Effect of Silvernano Particle And Graphene Powder on Mechanical, Micro Structural And Dry Wear Behaviour Properties of Al-7075 Hybrid Nano Composite

Syed.Siddiq[1], S.B.K.Reddy[2], P.Murari[3]
[1]Dept of Mechanical Engineering
[2, 3]Assistant professor, Dept of Mechanical Engineering
[1, 2] Gudlavalleru Engineering College, Gudlavalleru-521356

Abstract- *Metal matrix composites are significantly improved properties including high tensile strength, hardness, low density and good wear resistance compared to alloys or any other metals. In this work the Metal Matrix composites is developed by reinforcing of Silver Nano powder and Graphene Nano powder in Aluminum alloy Al7075, using Stir Casting Technique. The MMC's specimens are prepared by keeping the percentage of weight fraction of the reinforced particle Graphene Nano powder as constant i.e 1%, by varying percentage of weight fraction of the reinforced particle Silver Nano powder as 1% and 2% and the remaining aluminum alloy respectively.With increases in % of reinforcement of Graphene Nano powder and Silver Nano powder there is a significant drop of density from 2.81 g/cc to 2.75 g/cc, so there will be a weight loss of structure. With increases in % of reinforcement of Graphene Nano powder and Silver Nano powder there is a significant drop of wear rate (µm) by keeping the sliding velocity as 0.5, 1.0, 1.5 m/s over a time interval of 10 minutes on a disk diameter of 60mm.By adding the Silver Nano powder which increase the thermal conductivity of the specimen which enhance easy heat dissipation while testing resulting the less wear.*

Keywords- Al 7075, Metal Matrix Composites, Stir Casting Technique, Silver Nano powder, Graphene Nano powder.

I. INTRODUCTION

The method of research in Aluminum based Metal Matrix Composites (MMC's) are far reaching these days. These composites find various applications in the automobile industry, aerospace industry and in different marine engineering because of their high strength-toweightratio, high stiffness, hardness, wear resistance, high temperature resistance etc., compared to others. In metal matrix composites, several research works has-been carried out on Al alloys. Aluminum Alloy 7075 offers the highest strength of the common screw machine alloys. The superior stress corrosion resistance of the T173 and T7351 tempers makes alloy 7075 a logical replacement for 2024, 2014and 2017 in many of the most critical applications. TheT6 and T651 tempers have fair machinability. Alloy7075 is heavily utilized by the aircraft and ordnance industries because of its superior strength. In composites, materials are combined in such a way that enables us to make better use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term composites gives indication of the combinations of two or more material in order to improve the properties. Matrix composites are made to lower the cost, reduced weight and high-performance which can be easily available in the market for us to use.

Selection of material:

For conducting the experiment we selected the material as aluminium 7075 as Metal Matrix Composite & Silver Nano powder, Graphene Nano powder as reinforcement material.

Metal matrix material:

Al-7075:

It is very strong in strength compared to many steels andhas good fatigue strength, average machinability, highthermal and electrical conductivity, but has lessresistance to corrosion compared to the other Al alloys. It isused in sporting goods, electronic packaging, armoursand automotive industries.

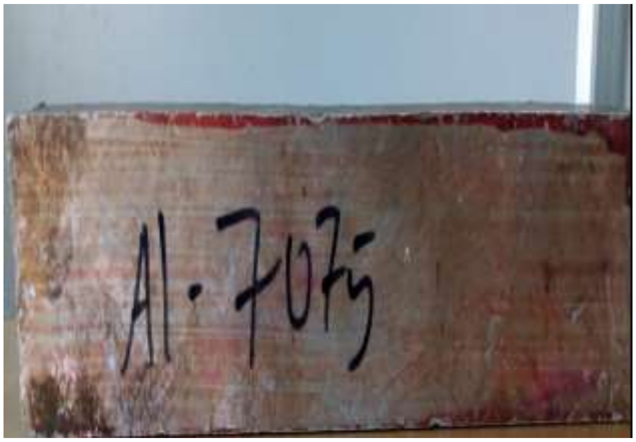


Fig-1:Al 7075

Table-1:Chemical Composition of Aluminum 7075

Component	Weight Percentage (W%)
Al	87.1-91.4
Cr	0.18-0.28
Cu	1.2-2
Fe	Max 0.5
Mg	2.1-2.9
Mn	Max 0.3
Si	Max 0.4
Ti	Max 0.2
Zn	5.1-6.1

