Chapter 3

Optimization of Stirrer Speed on the Mechanical Properties of Aluminium Graphite Stir Cast Composite

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Abstract

To develop a metal matrix composite with lubricant properties with the help of a stir casting process by varying the stirrer speed and they are tested for their mechanical properties. Casting machine is turned ON. Furnace temperature is set to 850°C. Pre-heated temperature is set to 180°C. Pathway temperature is set to 550°C. The furnace is allowed to heat up. Once it gets heated up to 600°C, the aluminum silicon alloy is dropped into the furnace. The alloy gets melted at around 800 to 850°C. Graphite fine powder is pre heated and then it is allowed to mix well with the molten metal. Graphite is reinforcement added and it is preheated to increase the wettablity. Stainless steel stirrer is used to mix the alloy and the graphite well. First the stirrer is rotated at 200 rpm once both the alloy and reinforcement gets mixed up into a single red hot molt which is poured. The molt now leaves from the bottom of the furnace through the pathway from the machine. The Path is

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maintained at 550°C to avoid the solidification of molt in the path. The pathway carries the molt to a die where the die is split up and the mould is taken out from the die. The die, furnace and pathway is coated with the non-stick paste to avoid the sticking of alloy in the walls. The same process is repeated for the stirrer speed of 400rpm, 600rpm, 800rpm and their mechanical properties are compared with each other to find the optimal stirrer speed.

Key words: Aluminium Graphite, Metal Matrix Composite, Stir Casting, Properties and Behaviour, Stirrer speed

1. Introduction

The primary objective of this project is to prepare a metal matrix composite which consists of Al-Si alloy and Graphite casted together using "stir casting" technique, by varying the stirrer speed. This is specially made to cast alloys and reinforcements together as a composite. Then the casted alloys are compared with each other by determining their hardness, compression, wear behavior, tensile strength and micro structure to optimize best stirrer speed.

This alloy conforms to BS1490. LM6 exhibits excellent resistance to corrosion under both ordinary atmospheric and marine conditions. For the severest conditions this property can be enhanced by anodic treatment.

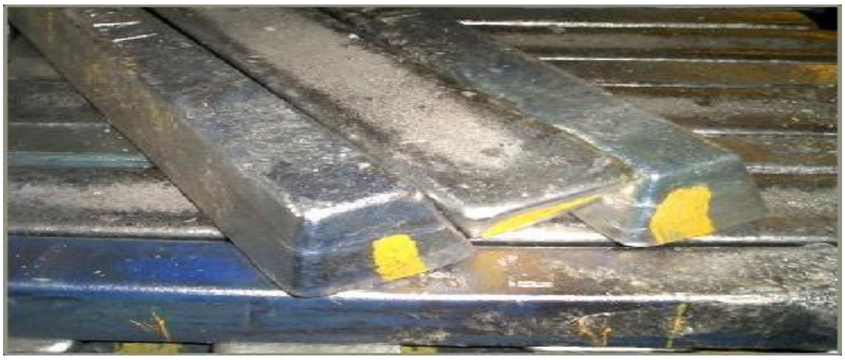

Fig 1. Al-Si Alloy

The Aluminum-silicon alloys possess exceptional casting characteristics, which enable them to be used to produce intricate castings of thick and thin sections. Fluidity and freedom from hot tearing increase with silicon content and are excellent throughout the range. The ductility of LM6 alloy enables castings to be easily rectified or modified in shape, e.g., simple components may be cast straight, and later bent to the required contour. LM6 is especially suited to castings that need to be welded although special care is needed when machining.

The mineral **Graphite** is an allotrope of carbon. It was named by Abraham Gottlob Werner in 1789 from the Ancient Graphiteeek Graphiteaphō, "to draw/write", for its use in pencils, where it is commonly called **lead** (not to be confused with the metallic element lead). Unlike diamond (another carbon allotrope), Graphite is an electrical conductor, a semimetal. It is, consequently, useful in such applications as arc lamp electrodes. Graphite is the most stable form of carbon under standard conditions. Therefore, it is used in thermochemistry as the standard.

