Mechanical Characterization And Optimization of Drilling Parameters on Al & As In Metal Matrix Composites

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Abstract- *Metal matrix composites (MMC) are an important group of structural materials used in automotive, defense and aerospace applications because of their low density, high specific strength and modulus, excellent physical and mechanical properties compared with the corresponding monolithic materials. Among a variety of (MMC) produced in last few decades aluminium matrix composites reinforced with various particle have attracted many researches. In the present work aluminium is reinforced with the asbestos of different weight percentages (0%,12%,17%&21%) using stir casting technique. The object of work is to study the mechanical characterization like tensile strength compression strength and hardness of all the different composition. The investigation aims to study the influence of drilling parameters are wt% speed, feed on the output responses like surface roughness (Ra) and thrust force(N).while drilling carbide drill bit, it has diameter 4mm,6mm to drill the tool material of MMC with combined of AL/AS. All the experiment are planned according to Taguchi's L16 orthogonal array in design of experiments. From the experimental data regression models were developed to predict the output responses with the selected parameter range. After conducting the experiments, quadratic response models were developed using Response Surface Methodology (RSM) for the observed responses ,surface roughness. The Optimization of machining parameters in drilling of MMC. From these analysis the carbide drill 4mm is better than 6mm carbide drill*

Keywords- Aluminum, Metal Matrix Composites, Asbestos, Tensile Strength, Compression strength, Brinell Hardness, Surface roughness, Thrust force

I. INTRODUCTION

A composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. Composite materials are having two phases. The reinforcing phase is the fibers, sheets, or particles that are embedded in the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Typically, reinforcing materials are strong with low density while the matrix is usually a ductile, or tough.

Wood is a composite – it is made from long cellulose fibers (a polymer) held together by a much weaker substance called lignin. Cellulose is also found in cotton, but without the lignin to bind it together it is much weaker.

Composite material is a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents (physical property of steel are similar to those of pure iron) . Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.

Stir casting: In conventional stir casting method, reinforced particulate is mixed into the aluminium melt by mechanical stirring. Mechanical stirring is the most important element of this process. . After the mechanical mixing, the molten metal is directly transferred to a shaped mould prior to complete solidification. The essential thing is to create the good wetting between particulate reinforcement and aluminium melt. . Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

II. EXPERIMENTATION

The work piece material is Aluminum alloy 1100.It is the purest form of aluminum having highest mechanical strength, high electrical conductivity, thermal conductivity, corrosion resistance, and workability.

Composition:

Table 2.1: Principle Composition of Aluminum 1100 Alloy

Principle Composition	Percentage
Copper	0.05-0.20%
Iron	0.25%
Manganese	0.05%
silicon	0.15%
Zinc	0.1%
Aluminum	Remaining percentage

Aluminum is reinforced with Asbestos powder having a 40 micron size particulates in the following way

Aluminum + Asbestos (0%)

Aluminum + Asbestos (12%)

Aluminum + Asbestos (17%)

Aluminum + Asbestos (21%)

2.1 STIR CASTING MOULD FURNANCE

The composites were prepared by stir casting process the original setup of the stir casting process. Electrical furnace with a temperature range of 1500 C was used to melt the matrix material. Controller with k type - thermocouple to control and measure the temperature. An electric motor is fixed at the top of the furnace to provide stirring motion to the stirrer. The speed of the stirrer can be varied as the setup has a speed controller attached to it.

Figure 2.1: Stir Casting Furnace

Specifications of the stir casting furnace:

Capacity: 1kg -5kg

Fast heating rate: furnace attain 6000c in 30 minutes

Fast cooling rate:provision to cool the melt at various cooling rate

Inner chamber size:225×225×250mm

Control panel with PID temperature controller for furnace temperature.

Stirrer assembly up/down:DCdrive to control stirrer speed

The calculation

d=diameter of the compaction die =2.5cm

h=height of the compaction die =15cm

V=volume of the compaction die

$V=\pi r2h$

$=\pi(1.25)2(15)$

$=73.593cm3$

Density of aluminium =2.7g/cm3

Mass =density×volume

=2.7(g/cm3)×73.593(cm3)

=198.7011gms.

=total mass of compaction.

Procedure of Experiment

The Aluminum scraps were cut into small pieces and hammered to get small tablets of aluminum scarp. About 1000gms of aluminum scrap was taken in the graphite crucible. The graphite crucible was placed inside the container of the furnace.

A base made up of refractory material was placed below the crucible, to prevent it from tilting or tumbling down. The furnace along with the crucible containing the aluminum scraps was heated up to a temperature of about 8000c to melt the aluminum completely and add the copper particulates inside the crucible and the stirring is done and maintain the temperature of 10000c for about 15 minutes . The crucible was taken out of the furnace with the help of tongs and by taking other safety measures like wearing insulating hand gloves.

