.

Specimen dimensions:

Diameter	20 cm
length	100 cm

As the specimen was not fitting in the lathe machine, we grinded the specimen to reduce the size of the specimen to get required dimensions and later turning operations were conducted.

Work Material Structural Analysis

Fig. 2.1. Stir casting process.

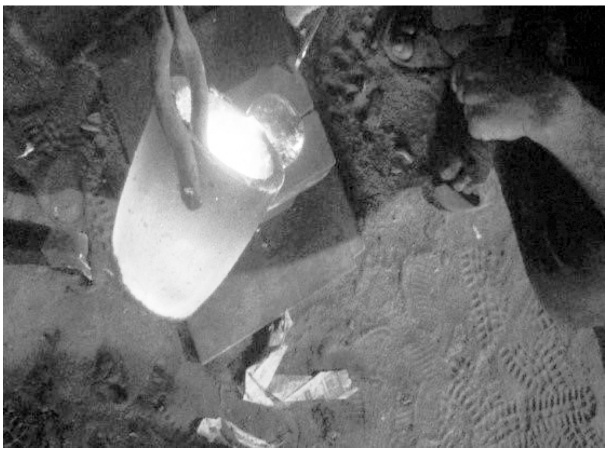


Fig. 2.2. Pouring of liquid metal in die pattern.

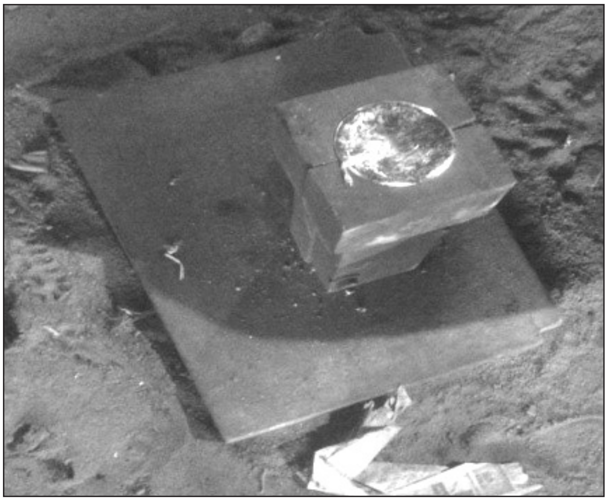


Fig. 2.3. Castings after solidification.

Fig. 2.4. Prepared specimen.

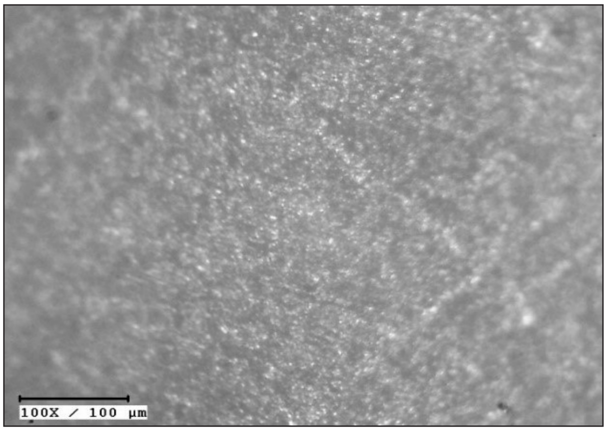


Fig. 2.5. Al6061-MgO 1% at 100x.

The above figures shows microstructure of prepared specimen with 100X, 450X magnification for the following composition

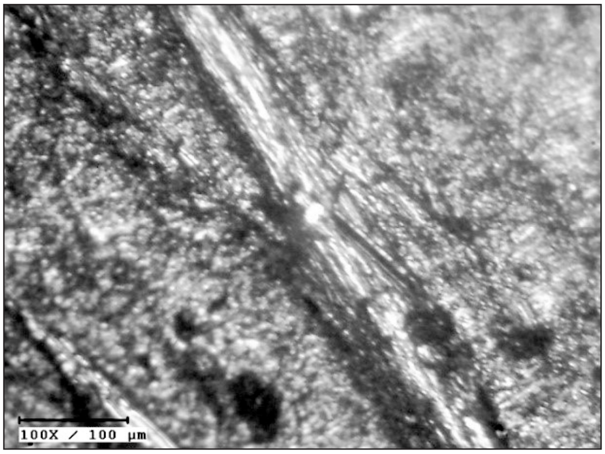


Fig. 2.6. Al6061-MgO 1% at 450x.

