IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Study And Experimentation on Mechanical Characteristics of Compositional Aluminum Alloys and Chemical Composition Influences Engine Cylinder Blocks

Sai Vishnu S[1] S, Sridevanand R K[2], Srinith kumar P[3], Karthi P[4]

[1,2&3] UG Final Year student, Department of Mechanical Engineering, Kumaraguru College of Technology, Coimbatore.

[4]Assistant Professor 1, Department of Mechanical Engineering, Kumaraguru College of Technology, Coimbatore.

ABSTRACT

Aluminium alloy holds a significant position among the materials used in automotive components in the recent decades. In the past decades most of the car manufactures uses the Cast iron and Cast aluminium alloy for their engine blocks, but the former's mechanical advantages are used in the production of other parts, including cylinder heads and blocks, to a lesser degree. Variability within the same chemical composition of the material is one of the primary challenges in achieving aluminium alloy. In the recent decades most of the manufacture company started using the aluminium alloy for their engine blocks to enhance their properties of blocks. Different types of mechanical characteristic are taken into considerations to determine the high qualities of materials; moreover, there are a few chemical composition materials are taken into consideration and it provides a various different values based the chemical composition. Specimen-1 Aluminium (Al) 89.31, Silicon (Si) 0.276, Copper (Cu) 1.480, Magnesium (Mg) 2.340, Iron (Fe) 0.183, Zinc (zn) 6.020, Titanium (Ti) 0.059, Chromium (Cr) 0.192, Manganese (Mn) 0.140. The specimen-2 represents Aluminium (Al) 97.529, Silicon (Si) 0.593, Copper (Cu) 1.035 , Magnesium (Mg) 0.492, Iron (Fe) 0.225, Zinc (zn) 0.018 , Titanium (Ti) 0.016, Chromium (Cr) 0.013, Manganese (Mn) 0.082. The composition of specimen-3 Aluminium (Al) 89.2, Lead (Pb) 0.00410, Copper (Cu) 1.48, Magnesium (Mg) 2.34, Iron (Fe) 0.183, Zinc (Zn) 6.03, Titanium (Ti) 0.0590, Silicon (Si) 0.276, Manganese (Mn) 0.140, Lanthanum (La) 0.0380, Molybdenum (Mo) 0.0040, Zirconium (Zr) 0.0710, Nickel (Ni) 0.00930. And specimen-4 which has different composition Aluminium (Al) **98.5**, Lead (Pb) 0.00570, Copper (Cu) 0.0350, Magnesium (Mg) 0.492, Iron (Fe) 0.225, Zinc (Zn) 0.00108, Titanium (Ti) 0.0160, Silicon (Si) 0.539, Manganese (Mn) 0.0820, Lanthanum (La) 0.00160, Molybdenum (Mo) 0.00040, Zirconium (Zr) 0.0002, Nickel (Ni) 0.00780. Cast aluminum Specimen -1 which show the tensile value of 524.83 MPa in UTM machine, Specimen -2 which has a value of 269.63 MPa, Specimen-3 has a value of 270.19 MPa in the tensile strength and Specimen – 4 has a value of 524.13 MPa. Specimen -1 which show the value of 87.1 in Brinell hardness machine, and Specimen -2 which has a value of 149. The specimen -3 has a value of 85.7 from the machine. Specimen -4 shows the value of 147 in the Brinell hardness machine. Specimen -1 which show the value of 500.47 MPa in the yield strength machine, Specimen -2 which has a value of 251.02 MPa, Specimen -3 which show the value of 232.67 MPa in the yield strength machine, Specimen -4 which has a value of 439.11 MPa. Specimen -1 which show the value of 10.92 % in UTM machine, Specimen -2 which has a value of 20.48%, Specimen -3 which show the value of 21.94 % in UTM machine, and Specimen -4 which has a value of 9.60 %. Specimen -1 which show the value of 0.269 mm in creep test machine, Specimen -2 which has a value of 0.281 mm, Specimen -3 has a value of 0.1 mm in the creep test machine and Specimen -4 has a value of 0.17 mm in the creep test machine. Specimen -1 which show the value of 1836 microns in wear test machine, Specimen -2 which has a value of 1600 microns, Specimen -3 has a value of 1515 microns in the wear test machine and Specimen -4 has a value of 734 microns in the wear test machine.

Keywords: Aluminum Alloy. Al319, Al 356, Al357, Engine Block, Micro-Structure, Bonding, Elemental Composition, Eutectic, Tensile, Creep, Wear, Hardness.

1- INTRODUCTION

Aluminium amalgam components with different, frequently complex, structures, which are ordinarily made by die-casting handle, are common items in present day days and they are lightweight structures. This innovative strategy permits for getting interesting shapes of items, which gives remarkable plan openings for designers and architects. Aluminium amalgams with silicon of the 319 and 356 arrangement are expecting for motor squares. At the same time, these amalgams are characterised by tall quality properties, which they are exceptionally habitually utilized in different sorts of motor pieces.