Table 1: Alloy composition

Chemical Composition	%
Copper	0.1 max.
Magnesium	0.10 max.
Silicon	10.0-13.0
Iron	0.6 max.
Manganese	0.5 max.
Nickel	0.1 max.
Zinc	0.1 max.
Lead	0.1 max.
Tin	0.05 max.
Titanium	0.2 max.
Aluminum	Remainder

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2. Experimental Procedure

2.1 Stir Casting Method for Fabrication of MMCs

Liquid state fabrication of Metal Matrix Composites involves incorporation of dispersed phase into a molten matrix metal, followed by its Solidification. In order to provide high level of mechanical properties of the composite, good interfacial bonding (wetting) between the dispersed phase and the liquid matrix should be obtained. Wetting improvement may be achieved by coating the dispersed phase particles (fibers). Proper coating not only reduces interfacial energy, but also prevents chemical interaction between the dispersed phase and the matrix. The simplest and the most cost effective method of liquid state fabrication is Stir Casting.

2.1.1. Stir Casting

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. The stir casting process uses a casting furnace with a stirring motor running at a constant speed that allows uniform mixing of the dispersion in the molten mix. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

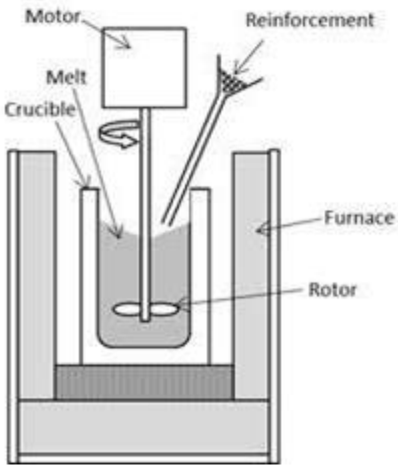

Figure 2. Stirring process

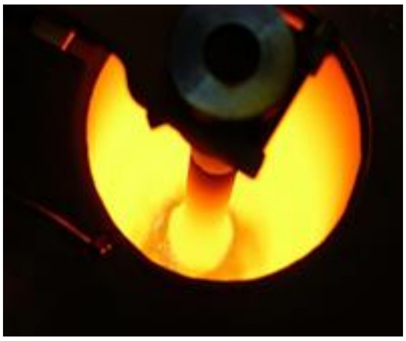

Figure 3. Internal view of cast chamber

2.2 Characterization Features of Stir Casting

1. Content of dispersed phase is limited (usually not more than 30 vol. %).

2. Distribution of dispersed phase throughout the matrix is not perfectly homogeneous:

- There are local clouds (clusters) of the dispersed particles (fibers);
- There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase.

3. The technology is relatively simple and low cost.

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2.3 Material Properties

2.3.1 Aluminium

Aluminium is a chemical element in the boron group with symbol Al and atomic number 13. It is a silvery white, soft, ductile metal. Aluminium is the third most abundant element and the most abundant metal in the earth's crust.

2.3.2 Physical Properties

Aluminium is a relatively light weight, ductile and malleable metal with appearance ranging from silvery to dull gray, depending on the surface roughness. It is nonmagnetic and does not easily ignite. A fresh film of aluminium serves as a good reflector (approximately 92%) of visible light and an excellent reflector (as much as 98%) of medium and far infrared radiation. The yield strength of pure aluminium is 7–11 MPa, while aluminium alloys have yield strengths ranging from 200 MPa to 600 MPa. It is easily machined, cast, drawn and extruded.

3. Experimental Process

3.1 Casting process

Casting machine is turned ON. Furnace temperature is set to 850°C. Pre-heated temperature is set to 180°C. Pathway temperature is set to 550°C.The furnace is allowed to heated up. Once it gets heated up to 600°C, the aluminum silicon alloy is dropped into the furnace. The alloy gets melted at around 800 to 850°C. Graphite fine powder is pre heated and then it is allowed to mix well with the molten metal. Stainless steel stirrer is used to mix the alloy and the graphite well. First the stirrer is rotated at 200 rpm once both the alloy and reinforcement gets mixed up into a single red hot molt which is poured.

