SURFACE ROUGHNESS STUDY ON AL-SI ALLOY SUBJECTED TO GRAIN REFINEMENT

N L Murali Krishna[1], Sachin N K[2]
[1]Associate Professor, [2]Assistant Professor
Department of Industrial & Production Engineering,
P.E.S College of Engineering, Mandya, Karnataka, India,

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 and electric coil 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 and electric coil vibration for the process of grain refinement. The main focus of study is to determine surface roughness. Experiments were conducted in the lathe by using carbide insert at various parameters such as cutting speed, feed and depth of cut and also Microstructure studied for the materials.

KEYWORDS: *Al-Si alloys, casting, turning, surface roughness, microstructures.*

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 vibration.
- Inducing the mechanical vibration to the molten metal without addition of refiner.
- Addition of grain refiner & including mechanical vibration.
- Inducing the Electric coil vibration to the molten metal without addition of refiner.
- Addition of grain refiner & including Electric coil vibration.

Surface roughness is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. Roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface. However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose. Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. On the other hand, roughness may promote adhesion.

II. EXPERIMENTAL DETAILS

2.1 Details of Alloy

The alloy selected for the study is aluminium7.2% 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 LM25 alloy element

Elements	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti	Al
%By Wt	0.1	0.4	7.2	0.5	0.3	0.1	0.1	0.1	0.05	0.2	Rem

2.2 Details of Grain Refiner

The refiner selected for the study was Al-5%Ti1B.
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

Table 2: Details of grain refiner, EMF vibration and mechanical vibration effect

Sample name	Grain refiner	Mechanical vibration(2 Min)	Electric coil vibration(2 Min)
A	-	-	-
E2	-	-	160V
E3	-	-	240V
E2W	2 %	-	160V
E3W	2 %	-	240V
8	-	8 Hz	-
12	-	12 HZ	-
8W	2 %	8 Hz	-
12W	2 %	12 HZ	-

2.3 Details of the Permanent Mould

Permanent mould made of EN 19 steel coated with mould coat and preheated to 3000C was used in the present investigation. The details of the mould used is shown in figure-1

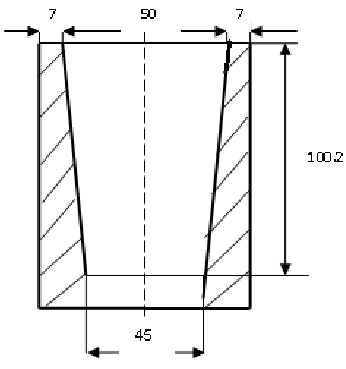

Figure.1 Details of the mould

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.

Double Acting Pneumatic Cylinder Details of the double acting pneumatic cylinder is shown in figure: 2 Maximum Stroke Length of the piston being 120mm. Diameter of the piston: 30mm Diameter of the piston rod: 12mm

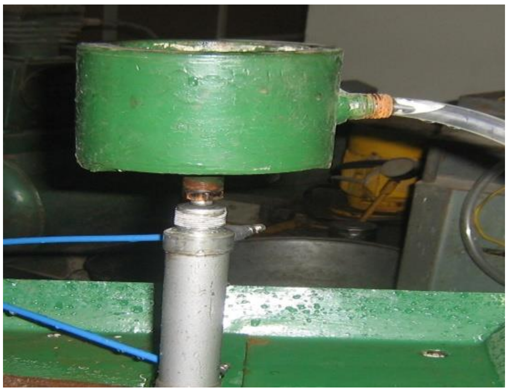

Figure 2: Mechanical Vibration

Figure 3: Electric coil vibration

2.5 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.

2.8 Test Parameters:

Diameter of specimen (d): 40mm
Length of the specimen: 30mm
Speeds studied: 270 rpm, 380 rpm and 540 rpm.
Feed: 0.5mm.
Depth of Cut: 0.5mm

Figure. 4: Al-Si casted specimen

Figure. 5: Microstructure specimens

2.9 Surface Roughness Measurement

The machined surface is tested for surface roughness R_a with the help of surfcom flex machine which measures the surface roughness

Figure. 6: Surfcom flex surface roughness measuring machine

III. RESULTS AND DISCUSSION

Table3 show the summary of surface roughness values with varying speeds with constant Feed and Depth of Cut

Table 3: Summary of Surface Roughness Values Using Varies Parameters

Material	Surface Roughness (RA) in µm for different Speed		
	270rpm	**380rpm**	**540rpm**
A	2.351	2.534	2.320
12	1.893	0.930	1.164
12W	1.322	2.024	2.088
E3W	0.802	0.865	0.877
E3	0.642	0.862	0.702
8	0.938	0.777	0.91
E2	0.802	0.694	0.842
8W	0.714	0.914	0.921
E2W	0.705	0.939	1.443