A disadvantage that hypoeutectic Al–Si amalgams display is their moo resistance to wear, so it is required to utilize wear-resistant amalgams in parts subjected to disintegration. The conditions experienced inside the combustion chamber of engine-blocks. Ordinary and shear stresses are caused by the blast of the compressed fuel and the responding relocation of the cylinder; additionally, the cylinder seals wear the fabric utilized for lining the combustion chamber.

In any case, the down to earth utilize of Mg combinations is constrained by their moo erosion resistance. The erosion resistance of aluminium amalgams can be expanded by utilizing the anodising prepare. This handle comprises in making a coating on the aluminium surface, which increments resistance to different outside components, such as corrosive rain, ocean water, or UV radiation.

2- TESTING OF SPECIMEN

2.1-CHEMICAL COMPOSITION OF ALUMINUM ALLOY

TABLE: - 2.1.1 CHEMICAL COMPOSITION

MATERIAL COMPOSITION(%)	CAST ALUMINIUM- 319	CAST ALUMINIUM-A356	ALUMINIUM ALLOY
Aluminium (Al)	90.897	87.53	85.996
Silicon (Si)	3.40	6.54	10.999
Copper (Cu)	3.88	2.20	1.357
Magnesium (Mg)	0.291	2.45	0.493
Iron (Fe)	0.435	0.20	0.623
Zinc (Zn)	0.465	0.50	0.532
Titanium (Ti)	0.163	0.30	0.105
Chromium (Cr)	0.01	0.18	-

Most common cast aluminium alloy are 319 and 356, they have higher strengths and withstanding capacity and where the Silicon dominant are higher in both cast aluminium; therefore, most of the manufactures choose the cast aluminium particularly the above series of material. The table 2.1.1 shows the compositions are taken from various journal papers and most of the journal suggest this composition for the engine blocks.

TABLE: - 2.1.2 CHEMICAL COMPOSITION

MATERIAL COMPOSITION (%)	ALUMINIUM ALLOY (Specimen-1)	ALUMINIUM ALLOY (Specimen-2)
Aluminium (Al)	89.31	97.529
Silicon (Si)	0.276	0.593
Copper (Cu)	1.480	1.035
Magnesium (Mg)	2.340	0.492
Iron (Fe)	0.183	0.225
Zinc (Zn)	6.020	0.018
Titanium (Ti)	0.059	0.016
Chromium (Cr)	0.192	0.013
Manganese (Mn)	0.140	0.082

The table 2.1.2 represents that specimen-1 Aluminium (Al) 89.31, Silicon (Si) 0.276, Copper (Cu) 1.480, Magnesium (Mg) 2.340, Iron (Fe) 0.183, Zinc (zn) 6.020, Titanium (Ti) 0.059, Chromium (Cr) 0.192, Manganese (Mn) 0.140. And the specimen-2 represents Aluminium (Al) 97.529, Silicon (Si) 0.593, Copper (Cu) 1.035 , Magnesium (Mg) 0.492, Iron (Fe) 0.225, Zinc (zn) 0.018 , Titanium (Ti) 0.016, Chromium (Cr) 0.013, Manganese (Mn) 0.082.

The below table 2.1.3 represents the different aluminium alloy material that has various other composition when compared to the above alloy materials. And the composition of specimen-3 Aluminium (Al) 89.2, Lead (Pb) 0.00410, Copper (Cu) 1.48, Magnesium (Mg) 2.34, Iron (Fe) 0.183, Zinc (Zn) 6.03, Titanium (Ti) 0.0590, Silicon

(Si) 0.276, Manganese (Mn) 0.140, Lanthanum (La) 0.0380, Molybdenum (Mo) 0.0040, Zirconium (Zr) 0.0710, Nickel (Ni) 0.00930. And the specimen-4 has the similar values when compared to the specimen-3

TABLE: - 2.1.3 CHEMICAL COMPOSITION

MATERIAL COMPOSITION (%)	ALUMINIUM ALLOY (Specimen- 3)	ALUMINIUM ALLOY (Specimen-4)
Aluminium (Al)	89.2	98.5
Lead (Pb)	0.00410	0.00570
Copper (Cu)	1.48	0.0350
Magnesium (Mg)	2.34	0.492
Iron (Fe)	0.183	0.225
Zinc (Zn)	6.03	0.0108
Titanium (Ti)	0.0590	0.0160
Silicon (Si)	0.276	0.539
Manganese (Mn)	0.140	0.0820
Lanthanum (La)	0.0380	0.00160

2.2 TENSILE STRENGTH

TABLE: - 2.2 TENSILE STRENGTH

S.NO	COMPONENTS	TENSILE STRENGTH	UNITS
1	Cast Aluminum- 319	250	MPa
2	Cast Aluminum-A 356	200	MPa
3	Aluminum Alloy	190	MPa
4	Specimen -1	524.83	MPa
5	Specimen -2	269.63	MPa

Specimen -1 which show the value of 524.83 MPa in UTM machine, and Specimen -2 which has a value of 269.63 MPa. The figure 2.2.1 tensile strength comparison graph which determines that the value of specimen varies based on the chemical composition and it illustrates that the different specimen shows the different values of the specimen.

