Machinability Studies on Sic Reinforced with Aluminium 6061 and 7075 Alloy

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ABSTRACT

Metal matrix composites are used mostly in aerospace, space ships, automotive, nuclear, biotechnology, electronic and sporting goods industries. Due to their high cost, experiments are usually done to reduce the cost of the composites and in expensive materials are utilized for metal matrix composites.

The machinability of MMC is different from the traditional materials because of presence abrasive reinforcement particles. During turning operation, the cutting forces (Ft, Ff & Fr) have increased with increase in weight percentage of SiC. At constant feed rate and different cutting speed, the cutting forces are increases on increasing the depth of cut. That indicates the power consumption during machining of aluminium alloy MMCs will increases on increasing the depth of cut at the same condition.

KEY WORDS: *Machinability, Metal Matrix Composites,* ***Al6061, Al7075.***

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1 INTRODUCTION

Composites are combinations of two materials in which one of the materials, called the reinforcing phase, is in the form of fiber sheets or particles and are embedded in the other material called the matrix phase. The primary functions of the matrix are to transfer stresses between the reinforcing fibers/particles and to protect them from mechanical and/or environmental damage whereas the presence of fibers/particles in a composite improves its mechanical properties such as strength, stiffness etc. A composite is therefore a synergistic combination of two or more micro-constituents that differ in physical form and chemical composition and which are insoluble in each other. The objective is to take advantage of the superior properties of both materials without compromising on the weakness of either.

It is possible to develop new material with a unique combination of properties previously unattainable with conventional materials. This ability to engineering materials with specific properties for specific applications represents a great potential advantage of composites. It is also possible to selectively reinforce particular areas of components, thus providing development of materials properties only in an area, which is truly necessary.

2. OBJECTIVES OF PRESENT WORK

The following are the objectives of the work.

Composites were prepared by using die-casting method for four different weight percentage of reinforcement namely SiC 2%, 4%, 6% and 8%

1. Effect of SiC on the hardness and Machinability characteristics of Al 6061 and 7075 MMCs studied.
2. Comparative study is made between Al 6061 and 7075 MMCs specimens for their hardness and Machinability characteristics along with matrix materials.
3. Study the Al 6061 and 7075 MMCs specimens for their microstructure changes such as phase change, formation of precipitates, etc.
4. Investigate the effect of SiC and Machinability parameters on performance of Al 6061 and 7075 MMCs.

3. EXPERIMENTAL DETAILS

3.1 **Material selection**

In the present investigation two base matrix materials are selected i.e, Al 6061 and Al 7075 and Machinability comparative study has been done on these two based composites.

The Al 6061 alloy (matrix material), 200µm size SiC particles (reinforcement) are used for fabrication of MMCs. The chemical composition of Al6061 is given in the Table 1.

Table 3.1: Chemical Composition of Al 6061

Chemicals	Si	Ti	Fe	Mn	Zn	Cu	Mg	Cr	Other	Al
Wt. (%)	0.4-0.8	0.15	0.7	0.15	0.25	0.15-0.40	0.8-1.2	0.04-0.35	0.05	Balanced

The Al 7075 alloy (matrix material), SiC 200 µm size particles (reinforcement) are used for fabrication of MMCs. The chemical composition of Al7075 is given in the Table 2.

Table 3.2: Chemical Composition of Al 7075

Composition	Zn	Fe	Mg	Mn	Cu	Si	Cr	Ti	Al
% Composition	5.6	0.5	2.5	0.3	1.6	0.4	0.23	0.2	Balanced

3.2 Casting (Gravity die casting)

Al 6061 ingots are melted in electrical resistance furnace and different weight percents silicon carbide reinforcement is added to get following composition composite specimens.

3.3 The measurement process is comprised of three stages

Stage – 1: The target physical variable (say force) is converted proportionally into another suitable variable (say voltage) called signal, by using appropriate sensor or transducer.

Stage – 2: The feeble and noisy signal is amplified, filtered, rectified (if necessary) and stabilized for convenience and accuracy of measurement.

Stage – 3: where the conditioned signal (say voltage) is quantitatively determined and recorded by using some read out unit like galvanometer, oscilloscope, recorder or computer.