Table-2:Properties of Al 7075

Properties	Density	Meltin point	Tensile strength	Fatigue strength	Hardness
Al 70752	2.81 g/cc	483°C	220Mpa	160Mpa	60

Reinforced material:

Silver Nano powder:

Silver Nano powder is very extremely useful in heat transfer application.Here the size of Silver Nano powder is 50 nm and 99.90% of purity was used.These are extremely very large surface area which permits the coordination of vast number of legends helps to form clusters.Silver Nano powder is available in various shapes.Some of the arediamond, octagonal,spherical and thin sheets are also used.But here we are used the spherical shape type.

Fig-2:Silver Nano powder

Graphene Nano powder:

Graphene is called the mother of all graphitic forms of carbon.It is a single layer of carbon atoms that are held together by a backbone of overlapping ‘sp2’ hybrids bonds .The extraordinary characteristics of graphene originated from the ‘2p’ orbital's,which in the form the ‘p’ state bands that delocalize over the sheet of carbons that constitute graphene. As a result grapheneexhibits extremely stiff, very high thermal conductivity, displays high mobility of charge carriers, while it is optically transparent. All these properties give graphene a comparative advantage over similar materials that have been used in different applications. As a result there is a need for high-quality graphene in bulk quantities for both industry and academia, in order to cover the demands of the parties involved and propel the material into commercial applications. For this reason, several preparation strategies have been proposed in literature and a number of them are already employed by companies supplying graphene.

Fig-3:Graphene Nano powder

II. LITERATURE SURVEY

[1]D.arshan-Mechnical and Tribological properties of Al-7075 and grapheme reinforced metal matrix composition by using liquid stir casting-He absorbed that ultimate tensile strength, yield strength and wear resistance of the composition

increases with increase in weight of graphene and hardness also increases-2018.

[2]R.deaqunio-lara-Tribological characterization of Al-7075 graphite graphite composition fabricated by mechanical alloying and hot extrusion by using hot extrusion milling process-He absorbed that strength and hardness of composites increases as the direct function of milling time and graphite content-2015.

[3]A.fsanchd.orri-mechanical and tribological properties of self-lubricating metal matrix nano composites reinforced by carbon nano tubes(CNT's) and grapheme by using self lubrication method-He absorbed that increase in self-lubricating mechanical and tribological properties for several application in automotive and aerospace industries. Wear rate and coefficient of friction also increases-2015.

[4]Emad omrani- Tribological performance of self lubricating aluminium matrix nano composition, role of graphene nano plate-lets by using powder metallurgy method-He absorbed that coefficient of friction decreases with increase in graphene with increase in the normal load, wear rate also increase with increase in graphene with increase in normal load-2015.

[5]Sandeep Kumar-Review on mechanical and tribological behavior of stir casting aluminium composite by using the mechanical stirring- He absorbed that it improve hardness, yield strength, tensile strength while ductility is increase, the addition of graphite tensile strength, elastic modules increase but hardness decreases-2014.

[6]A.elaya-Study on mechanical wear Al properties of Al-7075 graphite and al_2o_3 composite by using casting process-He absorbed that the effect of al_2o_3 graphite addition on the hardness of hybrid composite with increase in al_2o_3 ceramic particles, the hardness of hybrid composite increases with increase in al_2o_3 and itwas than that of base alloy in all composition-2012.

[7]R.flores-campos-microstructure and mechanical properties of 7075 aluminium alloy nano structure composite processed by using mechanical milling and direct hot extrusion-He absorbed thatBoth milling time and silver nanoparticles have a positive effect on the mechanical properties. The best mechanical properties were obtained at 1.0–1.5 wt.% of Ag–C NP's and a 10 h milling. The dispersion of silver nanoparticles and crystallization of phases are the main factors that cause the increase in the mechanical properties. Higher mechanical qualities of the produced composites can be achieved by heat treatment. Additionally, it is observed that the dispersion of the nanoparticles does not affect the ductility (2012).