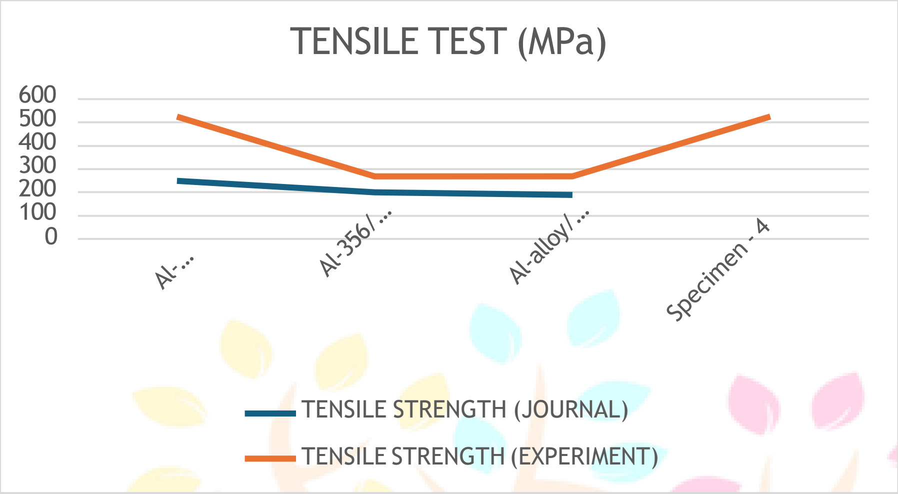

FIG:- 3.2.1 TENSILE STRENGTH COMPARISON GRAPH

2.3 BRINELL HARDNESS TEST

The readings are listed below Cast Aluminum- 319 which has a hardness values of 85 . Cast Aluminum-A 356 which has a hardness of 80. Aluminum Alloy has a value of 75. Specimen -1 which show the value of 87.1 in this machine, and Specimen -2 which has a value of 149. The specimen -3 has a value of 85.7 from the machine. Specimen -4 shows the value of 147 in the Brinell hardness machine. The below table 2.3 shows the Brinell hardness and 2.3.1 shows the comparison graph.

TABLE: - 2.3 BRINELL HARDNESS

S.NO	COMPONENTS	HARDNESS
1	Cast Al- 319	85
2	Cast Al-356	80
3	Aluminum Alloy	75
5	Specimen -1	87.1
6	Specimen -2	149
7	Specimen-3	85.7
8	Specimen-4	147

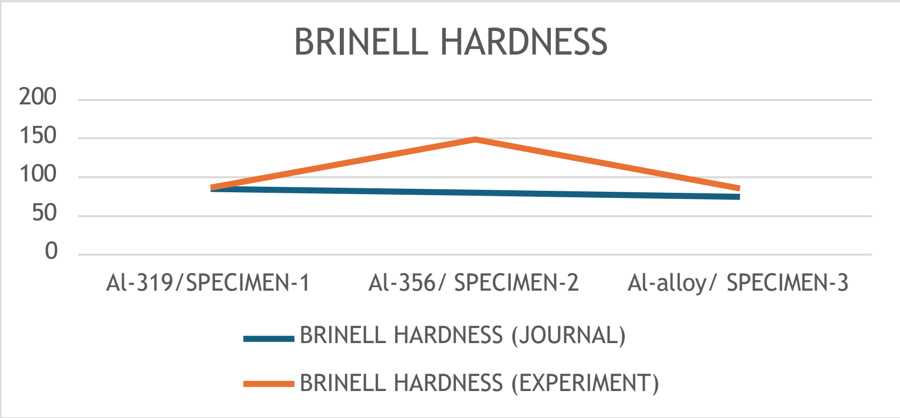

FIG:- 2.3.1 BRINELL HARDNESS COMPARISON GRAPH

2.4 MICROSTRUCTURE

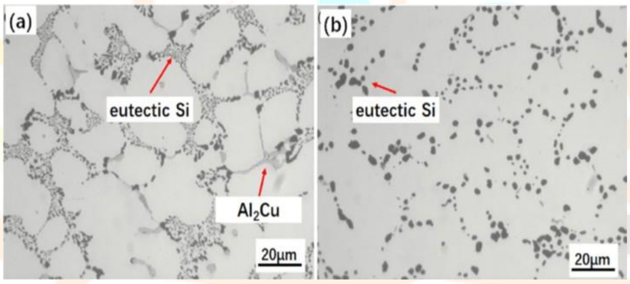

FIG: - 2.4.1 ALUMINIUM-319 [12]

The above figure 2.4.1 shows the microstructure of an Aluminum Alloy 319, which has a high amount of silicon inclusion in the component. It forms a eutectic phase diagram; moreover, there is an Al_2Cu inclusion on a minimal area, but silicon is a greater dominance in the components. With the help of microscope, the specimen is tested under 20x condition.

