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Thrust Force and Surface Roughness Analysis of Varying Percentage of Al 2024 Alloy as Matrix and as Reinforcement

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***Abstract* - MMC are the metal matrix composites having matrix and reinforcement material, in this project Al 2024 alloy is taken as matrix material and Zirconia as reinforcement material. Composites are prepared using stir casting method, where it is the simple and economic method with varying percentage of reinforcement i.e 0, 2, 4 & 6% reinforcement. Thrust force and surface analysis were made for the samples prepared with different drill bits i.e HSS, TiALN coated and uncoated carbide brill bits. After this SEM analysis were made.**

Key Words: Percentage reinforcement, Cutting force, Surface roughness, SEM analysis

1. INTRODUCTION

Machining of the composites is very difficult as it contains ceramic reinforcement particles in it. From the earlier studies it is stated that cutting parameter (speed, feed and percentage reinforcement) affects the cutting force and surface roughness of the MMNC. M. Nouari et al. studied that, HSS drill bits are not suitable for dry drilling operations and they suggested to use Uncoated cemented WC drill bit for constant feed and low cutting speed and for high speed drilling TiAlN+WC/C coated materials are recommended. J. Monaghan from their analysis showed, PCD drill bits gives smooth surface finish and less tool wear and it also have less cutting forces but PCD drill bits are costly compared to carbide drill bits hence in this study we tried used HSS, uncoated carbide and TiAlN coated carbide drill bits. Ahmet Taskesen et al. from their studies showed that with percentage reinforcement also influences the thrust force generation during machining.

2. EXPERIMENTAL PROCEDURE AND METHOD

In this work, composite materials containing of 2, 4, and 6% reinforced zirconia nano powder and remaining Al 2024 alloy were produced by stir casting method and the quantities considered for preparing castings are shown in the table 1.

SL No.	% Reinforcement	Al 2024 (Matrix) in grams	ZrO_2 (Reinforcement) in grams
1	0	1500	0
2	2	1470	30
3	4	1440	60
4	6	1410	90

Table-1: Quantity of reinforcement and matrix

After preparing castings, thrust force and surface roughness analysis (R_a), were carried out and 3 different drill bits i.e. HSS, Uncoated carbide and TiAlN coated carbide drill bit of same point angle and drill diameter were considered for preparing the castings, the specification of the drill bit is shown in the table 2 and figure 1 shows the image of the drill bit considered for conducting experiments.

SL No.	Drill Bit	Point angle	Flute Length	Overall Length	No of Flutes	Drill Diameter	Depth of penetration
1	HSS	118	75 mm	117 mm	3	8 mm	10 mm
2	Uncoated Solid Carbide	118	60 mm	95 mm	2	7.8 mm	10 mm
3	TiAlN coated carbide	118	86 mm	117 mm	4	8 mm	10 mm

Table-2: Specifications of different drill bits

Figure-1: Drill bits

For thrust force and R_a analysis speed and feed rates were varied i.e. speed considered are 355, 560 and 710 rpm and feed rate considered are 0.03, 0.05 and 0.08 mm/rev, so for each casting 3^2 i.e. 9 holes were drilled with one set of drill bits and is repeated for other drill bits, so in total 108 holes were drilled for analysis. Thrust force measurement were made by strain gauge type of drilling dynamometer having thrust force measuring range of 0 to 200Kgf and torque measuring range of 0 to 20 KN-m. And surface roughness were measured in Mitutoyo SJ-201 surface profiler having measuring range of -200µm to 150µm and any surface orientation of the work piece can be measured. Drilling of the composites were carried out in Kovosvit MAS manufacturer of VR2 model radial drilling machine, having the spindle rpm ranging from 90-4500 rpm, spindle diameter of

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60mm, table size of 550cube, the total weight of the machine is 13200kg.

Figure-2: Thrust force analysis

Figure-3: Surface roughness analysis

2.1 Rockwell Hardness test:

After castings preparation harness test were made for varying percentage reinforcement material to find the hardness values using 100kgf of major load by Rockwell hardness testing. For conducting experiments 1/16^{II} ball indenter is used and B scale (Al alloys) readings are taken. Three trials were made and average values of trials are considered.