The molt now leaves from the bottom of the furnace through the pathway from the machine. The Path is maintained at 550°C to avoid the solidification of molt in the path. The pathway carries the molt to a die where the die is split up and the mould is taken out from the die. The die, furnace and pathway is coated with the non-stick paste to avoid the sticking of alloy in the walls. The same process is repeated for the stirrer speed of 400rpm, 600rpm, 800rpm and their mechanical properties are compared with each other to find the optimal stirrer speed.

Figure 4. Aluminum stir caster setup

Figure 5. Stir casted material

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4. Results and Discussions

4.1 Tensile Test

Table 4.1 Tensile Test

Details	Tensile Strength (N/mm^2)
Al Si Alloy	160
Stirrer speed-200rpm	170
Stirrer speed-400rpm	173
Stirrer speed-600rpm	187
Stirrer speed-800rpm	181

4.2 Compression Test

Table 4.2 Compression Test

SI. No	Stirrer speed(rpm)	Buckling load(kgf)
1	200	5600
2	400	6000
3	600	6800
4	800	5900

Specimen Dimensions

1. Initial length or height of specimen h = 36mm.

2. Initial dia of specimen d0 = 16 mm.

Table 4.3 Compression results

SI. No.	Stirrer speed(rpm)	Load(N)	cross sec area (mm^2)	Stress (N/mm^2)
1	200	54936	1809.55	30.35
2	400	58860	1809.55	32.52
3	600	66708	1809.55	36.86
4	800	57879	1809.55	31.98

4.3 Micro Structure

Stirrer Speed 200 RPM: Microstructure consists of interdendritic net work of eutectic silicon particles rounded particles of CuAl2 and MgSi particles distribted in amatrix of alminium solid solution

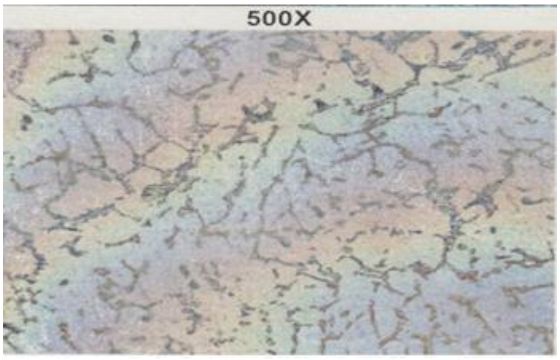

Fig 4.1 Stirrer Speed 200 Rpm

Stirrer Speed 400 Rpm: Microstructure consists of interdendritic net work of eutectic silicon particles rounded particles of $CuAl_2$ and Mg_2Si particles distributed in a matrix of aluminium solid solution

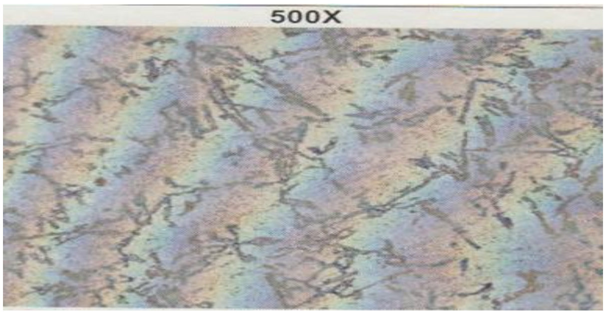

Fig 4.2 Stirrer Speed 400 Rpm

Stirrer Speed 600 Rpm: Microstructure consists of interdendritic net work of eutectic silicon particles rounded particles of $CuAl_2$ and Mg_2Si particles distributed in a matrix of aluminium solid solution

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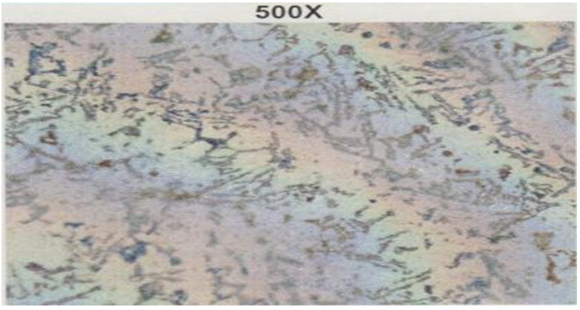

Fig 4.3 Stirrer Speed 600 Rpm

Stirrer Speed 800 Rpm: Microstructure consists of interdendritic net work of eutectic silicon particles rounded particles of $CuAl_2$ and Mg_2Si particles distributed in a matrix of aluminium solid solution