SPECIFICATIONS:-

- Mechanical Sensing Unit with Tool Holder and Tool with strain Gauges mounted on it.
- Digital Force Indicator - two/three channel, to read both forces simultaneously.
- Balancing Potentiometer for initial balancing l Range - 0 to 200 Kg, least count - 1 Kg.
- The set up is calibrated at our works

Unlike strain gauge type dynamometers, the sophisticated piezoelectric type (KISTLER) dynamometers can be used directly more accurately and reliably even without calibration by the user.

4. RESULTS AND DISCUSSION

4.1 Machinability Analysis

Only tangential cutting force measures the machinability property of the material with respect to variation of various parameters like cutting speeds, feed rates and depths of cut. The axial and radial cutting forces were consistently more or less proportional to the tangential cutting force and are therefore not reported. The complete data is enclosed in Tables 4.1

For composites with matrix Al6061 alloy 2%, 4%, 6% and 8% SiC reinforcement. That is the tangential cutting force increases with an increase in cutting speed, feed rate and depth of cut.

The SiC particulate produces discontinuities in the material and act as stress raisers, thereby resulting in the frequent fracture of chips during machining. The production of small chips is one of the criteria of good machinability since very long chips have been produce around the tool at high machining speeds.

The SiC reinforcement content in the composite causes rupture intermittently producing segments of chips with smaller lengths. Hence the composite material which produces shorter chips without chip breakers is well suited for continuous operation.

Figure 6.11and 6.12 shows the results for the machining of plain aluminium at depths of cut of 0.3, 0.6, 0.9 and 1.2 mm respectively.

It can be seen that there is a general trend of increase in tangential cutting force with an increase in cutting speed. The cutting force also tends to increase as feed rate or if the depth of cut is increased.

4.2 Effect of depth of cut and speeds on tangential force act during machining process

Figure 4.1 to 4.2 shows the influence of the depth of cut on the tool wear rate. In the test results shows the machining of Al6061/SiC for different depth of cuts of 0.3, 0.6, 0.9 and 1.2mm respectively.

As seen, the depth of cut has very little influence at lower speed but more significant at higher speed on the tool wear rate. When the depth of cut increases tangential cutting force also increases and the uncut chip thickness is kept the same. It is also observed from the graph that as the cutting speed increases tangential cutting force also increases

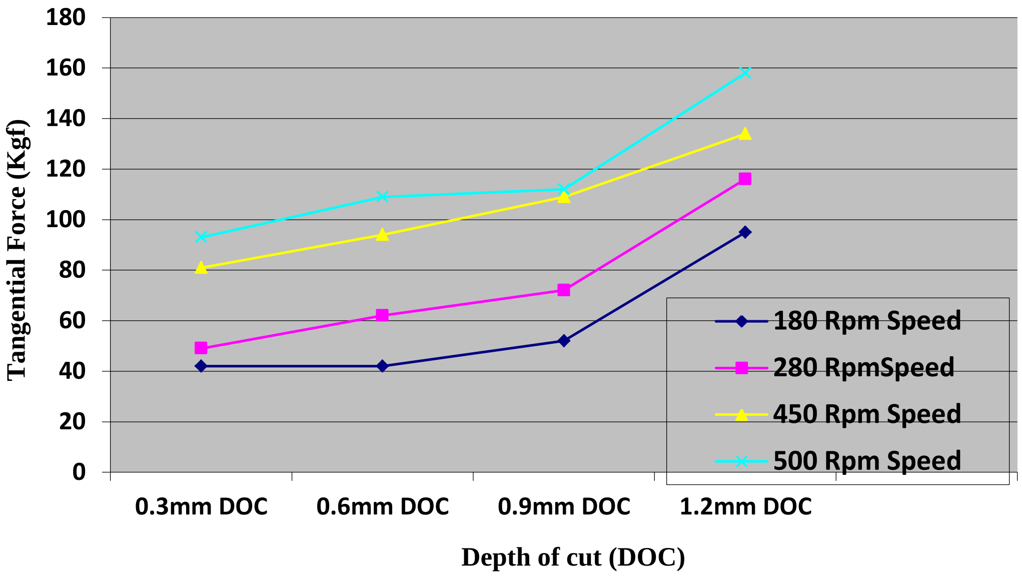

Figure 4.1: Variation of Tangential force act on material with variation of different depth of cut and speeds for constant 2% SiC and feed rate 0.2mm/rev

