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Machinability Study on Al-7si Alloy Subjected To Grain Refinement

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ABSTRACT
The present investigation deals with refining the grain structure of Al-7Si (LM25) alloy by adding a suitable amount of grain refiner namely Al-5T-1B and the same was subjected to mechanical vibration. The process involves melting of Al-7Si alloy in an electrical furnace and the molten alloy was degassed using hexachloro ethane degassing tablets. Then the grain refiner was added and later transferred to a pre coated and pre heated metallic die. The alloy was then subjected to mechanical vibration for the process of grain refinement. The Machinability of aluminium alloy during continuous turning of composite rods using carbide tool inserts. The main focus of investigation is to determine Power consumption & Force. Experiments were conducted in the lathe dynamometer by using carbide insert at various parameters such as cutting speed, feed and depth of cut. The effect of machining parameters, e.g. cutting speed and depth of cut on the Power consumption & Force investigated during experimentation
Keywords: Al-Si alloys, casting, Machinability test, turning.

I. INTRODUCTION

Use of cast Al–Si alloys as a tribological component in recent years has been expanding widely in military, automobile and general engineering industry. Aluminium–silicon eutectic and near eutectic alloys are cast to produce majority of pistons and are known as piston alloys. Silicon is probably one of the least expensive alloying additions commonly made to aluminium, which improves castability, increases strength to weight ratio, enhances corrosion resistance, decreases the co efficient of thermal expansion and Imparts wear resistance to aluminium. Grain refinement greatly influences the microstructure of the alloy. This affects the properties of castings to a great extent; hence the properties of material improve. General methods that are developed to achieve grain refinement in Al-Si alloy are listed below.

- Casting without addition of refiner and without inducing mechanical vibration.
- By inducing the mechanical vibration to the molten metal without addition of refiner.
- By addition of grain refiner & including mechanical vibration.

Machinability is a term that describes the ease or difficulty with which a metal can be machined. It can be measured by the life of the cutting tool or the material removal rate in relation to the cutting speed used. The good Machinability indicates Good surface finish and integrity, Long tool life, Low surface and power requirements.

II. EXPERIMENTAL DETAILS

2.1 DETAILS OF ALLOY

The alloy selected for the study is aluminium-7%silicon-0.4%magnesium alloy. The composition of the alloy was determined by subjecting the alloy to chemical test and the results result of same is shown in table below.

Table 1: CHEMICAL COMPOSITION OF LM-25 ALLOY

Elements	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti	Al
% By Wt	0.20	0.40	7.00	0.50	0.30	0.10	0.10	0.10	0.05	0.20	Rem

2.2 DETAILS OF GRAIN REFINER

The refiner selected for the study was Al-5%Ti-1B.
Quantity of Al-7Si alloy melted = 4 kg
The percentage of grain refiner adding = 2%
Weight of grain refiner to be added = (4000*2)/100 = 80gms

2.3 DETAILS OF THE PERMANENT MOULD

Permanent mould made of EN 19 steel coated with mould coat and preheated to 300^0C was used in the present investigation. The details of the mould used is shown in figure-1

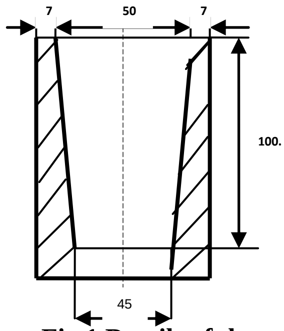

Fig.1 Details of the mould

2.4 DETAILS OF MECHANICAL VIBRATION EXCITER

Vibration exciter is an electrodynamic type of device. It essentially consists of a powerful magnet placed centrally surrounding which is suspended the exciter coil. This assembly is enclosed by a high permeability magnetic circuit for optimum performance and enough design care has been observed to minimize the leakage magnetic flux at top of the vibration table

2.5 MELTING AND TREATMENT OF THE ALLOY

For the process of melting a Graphite crucible coated with fresh lime (dried over night) was selected and placed in the electrical furnace. The alloy was then melted to a temperature of 725^0C. Degassing was carried out using hexachloroethane degassing tablets. The dross was skimmed off and the clean molten metal was transferred into the mould. Following treatment of the molten alloy were carried out in different stages:

- Without addition of refiner and without mechanical vibration.
- By inducing the mechanical vibration to the molten metal without addition of refiner.
- By addition of refiner and by inducing of mechanical vibration to the molten metal.