Percentage of reinforcement(Asbestos)

For sample 1(pure aluminum)

Mass for reinforcement:0gms

Mass for matrix material:198.7011gms

For sample 2(Asbestos 12%)

Mass for reinforcement:23.844gms

Mass for reinforcement:174.857gm

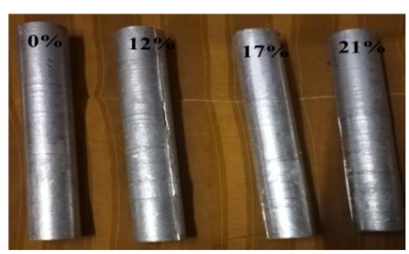


Figure 2.2: Metal Matrix Composites of Aluminum Composition

For sample 3(Asbestos 17%)

Mass for reinforcement:33.779gms

Mass for reinforcement:164.922gms
For sample 4(Asbestos 21%)
Mass for reinforcement:41.727gms
Mass for reinforcement:156.974gms

2.2 COMPRESSION TEST

Figure 2.3: Compression Machine

Procedure of Experiment

Preparation: Check all the things you need are ready. Check the compression machine is in working order. Wear hand gloves and safety goggles. Taking measurement: Take the measurement of specimens (which are sent to laboratory for testing). Calculate the cross sectional area (unit should be on mm2) and put down on paper. Do the same for each specimen Start machine: Turn on the machine. Place one specimen in the center of loading area. Lowering piston: Lower the piston against the top of the specimen by pushing the lever. Don't apply load just now. Just place the piston on top of specimen so that it's touching that. Applying load: Now the piston is on top of specimen. It is the time to apply load. Pull the lever into holding position. Start the compression test by Pressing the zero button on the display board. Increasing pressure: By turning pressure increasing valve counter-clockwise, adjust the pressure on piston so that it matches compression strength value. Apply the load gradually without shock.
Calculate the compressive strength: The result we got from testing machine is the ultimate load in KN

specimen dimensions:
length:25mm
diameter:23mm

Sample cu(%)	Intial (length) in mm	% reduction	Final (length) in mm	Deformation Length (int-fin)	Strength KN	Compression Strength (MPa)
0	25	10	22.5	2.5	25	50.95
0	24	20	19.2	4.8	34	69.29
0	23	30	16.1	6.9	45	91.71
12	25	10	22.5	2.5	38	77.45
12	24	20	19.2	4.8	61	124.33
12	23	30	16.1	6.9	87	178.22
17	25	10	22.5	2.5	91	185.47
17	24	20	19.2	4.8	119	242.54
17	23	30	16.1	6.9	162	330.19
21	25	10	22.5	2.5	90	188.83
21	24	20	19.2	4.8	111	226.24
21	23	30	16.1	6.9	154	313.88

size of compression plate:300mm dia
maximum working pressure:125bar

2.3 TENSILE TEST

Figure 2.4: Universal Tensile Machine

Procedure of Experiment

The specimens were chosen before experiment .Care is to be taken to ensure that the specimens did not have any notching or cracks from manufacturing or any surface defects that would adversely affect the tensile tests. Before loading the specimens in the machine, universal testing machine. Take the input of necessary information like gauge length and width of the specimen. The specimens were loaded into the machine, and a tensile test was performed. The data was recorded manually

Specimen dimensions:
Length:140mm
Diameter:25mm

Sample /parameter	Pure Aluminium	Al+ Asbestos 88%+12%	Al+ Asbestos 83%+17%	Al+ Asbestos 79%+21%
Length (mm)	140	140	140	140
Elongated(final length)	180.3	170.4	150.5	160.9
Load (KN)	2.6	3.1	3.9	3.4
Stress(N/mm^2)	5.29	6.31	7.94	6.93
Strain	0.287	0.217	0.075	0.149

2.4 BRINELL HARDNESS TEST

Figure 3.5: BrinellHardness Test

Procedure of Experiment

The indenter is pressed into the sample by an accurately controlled test force. The force is maintained for a specific dwell time, normally 10-15 seconds.After the dwell time is complete, the indenter is removed leaving a round indent in the sample.

The size of the indent is determined optically by measuring two diagonals of the round indent using either a portable microscope or one that is integrated with the load application device.