3. RESULTS AND DISCUSSIONS

Rockwell hardness test:

SL No.	% Reinforcement	Trial 1	Trial 2	Trial 3	Avg hardness no.
1	0	73	72	76	73.66
2	2	74	77	75	75.33
3	4	79	76	79	78
4	6	79	78	80	79

Table-3: Rockwell hardness test

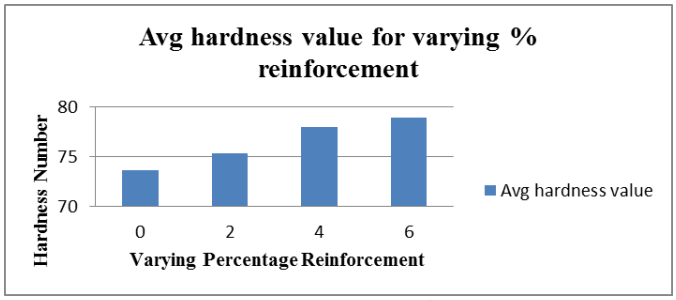

Figure-4: Graphical representation of hardness value

From the Rockwell hardness test, we can observe the increase in hardness value with the increase in percentage reinforcement and maximum hardness is found in 6% reinforced material with 79 HRB

Drill bit	SL NO	Speed (rpm)	Feed (mm/rev)	Thrust force (kgf)				Surface Roughness (Ra) µm			
				0%	2%	4%	6%	0%	2%	4%	6%
HSS	1	355	0.03	68	71	69	81	1.71	2.94	3.88	3.88
	2	355	0.05	83	90	99	115	2.86	3.2	4.43	4.72
	3	355	0.08	94	117	123	137	3.37	3.9	4.65	4.82
	4	560	0.03	50	55	59	68	2.91	2.93	4.26	6.78
	5	560	0.05	83	87	91	100	2.61	3.14	4.73	4.68
	6	560	0.08	119	131	121	123	4	4.37	4.93	5.55
	7	710	0.03	44	71	74	88	2.71	3.17	4.27	4.4
	8	710	0.05	75	96	99	108	3.52	3.5	4.06	4.82
	9	710	0.08	87	109	116	127	5.09	5.16	5.64	5.91
Uncoated Carbide	10	355	0.03	25	25	31	36	1.56	2.37	2.55	2.71
	11	355	0.05	30	41	44	45	1.9	2.22	2.63	2.78
	12	355	0.08	38	49	49	51	1.72	2.19	2.64	3.41
	13	560	0.03	30	35	39	41	1.4	2	2.22	3.35
	14	560	0.05	35	45	48	56	2.15	2.91	3.02	3.59
	15	560	0.08	49	54	54	63	2.72	3.02	3.14	4.74
	16	710	0.03	19	39	34	51	1.41	2.11	2.31	3.32
	17	710	0.05	27	50	54	62	2.06	2.23	2.43	3.32
	18	710	0.08	45	54	60	74	2.38	2.86	3.94	3.92
TiAlN coated	19	355	0.03	21	24	26	28	1.66	1.71	2.57	3.24
	20	355	0.05	29	31	33	35	2.18	2.86	3.12	3.47
	21	355	0.08	31	34	37	35	2.92	3	3.15	3.95
	22	560	0.03	15	17	20	29	1.2	2.18	3.03	4.95
	23	560	0.05	18	19	25	34	2.63	3.1	3.35	3.87
	24	560	0.08	23	26	30	39	3.2	3.53	4	5.27
	25	710	0.03	24	24	26	31	2.04	2.65	3.2	3.68
	26	710	0.05	28	26	32	39	2.56	3.04	3.7	4.04
	27	710	0.08	35	31	39	42	3.04	3.14	4.34	4.3

Table-4: Thrust force and surface roughness analysis

3.1 Thrust Force:

From the experimental data one can see that, with increase in percentage reinforcement thrust force value has increased and maximum thrust force is observed in 6% reinforced material. From the thrust force analysis we can see that with increase in speed and feed rate thrust force value has increased because increase in feed, increases the load acting on to the material by the drill bit hence thrust force increases. TiAlN coated carbide drill bit gives lower thrust force values compared to HSS drill bit. At the speed of 560rpm there is a decrease in thrust force value in HSS and TiAlN coated carbide drill bit and again increases at 710 rpm. So the order of preference will be TiAlN coated carbide drill bit followed by uncoated carbide and HSS drill bit.