Feed= 0.5 mm, Depth of cut= 0.5 mm

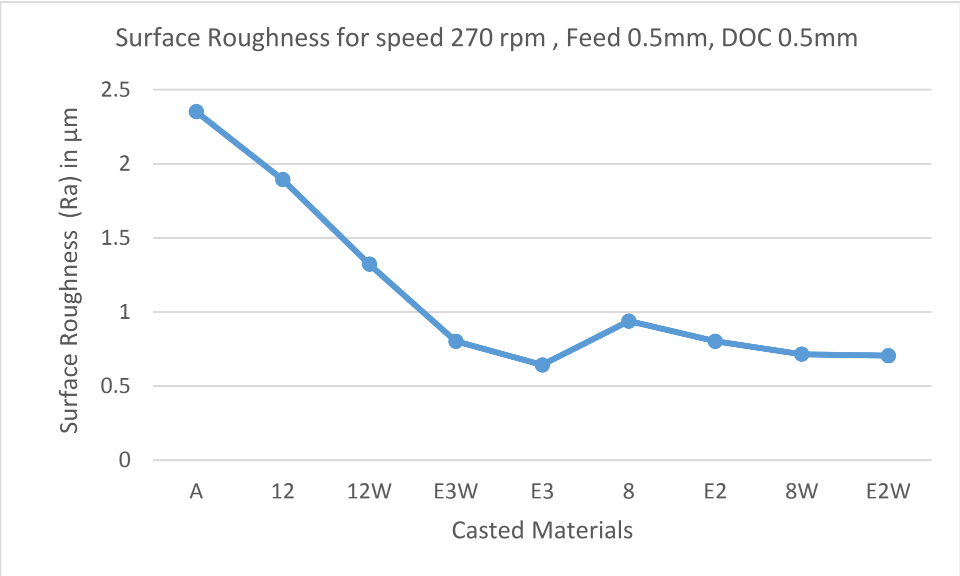

Figure 7: Characteristics of specimens at 270 rpm

The surface roughness trend for casted material at 270 rpm can be seen in graph 1. Material casted with grain refiner and EMF, Mechanical vibrations resulted better surface roughness compared to As casted and mechanical vibration without grain refiner casted material.

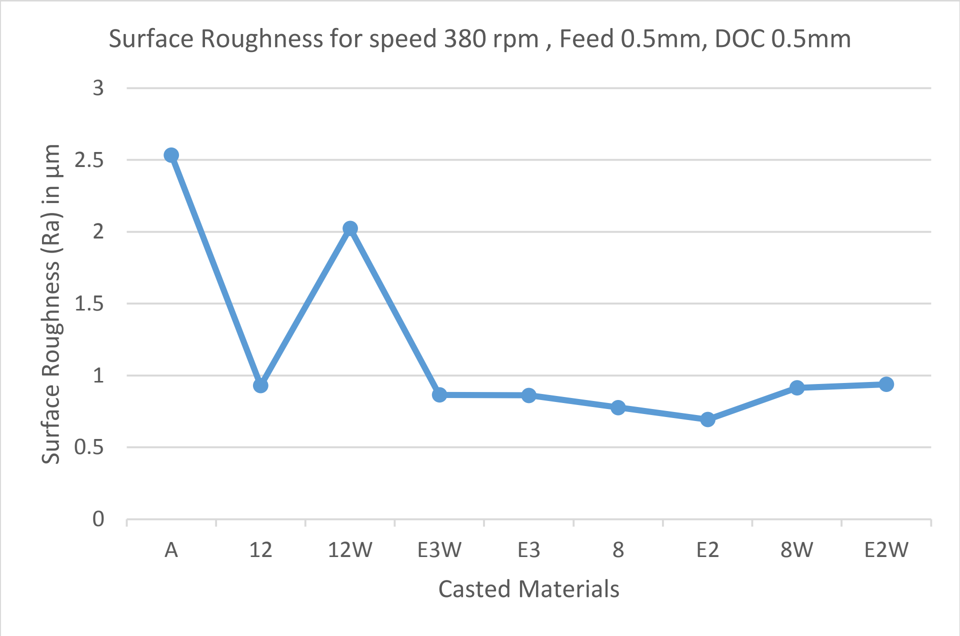

Figure 8: Characteristics of specimens at 380 rpm

The surface roughness trend for casted material at 380 rpm can be seen in graph 2. Material casted with grain refiner, Mechanical and EMF vibrations resulted better surface roughness compared to As casted material.