The test is achieved by applying a known load to the surface of the tested material through a hardened steel ball of known diameter. The diameter of the resulting permanent impression in the tested metal is measured and the BrinellHardness Number calculated as Indenter: carbide ball indenter

Diameter of intender:2.5mm
B-scale readings

Pure aluminum	82.363 HBW
Al- Asbestos (12%)	71.299 HBW
Al- Asbestos (17%)	183.73 HBW
Al- Asbestos (21%)	111.094 HBW

DESIGN OF EXPERIMENTS

Design of experiments (DOE) is a methodical, laborious method to revolve engineering complications, which applies principles and techniques at the data collection stage so as to ensure the generation of valid, defensible, and supportable engineering conclusions of the manufacturing process.

1. Improved process output .
2. Reduce variability and closer confirmations to nominal or target requirement.
3. Reduced development time.
4. Reduce overall cost.

Table() : Process Parameters and Levels used for experimentation

Process parameter levels with units	Notation	Levels			
		1	2	3	4
Weight % of Al-AS	%wt	0	12	17	21
Speed m/min	N	250	500	750	1000
Feed mm/rev	F	0.1	0.2	0.3	0.4

Table(): L16 Orthogonal arrays employed for experimentation

	L16		
RUN	Part1	Part2	Part3
1	1	1	1
2	1	2	2
3	1	3	3
4	1	4	4
5	2	1	2
6	2	2	1
7	2	3	4
8	2	4	3
9	3	1	3
10	3	2	4
11	3	3	1
12	3	4	2
13	4	1	4
14	4	2	3
15	4	3	2
16	4	4	1

Table(): Design Matrix for drilling

S. No	Coded Values			Original Values		
	Wt. %	N	F	Wt. %	N	F
1	1	1	1	0	250	0.1
2	1	2	2	0	500	0.2
3	1	3	3	0	750	0.3
4	1	4	4	0	1000	0.4
5	2	1	2	12	250	0.1
6	2	2	1	12	500	0.2
7	2	3	4	12	750	0.3
8	2	4	3	12	1000	0.4
9	3	1	3	17	250	0.1
10	3	2	4	17	500	0.2
11	3	3	1	17	750	0.3
12	3	4	2	17	1000	0.4
13	4	1	4	21	250	0.1
14	4	2	3	21	500	0.2
15	4	3	2	21	750	0.3
16	4	4	1	21	1000	0.4

Table():Experiment results for Ra d =4mm

S.No.	Wt % of Al-AS	Speed(N) Rpm	Feed (F) m/rev	Surface Roughness (Ra)
1	0	250	0.1	3.436
2	0	500	0.2	3.537
3	0	750	0.3	4.103
4	0	1000	0.4	4.316
5	12	250	0.1	3.516
6	12	500	0.2	2.885
7	12	750	0.3	3.275
8	12	1000	0.4	2.010
9	17	250	0.1	2.568
10	17	500	0.2	2.320
11	17	750	0.3	1.312
12	17	1000	0.4	1.410
13	21	250	0.1	2.081
14	21	500	0.2	1.040
15	21	750	0.3	1.113
16	21	1000	0.4	0.008

Table():Experiment results for Ra Carbide drill bit d= 6 mm

S.No.	Wt. %	Speed	Feed	Ra
1	0	250	0.1	3.212
2	0	500	0.2	3.365
3	0	750	0.3	3.821
4	0	1000	0.4	3.905
5	12	250	0.1	3.286
6	12	500	0.2	2.429
7	12	750	0.3	2.765
8	12	1000	0.4	2.211
9	17	250	0.1	2.324
10	17	500	0.2	2.185
11	17	750	0.3	1.143
12	17	1000	0.4	0.825
13	21	250	0.1	2.500
14	21	500	0.2	2.045
15	21	750	0.3	1.009
16	21	1000	0.4	0.005

Drilling parameters for al/as in MMC: the data pre processing is carried out for each of the performance characteristics of the research interest. The performance characteristics of surface roughness with respect to the independent machining parameters such as speed, feed, wt%.the drill diameter of carbide has 4mm, 6mm.in these surface roughness the minimum value mentioned in 21% of Al/AS

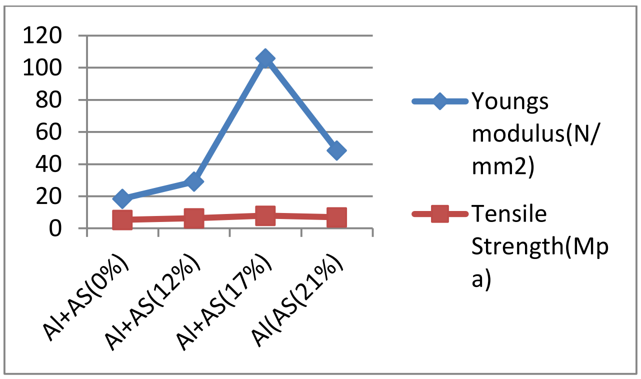
For carbide 6mm has better results to find out in these output parameter.