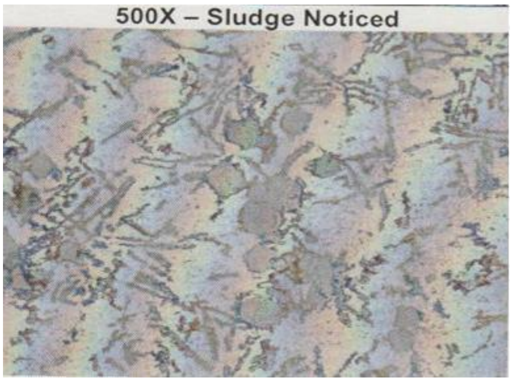

Fig 4.4 Stirrer Speed 800 Rpm

4.4 Wear Test

Table 4.4. Wear Test

Applied Load(kN)	**2**	**2**	**2**	**2**	**2**
Sliding distance(meter)	1000	2000	3000	4000	5000
Weight Loss(gm)	0.0004212	0.0007992	0.0008937	0.0010665	0.0015201
Wear volume loss(mm³)	9.156	0.296	0.331	0.395	0.563
Wear Volume Loss(cm³)	0.000156	0.000296	0.000331	0.000395	0.000563
Wear rate(cm³/Nm)	0.000000078	0.000000074	5.51667E-08	4.9375E-08	5.63-08
Wear rate(m²/N)	7.8e-14	7.4E-14	5.51667E-14	4.9375E14	5.63E-14

Table 4.5. Wear Test

Applied Load(kN)	1	2	3	4	5
Sliding distance(meter)	2000	2000	2000	2000	2000
Weight Loss(gm)	0.0004833	0.0005535	0.0006372	0.0014607	0.0018765
Wear volume loss(mm^3)	0.179	0.205	0.236	0.541	0.695
Wear Volume Loss(cm^3)	0.000179	0.000205	0.000236	0.000541	0.000695
Wear rate(cm^3/Nm)	8.95E-08	5.125E-08	3.93333E-08	6.7625E-08	6.95E-08
Wear rate(m^2/N)	8.95E-14	5.125E-14	3.93333E-14	6.7625E-14	6.95E-14

4.5 Test Graphs

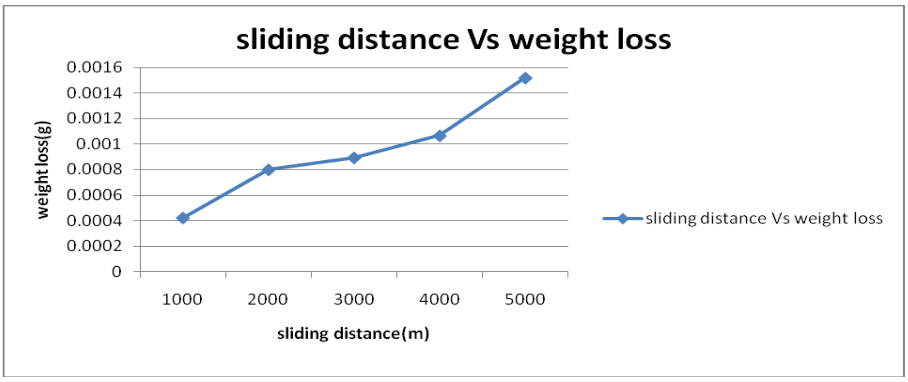

Fig 4.5. As the Sliding distance increases weight loss also increases.