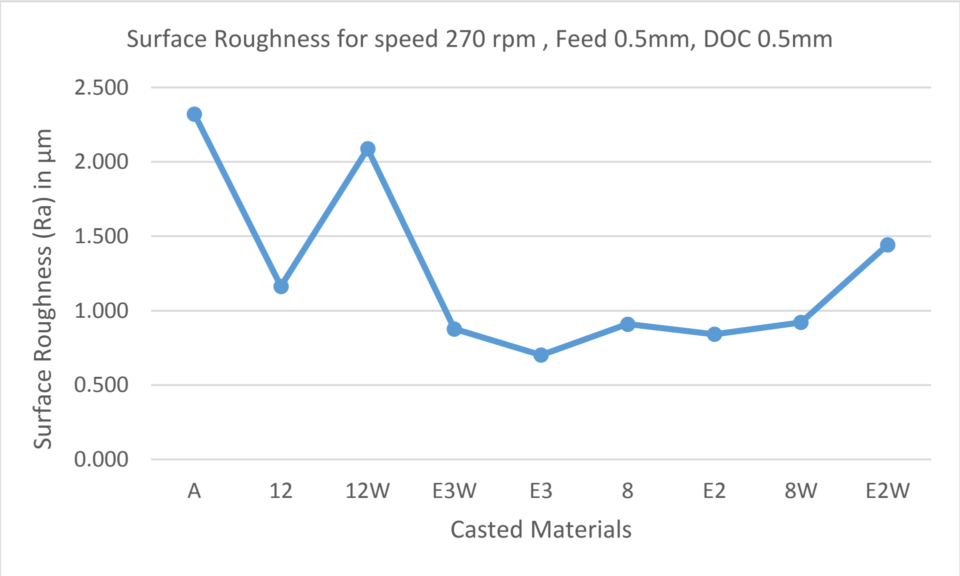

Figure 9: Characteristics of specimens at 540 rpm

The surface roughness trend for casted material at 540 rpm can be seen in graph 3. Material casted with grain refiner, Mechanical and EMF vibrations resulted better surface roughness compared to As casted material.

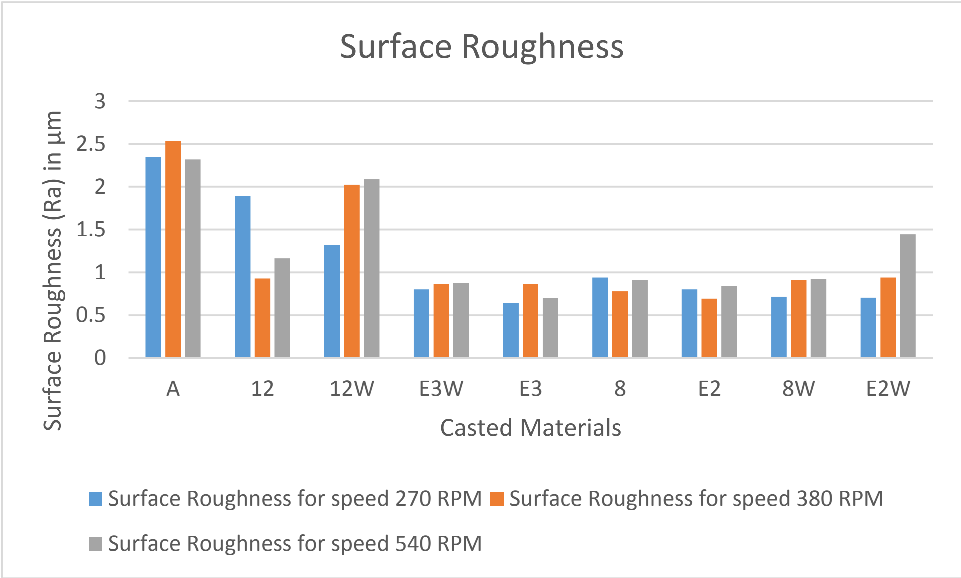

Figure 10: Characteristics of specimens at different speeds

The surface roughness trend for casted material at different speed can be seen in graph 4. Grain refiner and with Electric coil vibration resulted better surface roughness at higher rotation speed. Grain refiner and with mechanical vibration resulted better surface roughness at lower rotation speed**,** and also we can observe casted material with grain refiner, Electric coil and Mechanical vibration resulted better surface roughness compared to As casted material.

Microstructure examinations

Results of the investigation carried out on the grain refinement of Al-Si alloy, subjecting to mechanical vibration, Electric coil vibration with and without refiners are discussed here under.