Mg-1.2%,Si-0.8%,Cu-0.4%,Zn-0.25%,Mn-0.15%,Fe-0.7%,Cr-0.35%,MgO-1% and the remaining is Al.

The metallurgical properties are following,

1. The dark region constitutes of alloying elements which are Copper, Magnesium, Silicon, Chromium, Manganese, Zinc, Iron, MgO and white portion is aluminium.
2. Grain boundaries are oriented uniformly.
3. The darker regions formed and alloying elements in the form of dark spotsin the matrix due to the presence of MgO.

3. Machinability test on A6061-MgO

The machining is the one of most commonly employed operation in experimental work on metal cutting to produce symmetric shape parts by a single point cutting tool. Machining forces may affect the work piece deformation and dimensional accuracy and also type of chips generated during machining operation. Many researchers have investigated on machining phenomena and simulating with development of mathematical model or CAE model. The basic machining factors like cutting speed, feed, depth of cut are widely consider for investigation by many authors and optimized factors are generated from various mathematical or statistical methods. In this paper have considered the effects of cutting forces, calculated shear force and other cutting forces by using merchant circle concept. The Al6061+MgO specimen is fixed in the lathe machine and with the help of the dynamometer the, Y Direction force and Z direction force values are obtained from those values we can derive the merchant cycle.

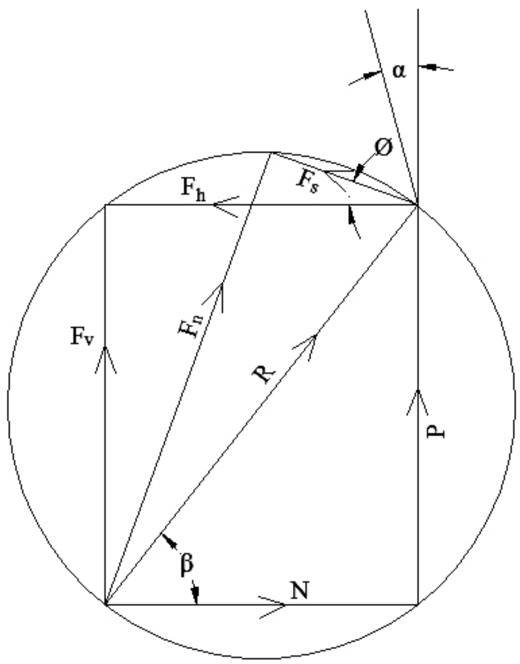
Table 3.1
Reading dynamometer's values obtained.

S No.	Speed (rpm)	Feed (mm/rev)	Depth (Mm)	Feed Force Y (Kgf)	Thrust Force Z (Kgf)
1	285	0.121	0.1	4	3
2	414	0.121	0.1	5	4
3	285	0.131	0.1	6	5
4	285	0.131	0.1	5	5
5	285	0.121	0.3	9	7
6	414	0.131	0.3	8	7

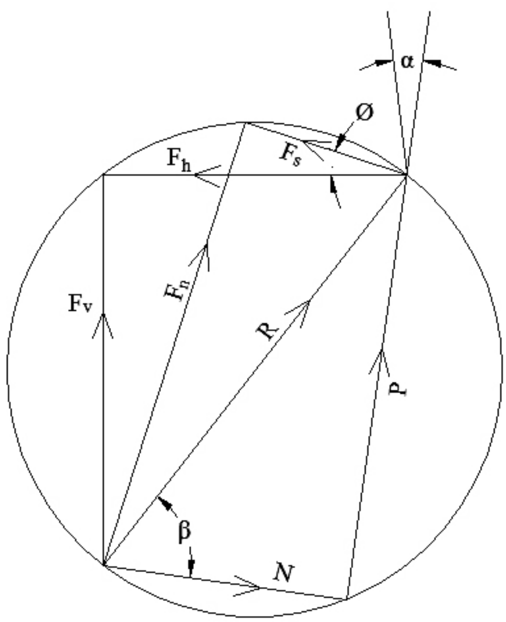
Table 3.2
Values of the resultant forces.