III. RESULTS AND DISCUSSIONS

3.1 TENSILE TEST READINGS

Table 3.1 : Tensile Test Readings

Sample /parameter	Pure Aluminium	Al+ Asbestos 88%+12%	Al+ Asbestos 83%+17%	Al+ Asbestos 79%+21%
Length (mm)	140	140	140	140
Elongated(final length)	180.3	170.4	150.5	160.9
Load (KN)	2.6	3.1	3.9	3.4
Stress(N/mm^2)	5.29	6.31	7.94	6.93
Strain	0.287	0.217	0.075	0.149
Youngs modulus(N/m m^2)	18.43	29.07	105.86	48.51



Fig(): The Effect of wt.% of Asbestos & Aluminum on Young's Modulus and Tensile Strength of Al/AS Composite

3.2 COMPRESSION TEST READINGS

Sample AS(%)	Intial (length) in mm	% reduction	Final (length) in mm	Deformation Length (int-fin)	Strength KN	Compression Strength (MPa)
0	25	10	22.5	2.5	25	50.95
0	24	20	19.2	4.8	34	69.29
0	23	30	16.1	6.9	45	91.71
12	25	10	22.5	2.5	38	77.45
12	24	20	19.2	4.8	61	124.33
12	23	30	16.1	6.9	87	178.22
17	25	10	22.5	2.5	91	185.47
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17	23	30	16.1	6.9	162	330.19
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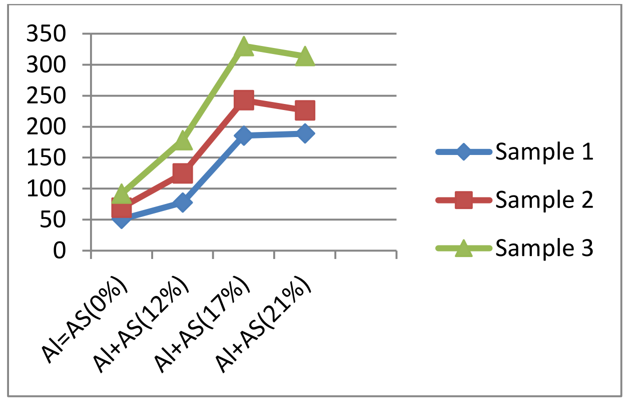

Fig (): The Effect of wt.17% of Asbestos & Aluminum on Compressive Strength of Al/AS Composite

3.3 EXPERIMENTAL VALUES OF BRINELL HARDNESS TEST

Pure aluminum	82.363 HBW
Al- Asbestos (12%)	71.299 HBW
Al- Asbestos (17%)	183.73 HBW
Al- Asbestos (21%)	111.094 HBW

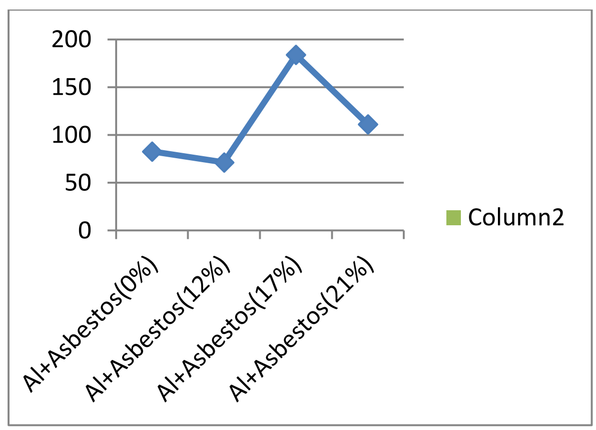

Fig (): The Effect of wt.% of Asbestos & Aluminum on Brinell Hardness of Al/AS Composite

IV.CONCLUSION

- The extensive study carried out during the present work to led following consulsions

- Stir casting is a viable option for the preparation of Metal matrix composites.
- The selected process parameter for study i.e., speed, feed, wt% and the tool material have an significant in machining of CNC.
- For mechanical characteristics 17% is better results for all tests like compression, tensile, hardness.

SURFACE ROUGHNESS:

- Speed, feed,wt% produced significant effect in surface roughness so selection of the optimum.
- Surface roughness is maintain less accuracy. the tool material affect both response parameters
- For using carbide drill bit d=4mm,d=6mm different drills to test on output parameters
- In surface roughness carbide drill with d=6mm,has the better result in the 21%.the minimum is 0.005.At the (speed=1000,feed=0.4).
- The condition of surface roughness to get better wt%.

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