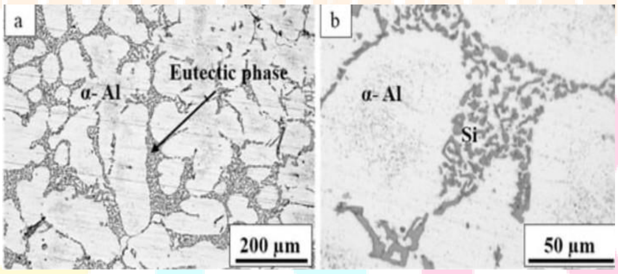

FIG: - 2.4.2 ALUMINIUM-356 [13]

The above figure 2.4.2 shows the microstructure of an Aluminum Alloy 356, which has a high amount of silicon inclusion in the component. It forms a eutectic phase diagram; moreover, there is an alpha phase of aluminum on a minimal area, but silicon is considerable in the components. With the help of microscope, the specimen is tested under 200x condition and even tested with 50x conditions.

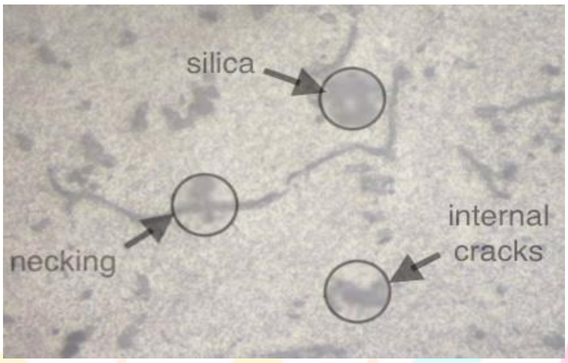

FIG: - 2.4.5 SPECIMEN-1

The above figure 2.4.5 shows the microstructure of an Aluminum Alloy, which has a considerable amount of silica inclusion in the component. It forms an internal crack in the diagram; moreover, there is a necking region shown on a picture, but silica is a considerable area in the components. This specimen used tested method of ASM Metal Handbook Vol-9 and the nature of test is micro examination. Etchant Sodium Hydroxide pellets + Type IV Distilled Water.

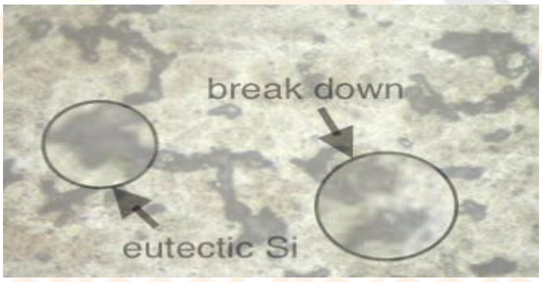

FIG: - 2.4.6 SPECIMEN-2

The above figure 2.4.6 shows the microstructure of an Aluminum Alloy specimen -2, which has a considerable amount of silicon (Si) inclusion in the component. It forms a eutectic phase Si diagram; moreover, but silicon is a considerable area in the components. With the help of microscope, the specimen is tested under 200x condition.

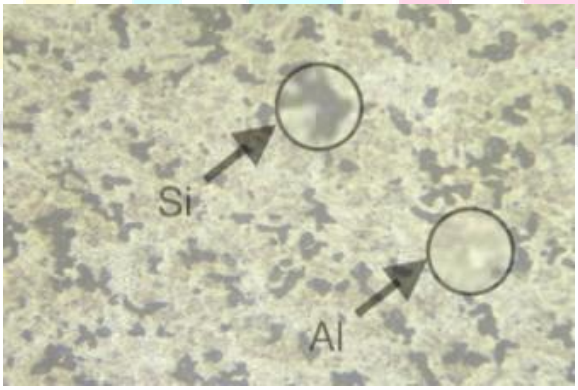

FIG: - 2.4.7 SPECIMEN-3

The above figure 2.4.7 shows the microstructure of an Aluminum Alloy specimen - 3, which has a considerable amount of silicon and aluminum inclusion in the component. With the help of microscope, the specimen is tested under 500x condition.

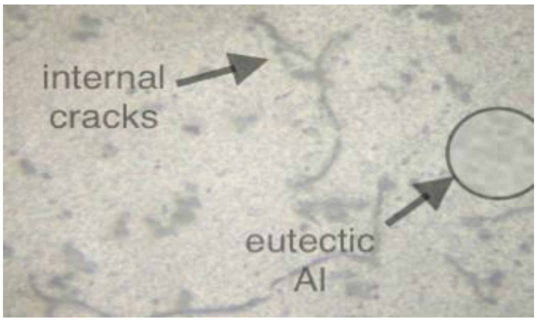

FIG: - 2.4.8 SPECIMEN-4

The above figure 2.4.8 shows the microstructure of an Aluminum Alloy Specimen – 4, which has a considerable amount of eutectic Al in the component. It forms a eutectic aluminum phase diagram; moreover, there is a internal cracks region shown on a picture, but silicon is a considerable area in the components.

2.5 YIELD STRENGTH

The table 2.5 above shows the yield strength and 2.5.1 shows the yield comparison graph test Specimen -1 which show the value of 500.47 MPa in this machine, and Specimen -2 which has a value of 251.02 MPa. The figure 3.5.1 yield strength comparison graph which determines that the value of specimen varies based on the chemical composition and it illustrates that the different specimen shows the different values of the specimen.