[8] K. Mohan- Microstructure and Mechanical Behaviour of Al 7075-T6 Subjected to Shallow Cryogenic Treatment-The improvement in fatigue strength of SCT Al alloy is due to uniform distribution of second-phase particles,which impedes crack growth effectively due its fine morphology. Higher dislocation density in the SCT alloy could also restrict crack movement as it breaks down the continuity of the slip plane from one grain to the adjacent grain, SCT is a cheaper process compared to DCT and it imparted substantial improvement in tensile (630 to 673 MPa) and fatigue properties of Al alloy (from 140 to 240 MPa) as evident from the present work (2015).

[9] Manik Singla- Microstructure and Mechanical Properties of Aluminium Based Metal Matrix Composite – A Review- In this paper aluminum based metal matrix are discussed using various different reinforcements such as fly ash, rice husk, coconut husk, ceramics etc. Different machining such as milling, turning, drilling and effect of changing parameters on aluminum based metal matrix is also discussed. Nowadays majority of aluminum based metal matrix are casted using stir casting .The reinforcements used are industrial waste thus saving cost of reinforcement. The future scope is to find other methods for making aluminum based metal matrix which are less expensive and a lot of work is already done using different reinforcements ,but still we do not have a specific percentage of reinforcement for optimum aluminum based metal matrix (2017).

[10] R. Karthigeyan- Mechanical Properties and Microstructure Studies of Aluminium (7075) Alloy Matrix Composite Reinforced with Short Basalt Fibre- Al (7075) alloy and their composites have been successfully developed through the stir castingbased liquid processing route with fairly uniform dispersion of basalt fibre, the hardness of Al7075/basalt fibre composite increases as the addition of basalt fibre particlesand the increment in hardness attributes to fibre particles dispersion in soft aluminium alloymatrix, the addition of short basalt fibre significantly improves the yield strength and the ultimatetensile strength of Al7075, when compared with that of unreinforced matrix. The ultimatetensile strength of Al 7075/Basalt fibre composite when reinforced with 6 vol. % is increasedby 65.51%, the improvement in strength values under tensile loading occurs without affecting the tensileductility, fractured surfaces under tensile loading of the cast Al (7075) alloy and their composites showsthe presence of equi-axed and shallow dimples in all the samples, the strength calculation involving the random

distribution of basalt fibres best fits theexperimental values (2012).

III. EXPERIMETAL WORK

Melting and Casting:

A bottom poured stir casting machine was used for melting the alloy for casting purpose, 7075 aluminums was cut into small pieces and were put into the stir casting machine which is preheated and then it was kept for melting. In order to avoid void formation during solidification Argon gas was used. The pre heated Silver Nano powder and Graphene powder were then added into the stir casting and by using a mechanical stirrer it was thoroughly mixed. As we are using the Silver Nano powder as the reinforcement material we have to use theultra-sonic vibrator for mixing of Silver Nano powder to avoid the moisture formation in the mixing. After thorough mixing with the vibrator it was poured into the dye which is already pre heated up to 500-700^{o}C.

Fig-4: Bottom poured stir casting machine with ultra-sonic vibrator

Measurement of surface wear & analysis:

Pin on disk setup was used here to test coefficient of friction, frictional force and rate of wear between two materials which are in contact.

Fig-5: Pin On Disk Test Machine

Fig-6: Surface Wear Specimen-ASTM-E8-35mm×10mm

Measurement of compression test:

Compression tests are performed on brittle materials as these materials fail in shear. It is seen that the shear develops along a diagonal plane which is maximum on a plane inclined at 45° from the direction of compression load. In compression loading, the fracture of the specimen takes place due to bulging action. The property of a material to bulge under compressive loading is called malleability. It is the ductility that is associated with tensile loading while it is malleability that is associated with compressive loading. The modulus of elasticity in tensile loading and compressive loading should be equal except for bi-modulus materials such as wood.

Fig-7: Universal Testing Machine for Compression Test

Fig-8: Specimen for Compression test as per ASTM-E8-13mm×26mm

Measurement of density test

Itis the Automatic Densi-meter DSG-1 is a high precision instrument that offers accurate, simple operation in almost any laboratory environment. An electronic balance determines specific gravity of rubber, plastic, ceramic, and various other materials with the single push of a button. Specific gravity of the sample can be directly read on the indicator screen simply and easily.