S No.	Feed Force Y1 (Kgf)	Feed Force Y2 (Kgf)	Thrust Force Z1 (Kgf)	Thrust Force Z2 (Kgf)	Resultant Force R1	Resultant Force R2
1	4	5	3	4	5	6.4
2	5	4	4	3	6.4	5
3	6	5	5	5	7.8	7.1
4	5	5	5	5	7.1	7.1
5	9	8	7	8	12	11.3
6	8	7	7	8	10.6	10.6

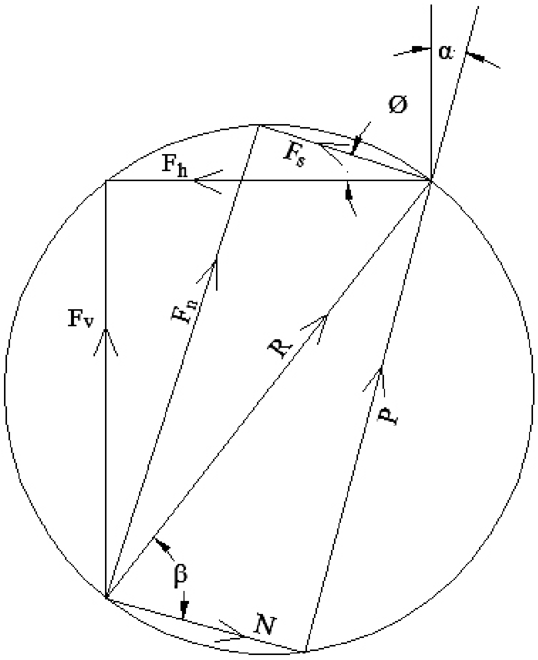
Determination of forces by Merchant Circle: The merchant circle concept was adopted for determination of all cutting forces, the calculated shear force and other cutting forces for six trails is as follows.