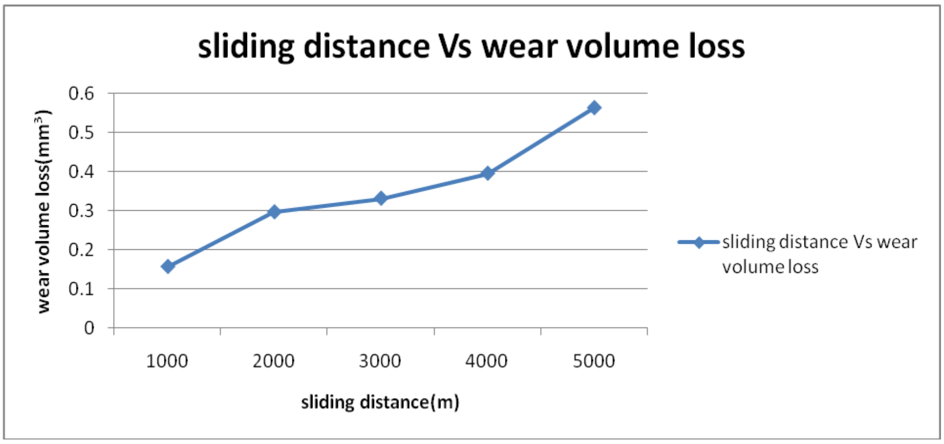

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Fig 4.6.As the Sliding distance increases wear volume loss also increases.

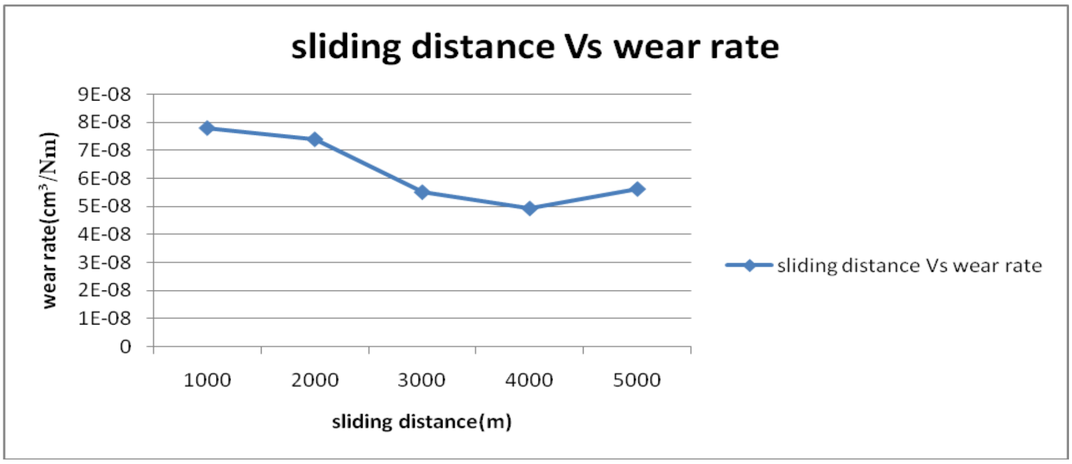

Fig 4.7.As the Sliding distance increases wear rate decreases

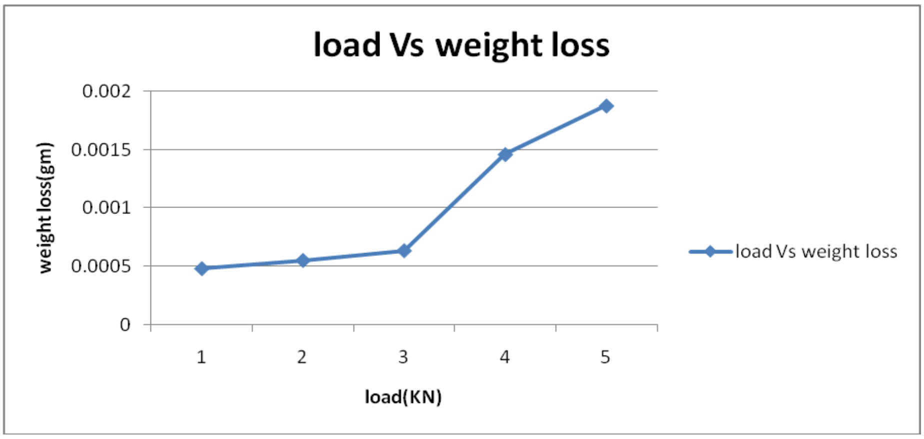

Fig4.8.As the Load increases weight loss also increases.