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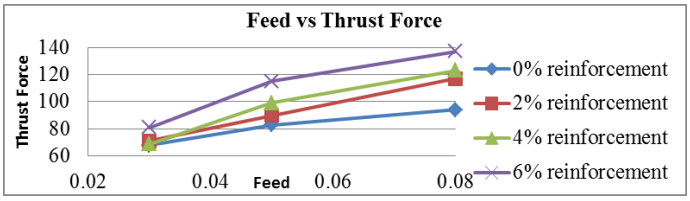

Figure-5: Feed vs Thrust force

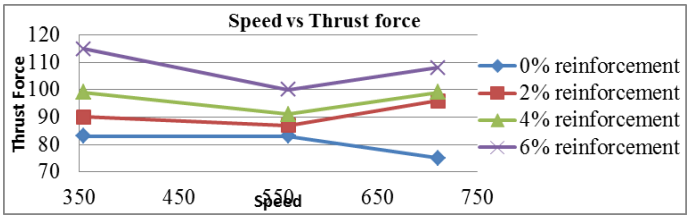

Figure-6: Speed vs Thrust force

3.2 Surface Roughness (R_a):

From the experimental data one can see that, with increase in percentage reinforcement R_a value has increased for all varying speed and feed rates. HSS drill bit gives more R_a values and lower R_a values are observed in uncoated carbide drill bits. With increase in speed and feed rate R_a values has increased in all drill bits and lower R_a is observed at 710 rpm and 0.03 mm/rev feed rate in uncoated carbide drill bit. So order of preference will be uncoated carbide followed by TiAlN coated carbide drill bit and HSS drill bit.