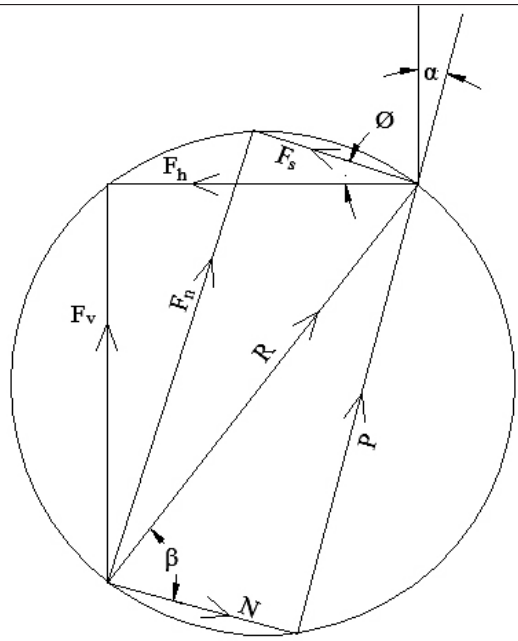
Trail 1 (α)=15°; (β)=52°; (Ø)=20°



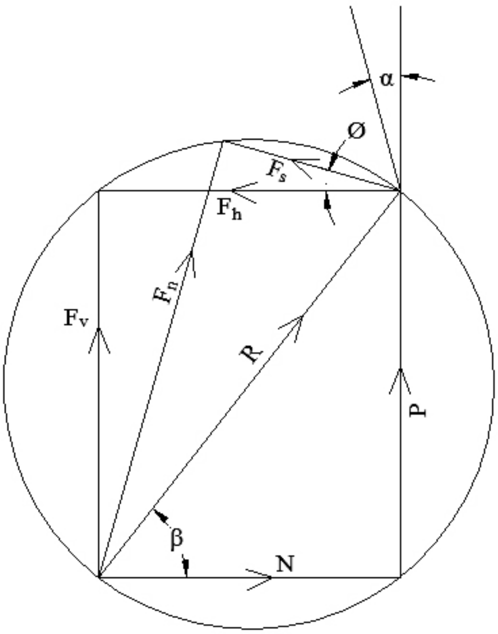
Trail 2 (α)=15°; (β)=60°; (Ø)=17.9°



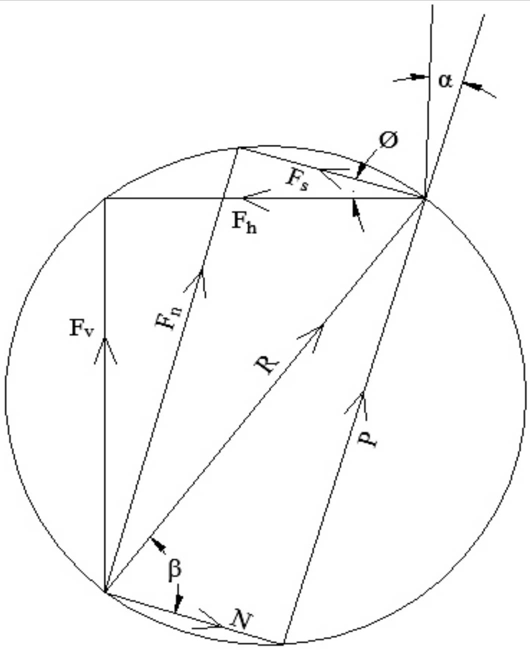
Trail 3 (α)=15°; (β)=67°; (Ø)=18°



Trail 4 (α)=15°; (β)=67°; (Ø)=17.9°



Trail 5 (α)=15°; (β)=52°; (Ø)=15.9°



Trail 6 (α)=15°; (β)=69°; (Ø)=16°

Graphs

speed	Feed	depth of	R	phi
285	0.121	0.1	0.345	20.09
414	0.121	0.1	0.302	17.55
285	0.131	0.1	0.318	18.5
414	0.131	0.3	0.304	17.67
285	0.121	0.3	0.275	15.95
414	0.121	0.3	0.262	15.18

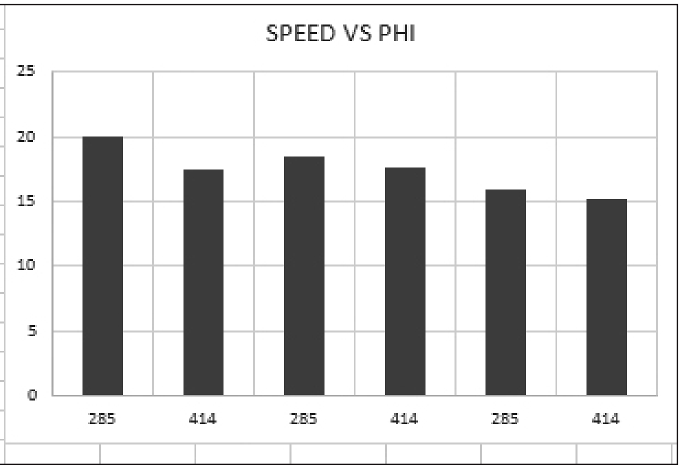


Fig. 3.1. Graph between speed and shear angle.

speed	Feed	depth of	R	phi
285	0.121	0.1	0.345	20.09
414	0.121	0.1	0.302	17.55
285	0.131	0.1	0.318	18.5
414	0.131	0.3	0.304	17.67
285	0.121	0.3	0.275	15.95
414	0.121	0.3	0.262	15.18