Fig-9: Electronic Specific Gravity Balance for Density Test

Fig-10: Specimen for Density test as per ASTM-E8-10mm×10mm

Measurement of surface micro structure:

The interface characteristics of grain bonding reflect in composite material property after reinforced. The visual interface of microstructure was observed. Optical microscope was been used for visual impact at magnification of 500X as per ASTM E112-63 standard.

Fig-11: Inverted Computerized Electronic Microscope

Fig-12: Specimen for Surface Micro Structure test as per ASTM-E8-18mm×18mm

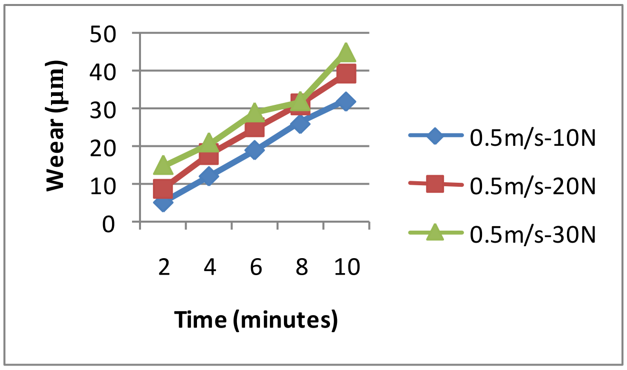
IV. RESULT AND DISCUSSION

Results of surface wear test analysis:

Wear test is conducted on pin on disc test.

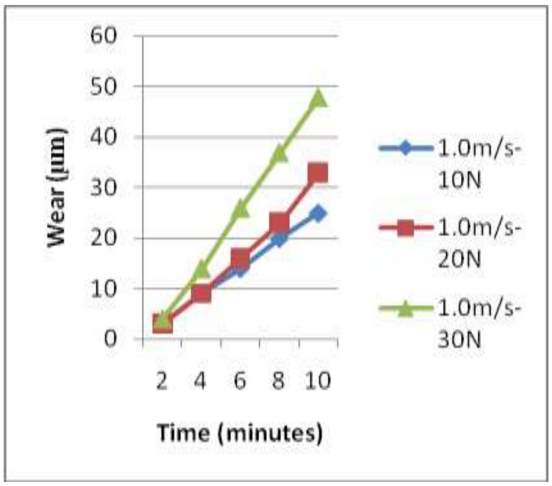
Table-3: Al-7075(0%Wt of Silver Nano particles +0%Wt of Nano Graphene powder)

Velocity (V)m/s	Load (L)N	Wear (W)µm				
		2	4	6	8	10
0.5	10	5	12	19	26	32
0.5	20	9	18	25	31	39
0.5	30	15	21	29	32	45
1.0	10	3	9	14	20	25
1.0	20	3	9	16	23	33
1.0	30	4	14	26	37	48
1.5	10	10	19	29	38	47
1.5	20	21	36	42	56	63
1.5	30	7	18	33	46	49



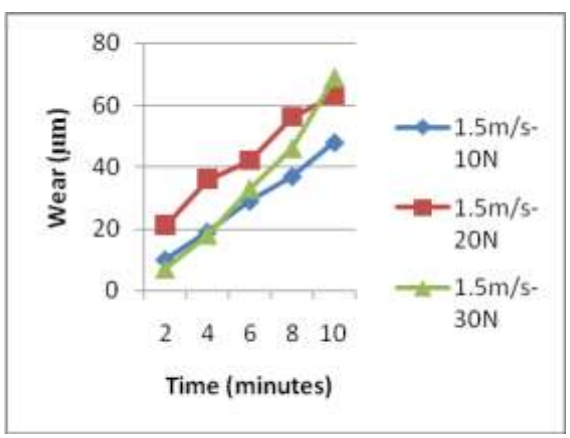
Graph:1 Time Vs Wear

At 0.5 m/s with track diameter 60mm, at 160 rpm speed fewer than 10, 20 and 30N loadsi.e. wear increases with increase in loads.



Graph:2 Time Vs Wear

At 1.0 m/s with track diameter 60mm, at 320 rpm speed fewer than 10, 20 and 30N loads i.e. wear increases with increase in loads.