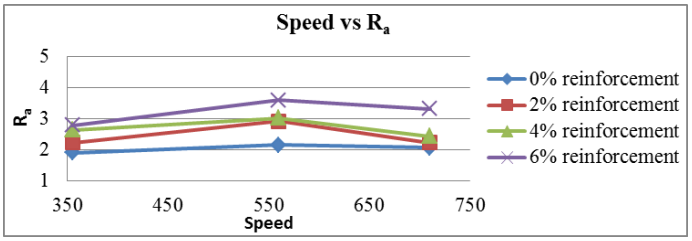

Figure-7: Speed vs Ra

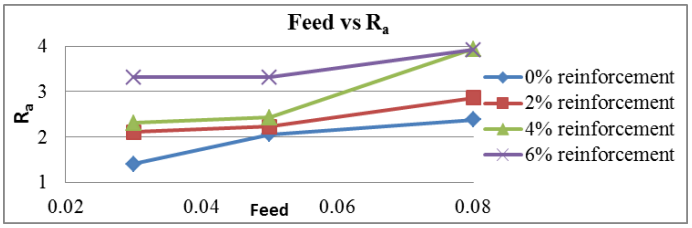

Figure-8:Feed vs Ra

3.3 SEM analysis:

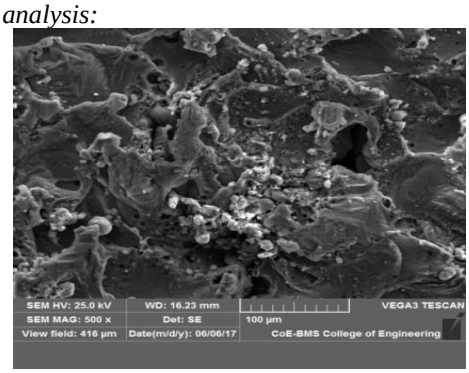

Figure-9: 2% reinforced material

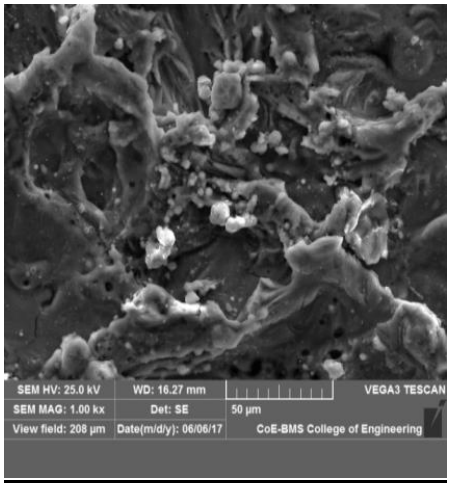

Figure-10: 4% reinforced material

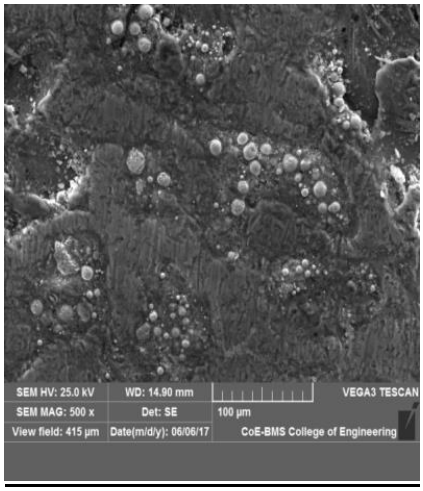

Figure-11: 6% reinforced material

From the SEM analysis it clear that with increase in percentage reinforcement, zirconia particles are almost uniformly distributed.

4. CONCLUSIONS:

Rockwell hardness test were carried out to find the hardness value of each specimen and it shows that with increase in reinforcement percentage, hardness value has increased and maximum hardness is observed in 6% reinforcement material and its value is 79HRB. SEM were made for the castings prepared to study the distribution of Zirconia particles and through SEM analysis we can see almost uniform distribution of Zirconia particles with increase in weight percentage value of reinforcement. By thrust force analysis we can conclude that with increase in percentage reinforcement, thrust force has increased and maximum thrust force is observed in 6% reinforced material. Analysis of thrust force values in case of HSS drill bit: we can conclude that with increase in speed and feed rate, thrust force has increased and an lower thrust force value is observed at speed of 560rpm and feed rate if 0.03mm/rev.

Analysis of thrust force values in case of uncoated carbide drill bit: we can conclude that with increase in speed and feed rate, thrust force has increased and the values obtained are lower

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when compared with HSS drill bit. At feed rate of 0.03mm/rev and speed of 355rpm thrust force value was lower. Analysis of thrust force value in case of TiAlN coated carbide drill bit: we can conclude that with increase in speed and feed rate, thrust force has increased. At speed of 560rpm, thrust force was lower when compared with 355 and 710rpm. At 0.03mm/rev and 560rpm we can observe the lower thrust force value. By analysing the surface roughness value we can conclude that with increase in percentage reinforcement, surface roughness (R_a) value has increased and maximum surface roughness value is observed in case of 6% reinforced material.

In case of HSS drill bit with increase in speed and feed rate, surface roughness value has increased, lower surface roughness value is observed at 355rpm and 0.03mm/rev. HSS drill bit gives more surface roughness values compared with the other drill bits. In case of uncoated carbide drill bit with increase in speed and feed rate, surface roughness value has increased. At 710rpm and 0.03mm/rev we can observe lower surface roughness value. In case of TiAlN coated carbide drill bit with increase in speed and feed rate, surface roughness value has increased. Lower surface roughness value is observed at 0.03mm/rev and 355rpm. From the machinability point of view uncoated carbide drill bit can be used for drilling operations of this MMNC as it consumes lower thrust force and gives lower surface roughness values.

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