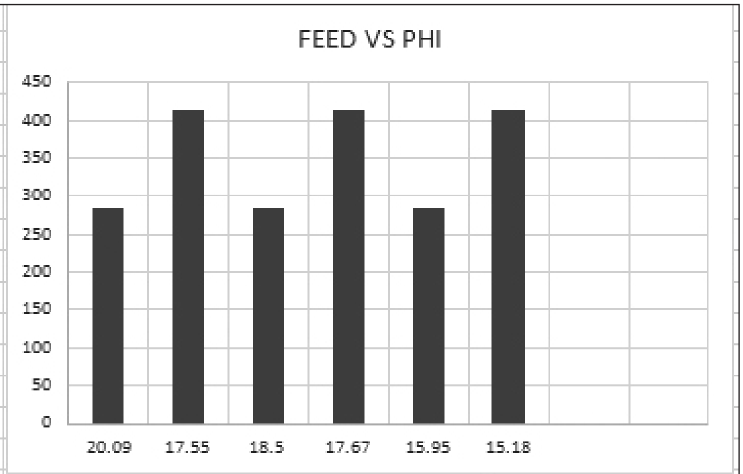


Fig. 3.2. Graph between feed and shear angle.

speed	Feed	depth of	R	phi
285	0.121	0.1	0.345	20.09
414	0.121	0.1	0.302	17.55
285	0.131	0.1	0.318	18.5
414	0.131	0.3	0.304	17.67
285	0.121	0.3	0.275	15.95
414	0.121	0.3	0.262	15.18

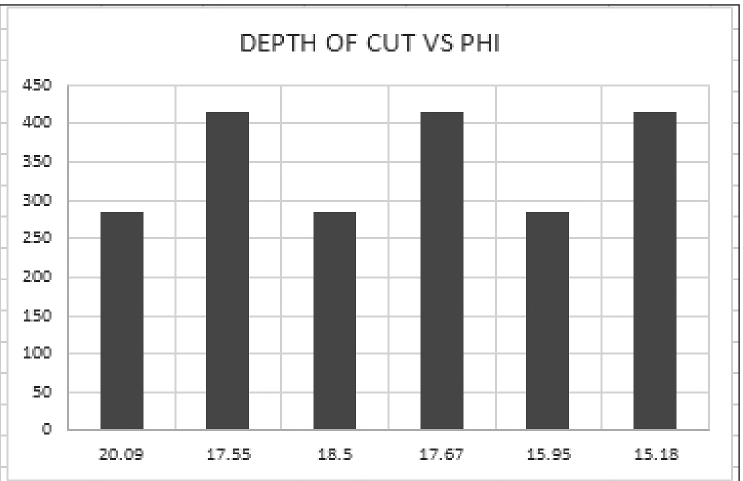


Fig. 3.3. Graph between depth of cut and shear angle.

In the above Fig: 3.1, 3.2 & 3.3 shows the graphical representation of speed, feed and depth of cut verses Shear angle respectively. The main effect and the interaction effects of the various turning parameters on resultant force and surface roughness, as predicted by the mathematical model is developed on the basis of experimental observations. Cutting speed has negative effect on resultant force. The two-level factorial design is found to be very efficient in studying the multiple variable turning operation. The variables are investigated simultaneously to study the main and the interaction effects on the resultant force within the range of study. After conducting the experiments, we observed that the different shear angles on different variables of machinability parameters, out of these variables observed better shear angle calculated from the merchant cycle by recognizing from these better shear angle we can reduce the cutting forces, improve the tool life and decrease the power consumption.

4. Conclusions

To vary the machinability parameters like speed, feed, depth of cut by using dynamometers and by measuring the chip thickness for each ofthe final values obtained after performing the experiment. After conducting 6 trials we observed better shear angle in trial number 1 with the respective mach inability parameters speed, depth of cut, feed. From metallurgical analysis grain structure and grain boundaries are clearly shown.

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