2.6 TOOL MATERIALS

The tungsten carbide cutting tool is ideal for finishing to general machining of most work piece materials at higher cutting speeds. Carbide tools have good resistance to wear, thermal shock and corrosion. Excellent for machining most steels, stainless steel, cast iron, nonferrous materials and alloys under stable conditions. It also performs well machining hardened and short chipping materials (Nagpal, 1986, Kalapkjian, 1997). The tool thickness of 4 mm and cutting point radius 0.4 mm. Tungsten carbide inserts was placed on a right-hand tool holder with a designation of SCLCR 12 which corresponds to the following:

Back rake angle = 5 degree, Side rake angle = 5 degree
End relief angle = 5 degree, Side relief angle = 5 degree
End cutting edge angle = 6 degree, Side cutting angle = 6 degree
Tool nose radius, R= 0.4mm.

2.7 LATHE-TOOL DYNAMOMETER

A Lathe-tool dynamometer is a multi-component dynamometer that is used to measure forces during the use of the machine tool. Lathe-tool dynamometers are increasingly used for the accurate measurement of forces and for optimizing the machining process. These multi-component forces are measured as an individual component force in each co-ordinate, depending on the coordinate system used. The forces during machining are dependent on depth of cut, feed rate, cutting speed, tool material and geometry, material of the work piece and other factors such as use of lubrication/cooling during machining. Lathe-tool dynamometers are increasingly used for the accurate measurement of forces and for optimizing the machining process. These multi-component forces are measured as an individual component force in each co-ordinate, depending on the coordinate system used. The forces during machining are dependent on depth of cut, feed rate, cutting speed, tool material and geometry, material of the work piece and other factors such as use of lubrication/cooling during machining.

2.8 TEST PARAMETERS:

- Diameter of specimen (d) : 40mm
- Length of the specimen : 30mm
- Speeds studied: 250 rpm, 420 rpm, 710rpm and 1200 rpm.

III. Results and discussion

3.1 FORCE MEASUREMENT

Experimental data related to three different types of casting.

- Casting without addition of refiner and without inducing mechanical vibration. (Fx)
- By inducing the mechanical vibration to the molten metal without addition of refiner. (Fy)

- By addition of grain refiner & including mechanical vibration. (Fz).

Results of force tests are presented in terms of graphs, which show the variation of different forces with different cutting speed and depth of cut. The three components of forces are Thrust force, Radial force, Cutting force.

FOR THRUST FORCE (N) (SPEED VARYING)

SL NO	Cutting speed in rpm	Depth of cut in mm	Fx	Fy	Fz
1	250	1.0	15	11	8
2	420	1.0	18	14	11
3	710	1.0	16	12	9
4	1200	1.0	13	10	6

FOR THRUST FORCE (N) (DOC VARYING)

SL NO	Cutting speed in rpm	Depth of cut in mm	Fx	Fy	Fz
1	250	0.5	14	10	8
2	250	1.0	15	11	7
3	250	1.5	14	10	9
4	250	2.0	13	9	6

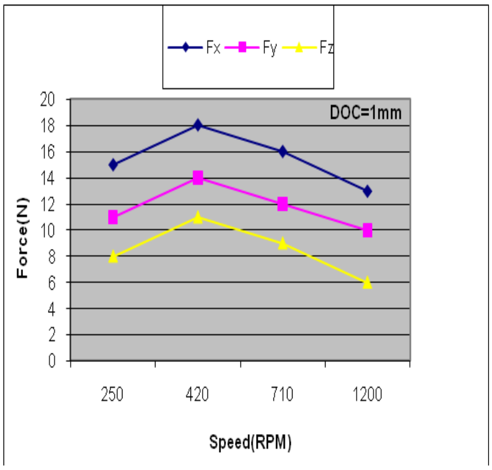

Fig 3.1(a)

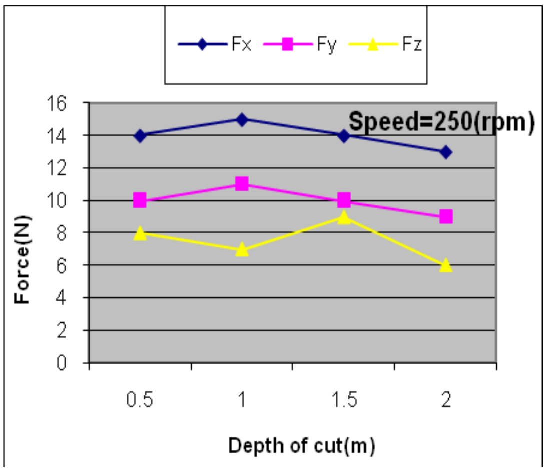

Fig 3.1(b)

It is observed from the Thrust Force Graph that when depth of cut kept constant & speed is increased continuously, clearly shows that Casting without addition of refiner and without inducing mechanical vibration (Fx), force required relatively high (4-6N) compare to Fy (with vibration) & Fz (with grain refiner & vibration) and also we can see Fz (with grain refiner & vibration) force required relatively low(2N) compare to Fy (with vibration) and also at 420 rpm force required more compare to250, 710, 1200 rpm. When speed kept constant & depth of cut increased continuously same as the above but when compare to increase speed force required relatively low in increase depth of cut..