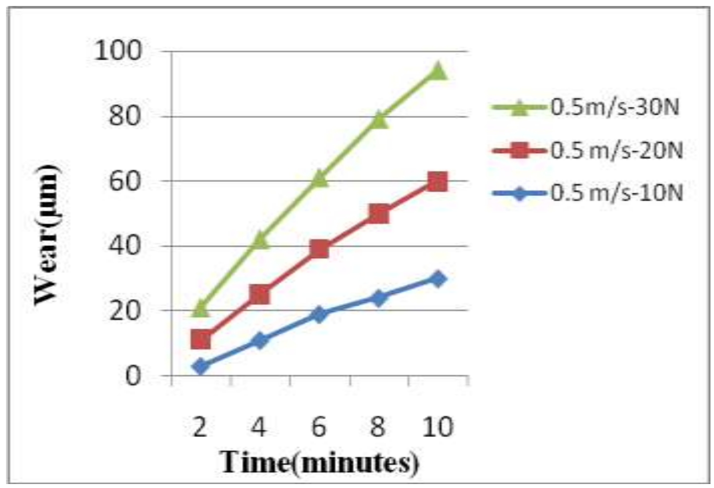


Graph: 3 Time Vs Wear

At 1.5 m/s with track diameter 60mm, at 480 rpm speed fewer than 10, 20 and 30N loads i.e. wear increases with increase in loads.

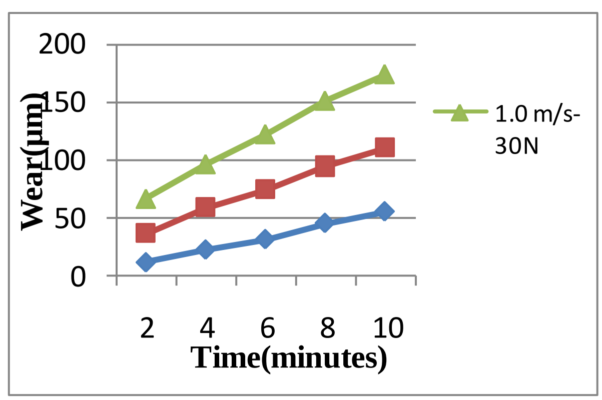
Table-4: Al-7075(1%Wt of Silver Nano particles +1%Wt of Nano Graphene powder)

Velocity (V)m/s	**Load (L)N**	**Wear (W)µm**				
		2	**4**	**6**	**8**	**10**
0.5	10	3	11	19	24	30
0.5	20	8	14	20	26	30
0.5	30	10	17	22	29	34
1.0	10	11	22	31	45	55
1.0	20	25	36	43	49	55
1.0	30	30	38	48	57	64
1.5	10	14	24	33	43	50
1.5	20	19	30	39	52	60
1.5	30	28	36	44	50	58



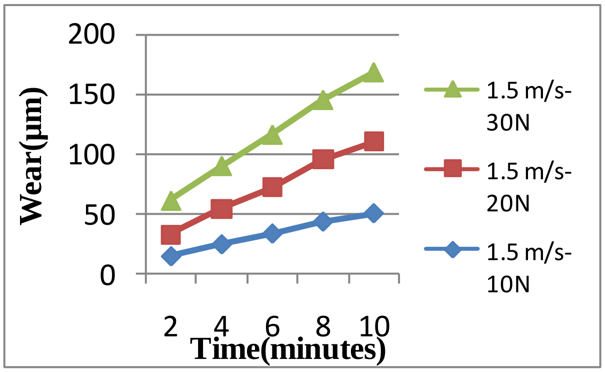
Graph: 4 Time Vs Wear

At 0.5 m/s with track diameter 60mm, at 160 rpm speed fewer than 10, 20 and 30N loads i.e. wear increases with increase in loads.



Graph: 5 Time Vs Wear

At 1.0 m/s with track diameter 60mm, at 320 rpm speed fewer than 10, 20 and 30N loads i.e. wear increases with increase in loads.