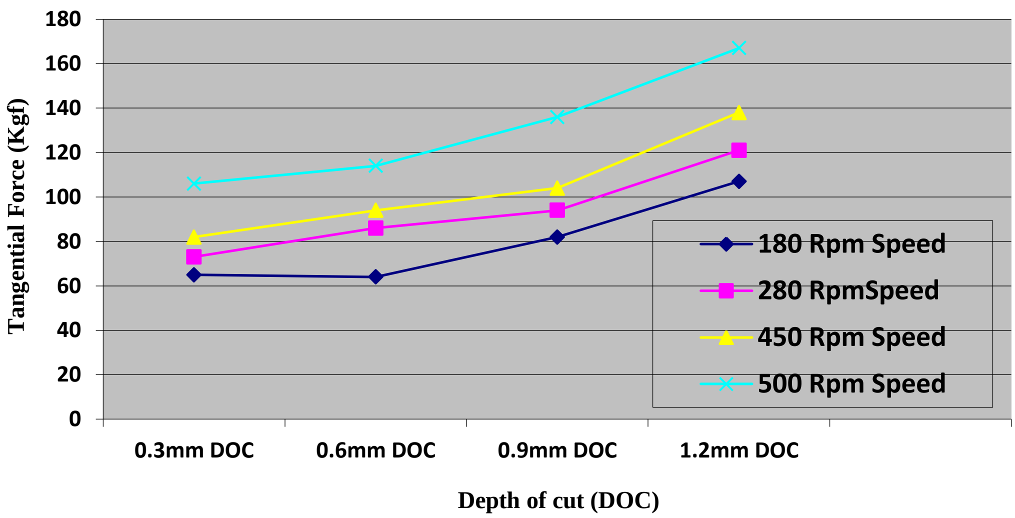

Figure 4.2: Variation of Tangential force act on material with variation of different depth of cut and speeds for constant 2% SiC and feed rate 0.4mm/rev

Table 4.1: Experimentally obtained machining force (tangential force) for Al matrix and Al/ SiC MMCs

Specimen	Al6061 matrix alloy				Al/2% SiC				Al/4% SiC				Al/6% SiC				Al/8 %SiC			
Feed rate mm/rev	0.1	0.2	0.4	0.6	0.1	0.2	0.4	0.6	0.1	0.2	0.4	0.6	0.1	0.2	0.4	0.6	0.1	0.2	0.32	0.4
Speed, rpm	Dept of cut = 0.3 mm																			
180	34	57	65	96	42	65	79	86	47	72	85	115	55	79	88	122	59	81	92	124
280	47	58	79	102	49	73	95	102	53	78	115	134	58	85	125	153	86	114	131	159
450	81	88	99	109	81	82	101	112	91	107	125	135	98	109	124	139	102	112	132	142
500	89	97	104	118	93	106	107	115	97	107	110	120	106	126	139	108	108	141	109	143
Dept of cut = 0.6 mm																				
180	42	52	85	125	42	64	82	114	53	74	102	138	61	91	118	162	65	95	120	172
280	62	66	88	124	62	86	98	124	71	83	112	125	78	104	138	178	82	106	142	181
450	90	92	105	115	94	94	112	132	104	121	129	135	104	120	129	138	107	125	130	141
500	109	115	119	137	109	114	124	139	114	122	135	155	121	138	169	182	124	139	171	190
Dept of cut = 0.9 mm																				
180	51	57	76	125	52	82	104	126	61	97	102	142	65	102	119	153	67	108	121	154
280	72	73	88	147	72	94	114	135	74	102	127	158	97	119	138	169	98	121	129	169
450	109	114	120	154	109	104	123	140	114	126	144	161	113	132	152	178	118	138	170	179
500	110	130	197	235	112	136	195	206	121	132	195	224	122	154	198	235	123	159	201	252
Dept of cut = 1.2 mm																				
200	89	91	112	119	95	107	125	134	98	102	132	142	111	131	125	144	121	141	132	152
315	109	120	139	147	116	121	138	157	112	132	164	178	128	144	142	196	137	151	149	204
400	132	139	228	267	134	138	228	266	132	148	169	265	144	159	181	276	144	162	189	286
500	151	165	273	320	158	167	278	318	164	175	279	321	194	202	279	341	194	212	288	352

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5. CONCLUSIONS

Following conclusions are drawn from experimental details.

- ✓ As depth of cut increases tangential cutting force acting on material is also increases, And vice-versa
- ✓ Tangential cutting force acting on material is increases with increase in speed.
- ✓ As the Tangential cutting force acting on material is increases with increases in feed rate.

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