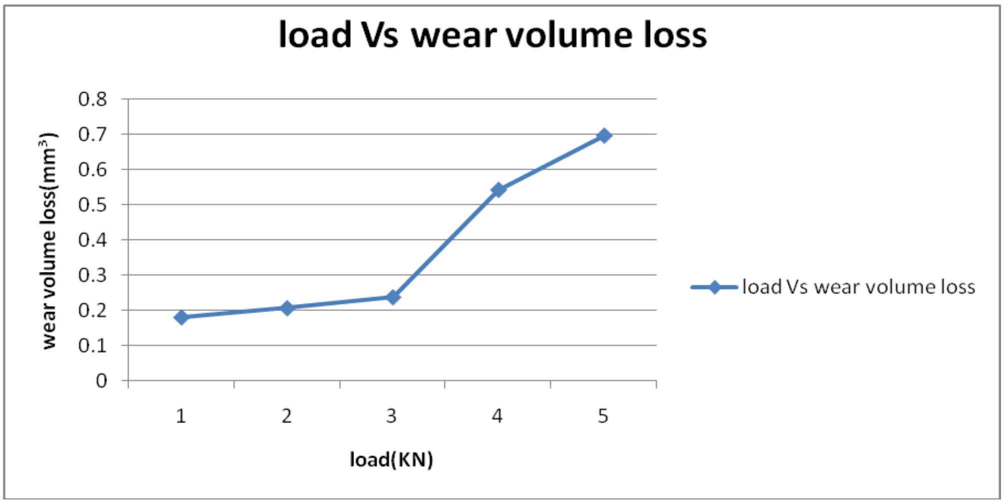

Fig 4.9.As the Load increases wear volume loss also increases.

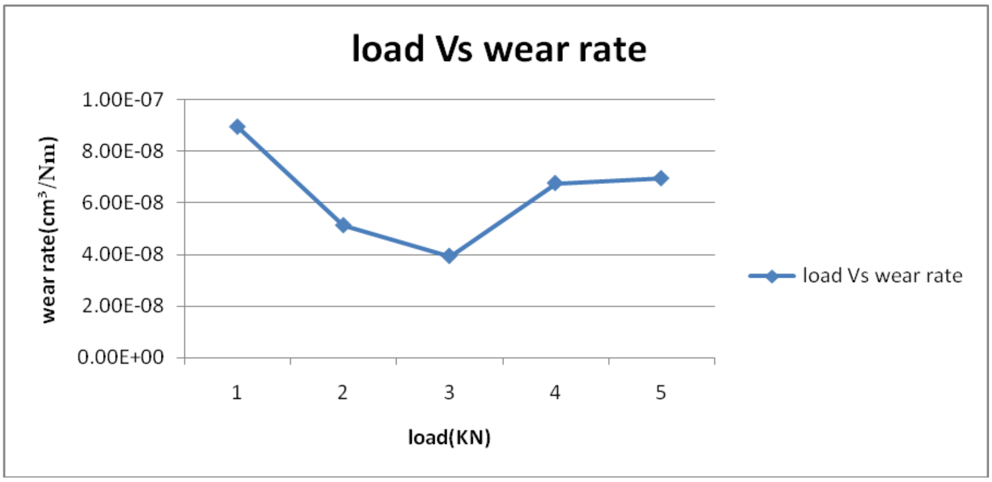

Fig 4.10.As the Load increases wear rate fluctuates.

4.6 Hardness Test

Brinell hardness taken @ 100 kg load using a 1/16th inch ball indenter.

200 RPM

1. 49 BHN
2. 56 BHN
3. 71 BHN

600 RPM

1. 62 BHN
2. 63 BHN
3. 64 BHN

400 RPM

1. 50 BHN
2. 52 BHN
3. 58 BHN

800 RPM

1. 48 BHN
2. 54 BHN
3. 61 BHN

5. Conclusion

By examining the microstructure of the Aluminum Graphite composites, the composite with the stirrer speed of 600 rpm has the better distribution of graphite. The hardness, compression strength

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and tensile strength are also high in this (600) particular rpm. Therefore we conducted the wear test for the particular specimen which is casted at the stirrer speed of 600 rpm which shows that as the sliding distance increases the weight loss, wear volume loss tends to increase. The wear rate tends to decrease as the sliding distance increases. As the load increases, weight volume losses tend to increase. The load and the wear rate are plateaued. This perfectly matches with the wear equation.

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