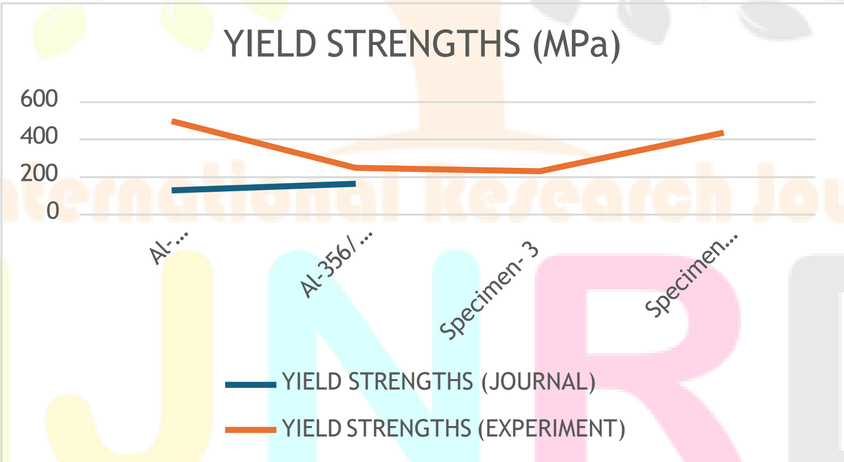

FIG:- 2.5.1 YIELD STRENGTH COMPARISON GRAPH

TABLE: - 2.5 YIELD STRENGTH

S.NO	COMPONENTS	YEILD STRENGTH	UNITS
1	Cast Aluminum- 319	130	MPa
2	Cast Aluminum-A 356	165	MPa
3	Specimen -1	500.47	MPa
4	Specimen -2	251.02	MPa
5	Specimen – 3	232.67	MPa
6	Specimen – 4	439.11	MPa

2.6 ELONGATION

The table 2.6 below shows the elongation test and 2.6.1 shows the comparison graph Cast Aluminum- 319 which has a elongation values of 1.5%. Cast Aluminum-A 356 which has a strength of 3.5%. Specimen -1 which show the value of 10.92 % in this machine, and Specimen -2 which has a value of 20.48%.

TABLE: - 2.6 ELONGATION

S.NO	COMPONENTS	ELONGATION	UNITS
1	Cast Aluminum- 319	1.5	%
2	Cast Aluminum-A 356	3.5	%
3	Specimen -1	10.92	%
4	Specimen -2	20.48	%
5	Specimen – 3	21.94	%
6	Specimen – 4	9.60	%

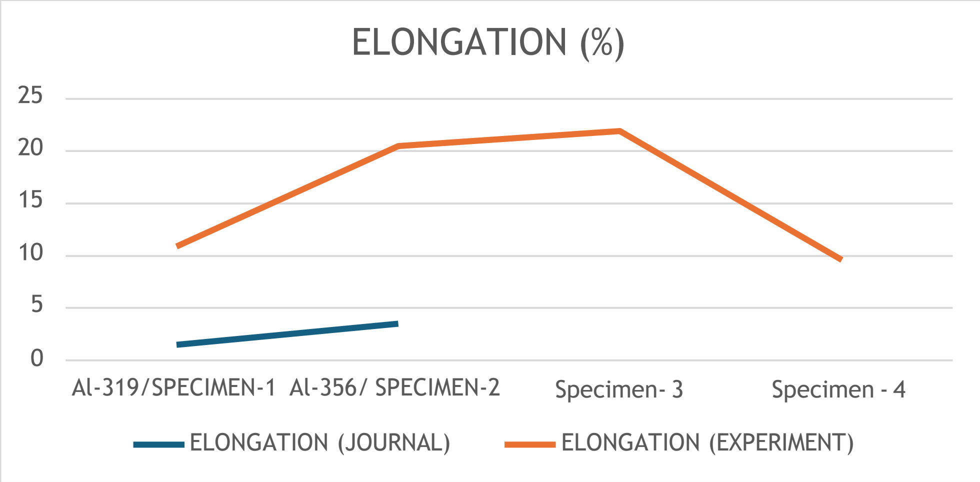

FIG:- 2.6.1 ELONGATION COMPARISON GRAPH

2.7 CREEP

The table 2.7 below shows the creep test and 2.7.1 shows the creep comparison test Cast Aluminum- 319 which has a elongation value of 0.135. Cast Aluminum-A 356 which has a strength of 0.158. Aluminum alloy from journal has a value of 0.120. Specimen -1 which show the value of 0.269 in this machine, and Specimen -2 which has a value of 0.281 and the specimen -3 has a value of 0.287.