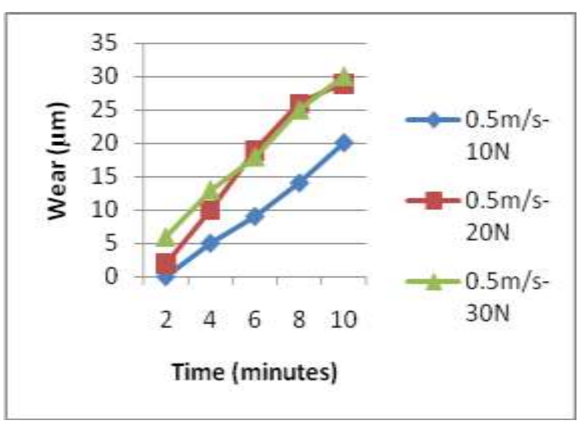


Graph: 6 Time Vs Wear

At 1.5 m/s with track diameter 60mm,at 480 rpm speed fewer than 10,20 and 30N loads i.e. wear increases withincrease in loads

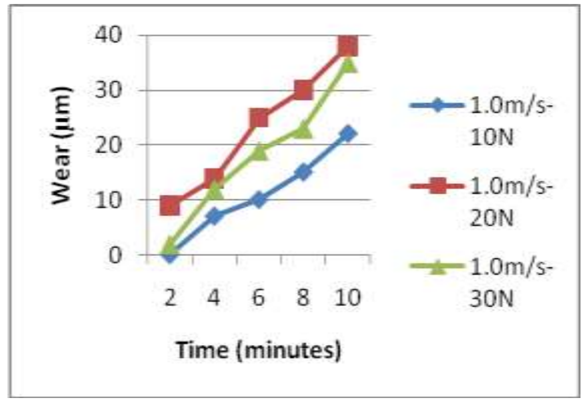
Table-5: Al-7075(2%Wt of Silver Nano particles +1%Wt of Nano Graphene powder)

Velocity (V)m/s	**Load (L)N**	**Wear (W)µm**				
		2	**4**	**6**	**8**	**10**
0.5	10	0	5	9	14	20
0.5	20	2	10	19	26	19
0.5	30	6	13	18	25	30
1.0	10	0	7	10	15	22
1.0	20	9	14	25	30	38
1.0	30	2	12	19	23	35
1.5	10	6	13	14	26	32
1.5	20	10	25	34	45	56
1.5	30	19	38	57	79	101



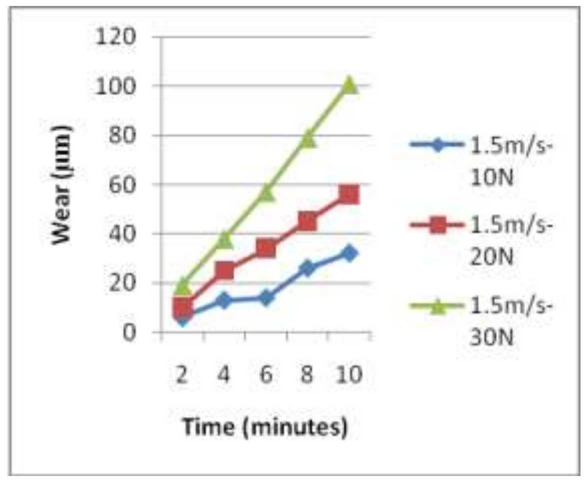
Graph: 7 Time Vs Wear

At 0.5 m/s with track diameter 60mm, at 160 rpm speed fewer than 10, 20 and 30N loadsi.e. wear increases with increase in loads.



Graph: 8 Time Vs Wear

At At 1.0 m/s with track diameter 60mm, at 320 rpm speed fewer than 10, 20 and 30N loads i.e. wear increases with increase in loads.

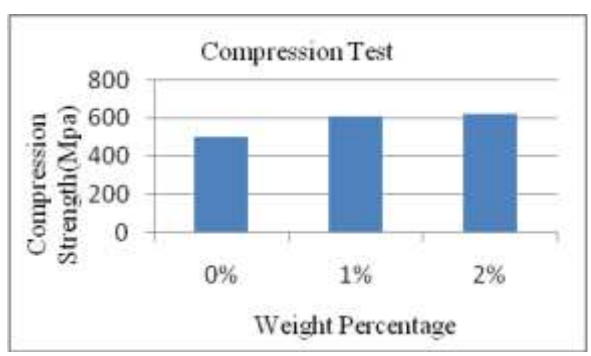


Graph: 9 Time Vs Wear

At 1.5 m/s with track diameter 60mm,at 480 rpm speed fewer than 10,20 and 30N loads i.e. wear increases with increase in loads.