FOR RADIAL FORCE (N) (SPEED VARYING)

SL NO	Cutting speed in rpm	Depth of cut in mm	Fx	Fy	Fz
1	250	1.0	8	5	4
2	420	1.0	8	4	4
3	710	1.0	8	4	3
4	1200	1.0	7	4	3

FOR RADIAL FORCE (N) (DOC VARYING)

SL NO	Cutting speed in rpm	Depth of cut in mm	Fx	Fy	Fz
1	250	0.5	6	5	3
2	250	1.0	7	5	3
3	250	1.5	8	4	2
4	250	2.0	8	5	2

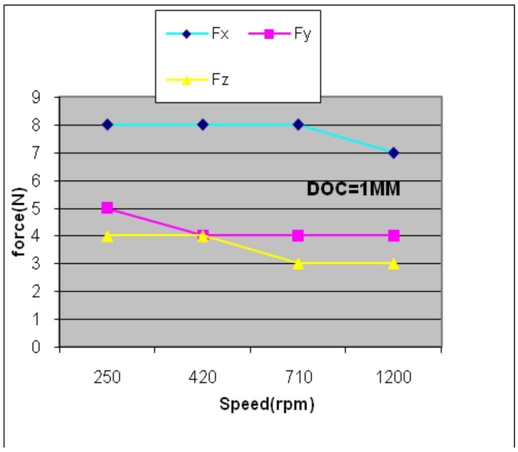

Fig 3.2(a)

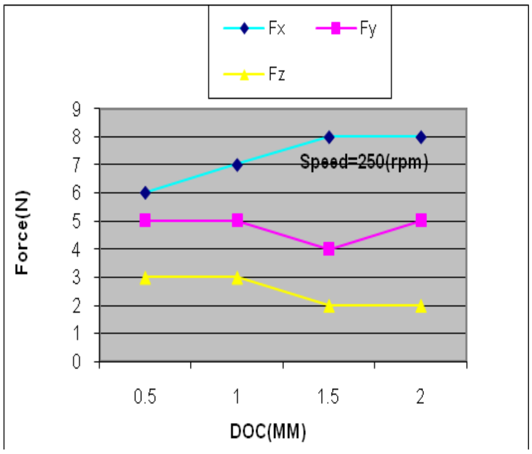

Fig 3.2(b)

It is observed from the Radial Force Graph that when depth of cut kept constant & speed is increased continuously, clearly shows that Casting without addition of refiner and without inducing mechanical vibration (Fx), force required relatively high (3-4N) compare to Fy (with vibration) & Fz (with grain refiner & vibration) and also we can see Fz (with grain refiner & vibration) force required relatively low (1N) compare to Fy (with vibration). When speed kept constant & depth of cut increased continuously same as the above but in the 1.5 mm depth force required is low compare to 0.5, 1.0,2.0 mm.

FOR CUTTING FORCE (N) (SPEED VARYING)

SL NO	Cutting speed in rpm	DEPTH OF CUT IN MM	Fx	Fy	Fz
1	250	1.0	41	29	19
2	420	1.0	47	31	25
3	710	1.0	52	36	29
4	1200	1.0	49	41	31

FOR CUTTING FORCE (N) (DEPTH OF CUT VARYING)

SL NO	Cutting speed in rpm	Depth of cut in mm	Fx	Fy	Fz
1	250	0.5	39	33	22
2	250	1.0	42	35	28
3	250	1.5	45	40	27
4	250	2.0	43	41	32

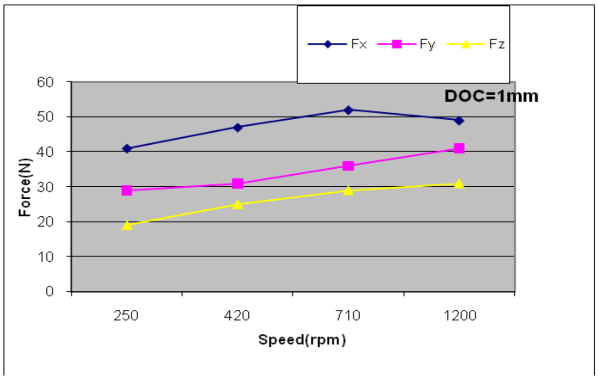

Fig 3.3(a)