TABLE: - 2.7 CREEP TEST

S.NO	COMPONENTS	CREEP	UNITS
1	Cast Al- 319	0.135	mm
2	Cast Al-356	0.158	mm
3	Al-journal paper	0.120	mm
4	Specimen -1	0.269	mm
5	Specimen -2	0.281	mm
6	Specimen-3	0.287	mm

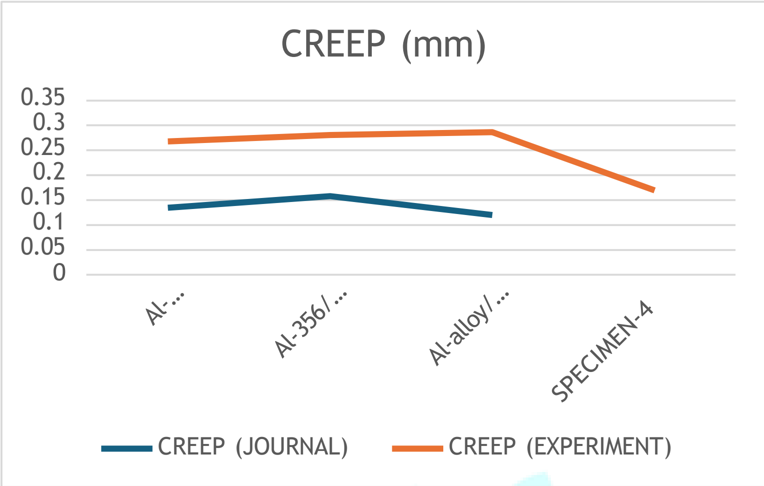

FIG:- 2.7.1 CREEP COMPARISON GRAPH

CREEP GRAPH SPECIMEN – 1

Specimen -1 and creep fig :- 2.7.2 shows a different value with a load of 10kg and the deformation rate would be 0.281 and it sustains with a temperature of 200°C and the creep rate of 0.269 mm is been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

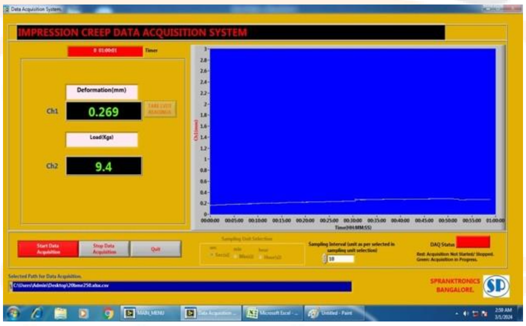

FIG:- 2.7.2 CREEP GRAPH FROM SPECIMEN-1

CREEP GRAPH SPECIMEN – 2

Specimen -2 and creep fig:- 2.7.3 shows a different value with a load of 10kg and the deformation rate would be 0.281 and it sustains with a temperature of 200 °C and the creep rate of 0.281 mm is been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

FIG:- 2.7.3 CREEP GRAPH FROM SPECIMEN-2

CREEP GRAPH SPECIMEN – 3

Specimen -3 and creep fig:- 2.7.4 shows a different value with a load of 10kg and the deformation rate would be 0.1 and it sustains with a temperature of 200 °C and the creep rate of 0.1 mm is been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

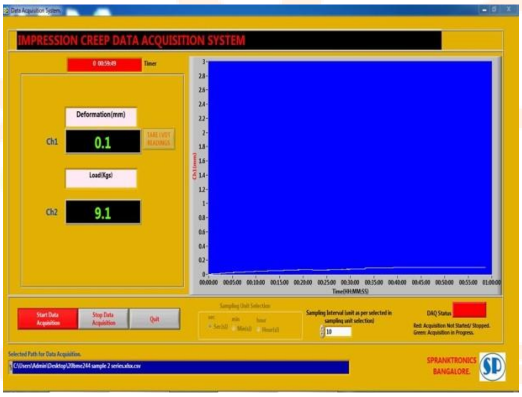

FIG:- 2.7.4 CREEP GRAPH FROM SPECIMEN-3

CREEP GRAPH SPECIMEN – 4

Specimen -4 and creep fig:- 2.7.5 shows a different value with a load of 10kg and the deformation rate would be 0.17 and it sustains with a temperature of 200 °C and the creep rate of 0.17 mm is been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

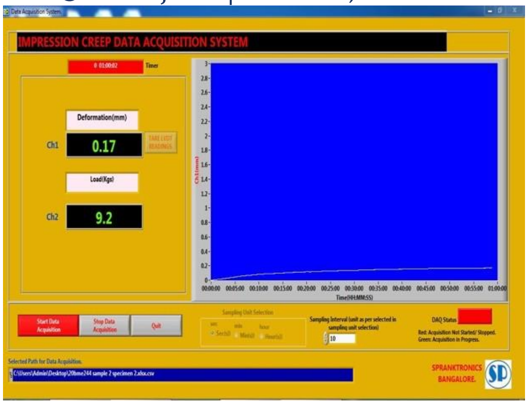

FIG:- 2.7.5 CREEP GRAPH FROM SPECIMEN-4

2.8 WEAR

The table 2.8 below shows the wear test of the component which is tested in wear test machine and they have different values based on their composition and shows the different reading in the machine. Specimen -1 which show the value of 1836 microns in this machine, and Specimen -2 which has a value of 1600 microns and the specimen -3 has a value of 1515 microns. The specimen – 4 has a value of 734 microns which is tested with the wear test machine.