Result of Compression test:

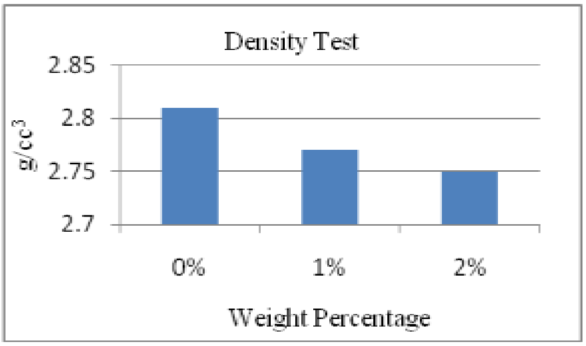
With the increase in weight percentage of reinforcement there is an increase in the value of compressive strength.



Graph: 10 Result of Compression test

Results of density test:

It was observed that the addition of Silver Nano particle powder and graphene powder with the Al 7075 alloy matrix significantly decreases the density of the resultant composites when compared to the base alloy.



Graph: 11 Result of Density test

Result of Surface Micro Structure:

With increase in % of reinforcement of the material there will the new formation of grain structure.

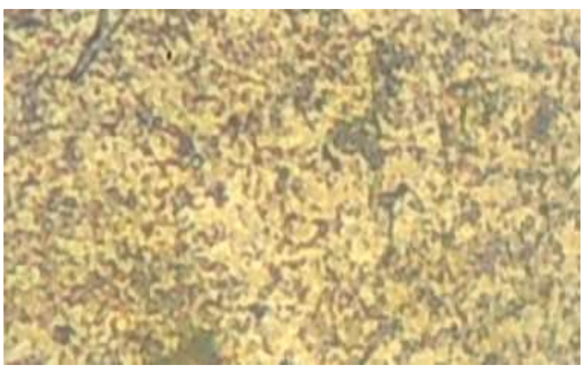


Fig-13: Pure (Wt %)

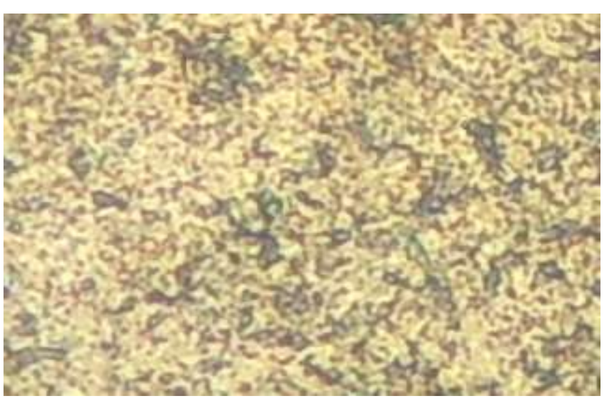


Fig-14: 1 (Wt %)

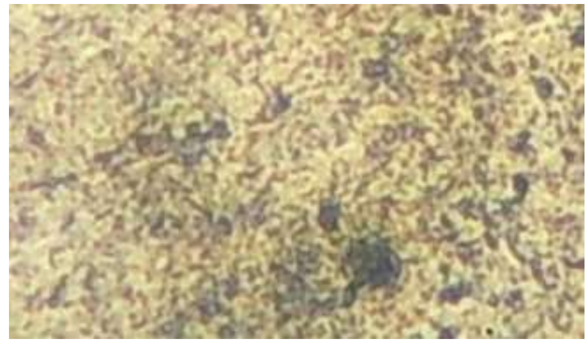


Fig-15: 2 (Wt %)

V. CONCLUSION

- With increases in % of reinforcement of Graphene Nano powder and Silver Nano powder there is a significant drop of density from 2.81 g/cc to 2.75 g/cc, so there will be a weight loss of structure.
- With increases in % of reinforcement of Graphene Nano powder and Silver Nano powder there is a significant drop of wear rate (µm) by keeping the sliding velocity as 0.5,1.0,1.5 m/s over a time interval of 10 minutes on a disk diameter of 60mm.
- By adding the Silver Nano powder which increase the thermal conductivity of the specimen which enhance easy heat dissipation while testing resulting the less wear.

REFERENCE

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