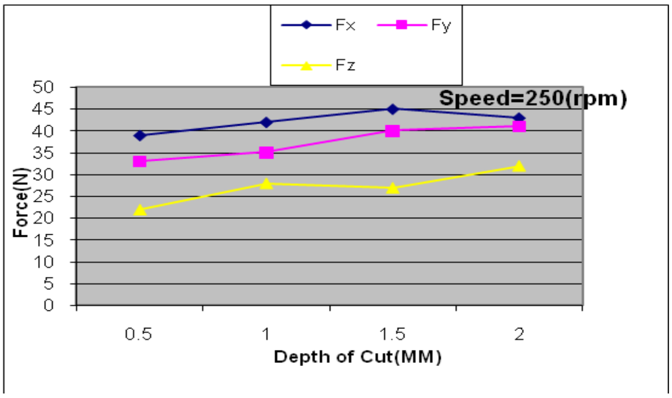

Fig 3.3(b)

continuously, clearly shows that Casting without addition of refiner and without inducing mechanical vibration (Fx), force required relatively high (10-20N) compare to Fy (with vibration) & Fz (with grain refiner & vibration) and also we can see Fz (with grain refiner & vibration) force required relatively low (10N) compare to Fy (with vibration). When speed kept constant & depth of cut increased continuously same as the above but when compare to increase speed, force required relatively low in increase depth of cut.

3.2 POWER MEASUREMENT

3.2.1Formulas:

Power consumption= cutting force x V

Where V= ∏ x d x N/60

Where d= Diameter of the specimen in m N= Speed in rpm

FOR POWER (W) (SPEED VARYING)

SL NO	Cutting speed in rpm	DEPTH OF CUT IN MM	Power (W)		
			Fx	Fy	Fz
1	250	1.0	21.46	15.86	9.94
2	420	1.0	41.34	27.26	21.99
3	710	1.0	77.32	53.53	43.12
4	1200	1.0	123	103	77.91

FOR POWER (W) (DEPTH OF CUT VARYING)

SL NO	Cutting speed in rpm	DEPTH OF CUT IN MM	Power (W)		
			Fx	Fy	Fz
1	250	0.5	20.42	17.27	11.51
2	250	1.0	21.99	18.32	14.66
3	250	1.5	23.56	20.94	14.13
4	250	2.0	22.51	21.46	16.75

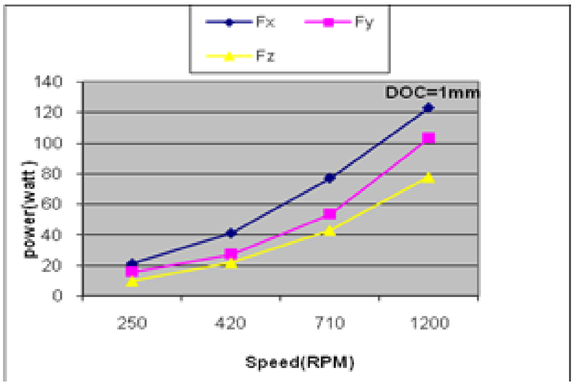

Fig 3.4(a)

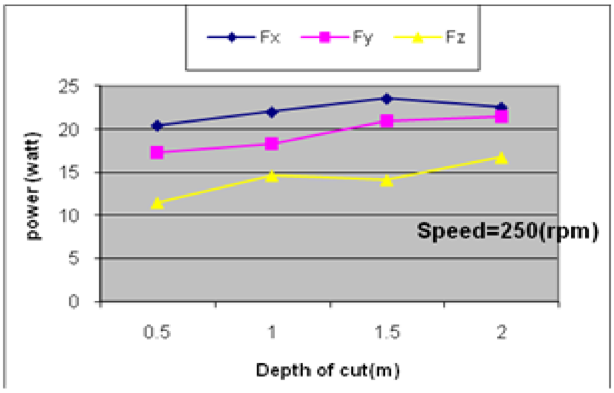

Fig 3.4(b)

It is observed from the above Graph that when depth of cut kept constant & speed is increased continuously power increases, and Casting without addition of refiner and without inducing mechanical vibration (Fx), power required relatively high (15-20W) compare to Fy (with vibration) & Fz (with grain refiner & vibration) and also we can see Fz (with grain refiner & vibration) force required relatively low (5W) compare to Fy (with vibration). When speed kept constant & depth of cut increased continuously same as the above but when compare to increase speed power required relatively low in increase depth of cut.

IV. Conclusion

The results of the present investigation found that there is a considerable improvement in the Force and Power consumption upon the alloy subjected to mechanical vibration, and addition grain refiner compare to alloy without addition of refiner and without inducing mechanical vibration.

V. ACKNOWLEDGEMENTS

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