TABLE: - 2.8 WEAR TEST

S.NO	COMPONENTS	CREEP	UNITS
1	Cast Al- 319	1389	Microns
2	Cast Al-356	1650	Microns
3	Al-journal paper	1870	Microns
4	Specimen -1	1836	Microns
5	Specimen -2	1600	Microns
6	Specimen-3	1515	Microns
7	Specimen – 4	734	Microns

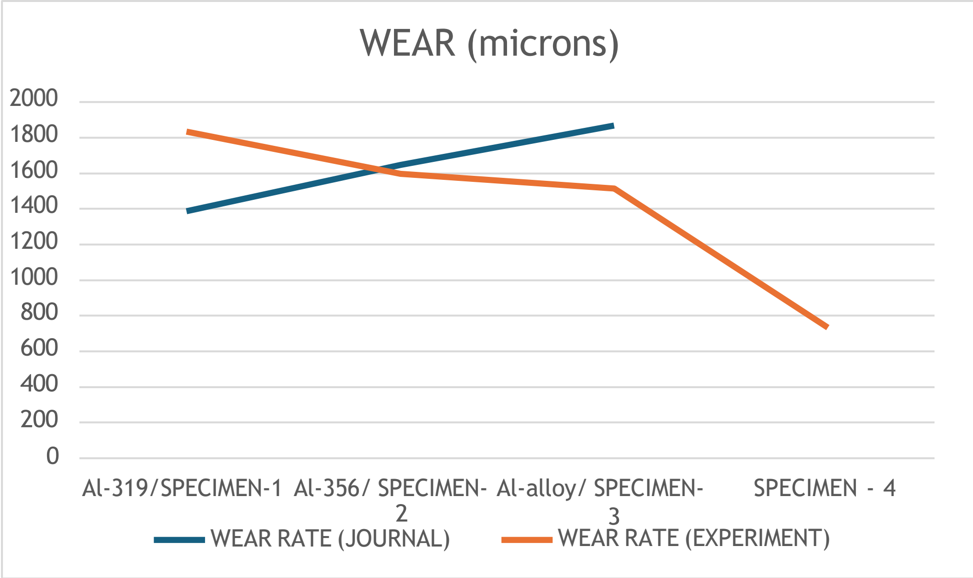

FIG:- 2.8.1 WEAR COMPARISON GRAPH

WEAR GRAPH SPECIMEN – 1

Specimen -1 and wear fig:- 2.8.2 shows a different value with a load of 10N and the wear rate would be 1836 microns and it sustains with a temperature of 40 °C and the creep rate of 1836 microns is been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

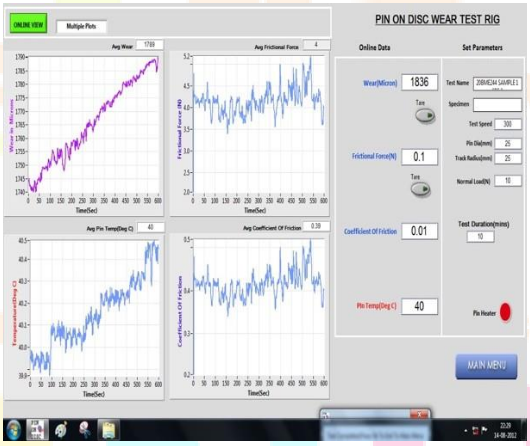

FIG:- 2.8.2 CREEP TEST GRAPH SPECIMEN-1

WEAR GRAPH SPECIMEN – 2

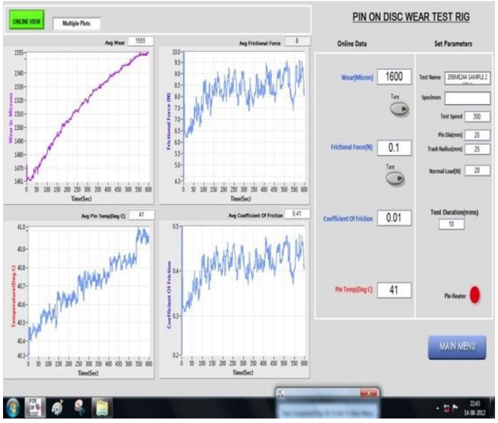

FIG:- 2.8.3 WEAR TEST GRAPH SPECIMEN-2

Specimen -2 and wear fig:- 2.8.3 shows a different value with a load of 10N and the wear rate would be 1600 microns and it sustains with a temperature of 41℃ and the wear rate of 1600 microns is been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

WEAR GRAPH SPECIMEN – 3

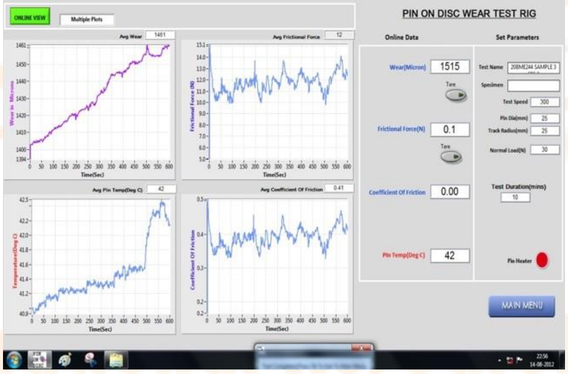

FIG:- 2.8.4 WEAR TEST GRAPH SPECIMEN-3

Specimen -3 and wear fig:- 2.8.4 shows a different value with a load of 10N and the wear rate would be 1515 microns and it sustains with a temperature of 42 ℃ and the wear rate of 1515 microns is been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