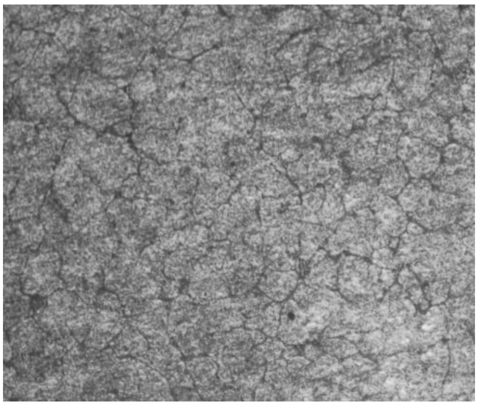

Figure 11: As casted Material

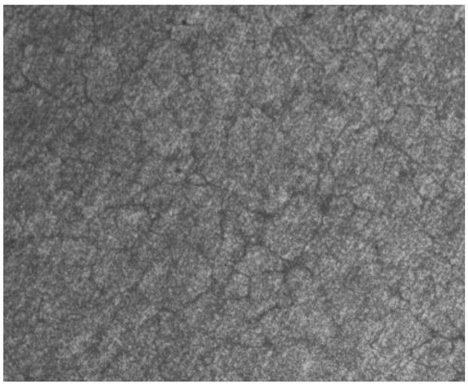

Figure 12: Electric coil vibration

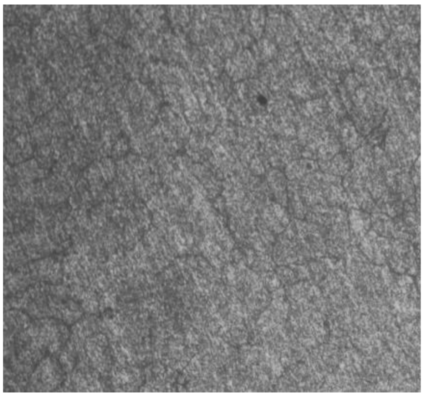

Figure 13: Electric coil vibration
With addition of 2% grain refiner

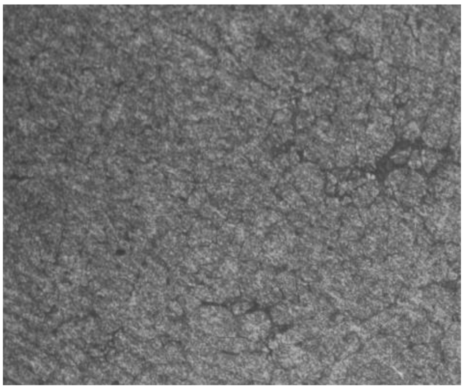

Figure 14: mechanical vibration

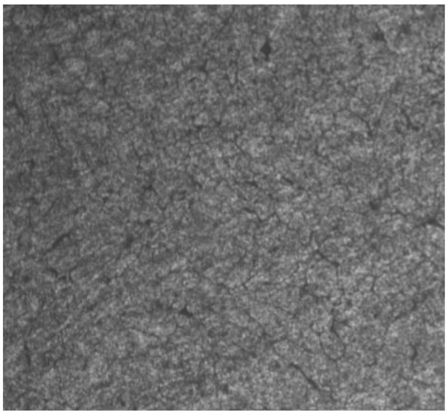

Figure 15: mechanical vibration with grain refiner.

Above figures shows the structure of the Al-Si alloy subjected to Electric coil, Mechanical vibration and along with grain refiners. It can be seen that the microstructure of alloy is comprised of aluminum matrix which is strengthened by Si precipitates, and a dispersion of eutectic silicon particles and intermetallic, and also the grain size is reduced and close grain structure is obtained compared to As casted (without vibration and grain refiner).

IV. CONCLUSION

Selection of rotational speed plays an important role in obtaining high or low surface finish. Significant effect on surface roughness has been observed with respect to Electric coil, Mechanical vibration and along with grain refiners.

- In microstructure examination Coarse acicular silicon particles are seen distributed along primary aluminum dendrite boundaries. Grain structure gets reduced and a closed structure is observed when alloy is subjected grain refinement by mechanical vibration, Electric coil vibration and addition of grain refinement.
- There is a considerable improvement in the surface roughness upon the alloy subjected to mechanical vibration, Electric coil vibration and addition grain refiner compare to alloy without addition of refiner and without inducing mechanical & electric coil vibration.

V. FUTURE WORK

The scope of grain refinement and the enhancement in the property value may be brought about by inducing mechanical vibration during the process of solidification and various cooling rate, different types of grain refiner.

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AUTHORS BIOGRAPHY

Sachin N K, has received post graduate from Vidya Vikas College of Engineering, Mysore. I have 2years of experience in teaching. Currently working at P.E.S College of Engineering, Mandya. Interest research area is Quality, Welding and Composite materials.

N L Murali Krishna, has received post graduate from IIT Delhi in 2000, and received PhD from VTU Karnataka in 2016. He has 26years of experience in teaching. Currently working at P.E.S College of Engineering, Mandya. Interest research area is Micro finish and Composite materials.