WEAR GRAPH SPECIMEN – 4

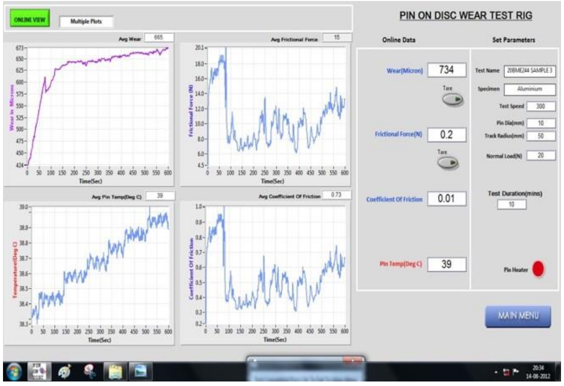

FIG:- 2.8.5 WEAR TEST GRAPH SPECIMEN-4

Specimen -4 and wear fig:- 2.8.5 shows a different value with a load of 10N and the wear rate would be 734 microns and it sustains with a temperature of 39 °C and the wear rate of 734 microns has been removed from the material and it is comparatively higher when compared to Al-319 and A-356.

REFERENCES

[1]. European Aluminium Association (EAA)., 2011, Aluminum Automotive Manual, The Aluminum Inc. 900 19th Street, N.W, Washington DC 20006 www.aluminium.org.

[2]. Torres, R.., Esparza, J.,Velasco, E., García- Luna, S. and Colás, R., 2006,'Characterisation of An Aluminium Engine Block', Int. J. Microstructure and Materials Properties, Vol. 1, No 2, pp.129– 138. 130

[3]. Ghazaly, M. Nouby, Engine Block, Automotive and Tractor Engineering Department, College of Engineering, Minia University, 61111, India, https://www.scribd.com/doc/98724458/case- study- engine block, email. auto@ gmail.com 2011.

[4]. Nguyen, H., Manufacturing Processes and Engineering Materials Used in Automotive Engine Blocks , Materials Science and Engrg (EGR250) Term Paper submitted to School of Engineering of Grand Valley State University, USA, 2005.

[5]. Farag, M. Mahmoud, Materials and Process Selection for Engineering Design, published by CRC Press , 37-41 Mortimer Street, London, England, 3rd Edition, Pages 89-95 B/W ISBN 9781466564091, 2013.

[6]. Manshadi, B.D., Mahmudi, H., Abedian, A. and Mahmudi, R., A Novel Method for Materials Selection in Mechanical Design: Combination of Nonlinear Normalization and A Modified Digital Logic Method, published by Materials and Design, 2007,volume 28, pages 8–15.

[7]. Takur, S., Kiran Kumar, P. and Madhusudhan,T, Selection of Material by Weighted Property Method for Savonius Vertical Axis Wind Turbine Rotor Blade, published by Int. Research Journal of Engineering and Technology.(IRJET). e- ISSN: 2395-0056, ., 2015, Vol: 02 Issue: 01.

[8]. Mohammad, B. N. and Akpan, P. P, Behavior of Aluminum Alloy Castings under Different Pouring Temperatures and Speeds, http://lejpt. Academic direct. org/A, . , 2006.

[9]. vlab.amrita.edu, 2011, Lee's Disc Apparatus from lab.amrita.edu/ ?sub=1& birch=194& sim Copyright @ 2017 under the NME ICT initiative of NHRD.

[10] Ramona, P., Gunther, R., Josef, B., Helmut, A., Peter, J. U and Stefan, P., Property Criteria for Automotive Al-Mg-Si Sheet Alloys, published online by. Multidisciplinary Digital Publishing Institute (MDPI 10.3390/ma7075047, 2014.

[11] S.C Eze, D.S Yawas and E.T Dauda, Comparative Analysis of Some Models of Motorcycle Aluminum Engine Blocks Using Weighted Property Method (WPM). by *S.C Eze, et. al. International Journal of Engineering Research and Applications*, *www.ijera.com*, *June 2022.*

[12] Mohamed Abdelgawad Gebril, Osama M. Irfan on *Metals* 2023, The Microstructural Refinement of the A356 Alloy Using Semi-Solid and Severe Plastic-Deformation Processing.

[13] Francis Breton, Kun Liu, Zhixing Chen on June 2020, Differential Scanning Calorimetry Fingerprints of Various Heat-Treatment Tempers of Different Aluminum Alloys, published on research gate.

[14] sugrib kumar shaha, Sarker Dyuti, ASM international Thermal Spray Conference , on May 2010, Effect of Temperature on Wear Characteristic of Cast Iron by Research Gate.

[15] Hugo F Lopez, Ernesto Rinco, Creep Properties of the As-Cast Al-A319 Alloy: May 2016, Metallurgical and Materials Transactions A 47(8), in Research Gate

[16] S.Ramesh,R. Kolachi, L.Shan, Creep Behavior of A356 Aluminum Alloy Reinforced with Multi- Walled Carbon Nanotubes by Stir Casting Materials 2022, 15(24),8959; https://doi.org/10.3390/ma15248959.