EXPERIMENTAL EVALUATION OF MECHANICAL PROPERTIES OF ALUMINIUM-SILICA ALLOY & STATIC ANALYSIS ON ITS BEARING PERFORMANCE

A Project Report submitted

In partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

In

MECHANICAL ENGINEERING

by

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Autonomous status accorded by UGC & Andhra University

(Approved by AICTE, Permanently affiliated to Andhra University, Accredited by NBA and approved by NAAC with 'A' grade)

SANGIVALASA, VISAKHAPATNAM – 531162

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This is to certify that this report entitled **"Experimental Evaluation of Mechanical Properties of Aluminium-Silica Alloy And Static Analysis on Its Bearing Performance"** has been carried out by **B.Someswar Rao(315126520017), A.Prasanna (315126520007), CH.Nava Teja (315126520034),D.KrishnaChaitanya (315126520036), D.Ramakrishna Saseendra (315126520037)** under the esteemed guidance of **Mr. P.S.V.N.B.Gupta** in partial fulfilment of the requirements of degree of Bachelor of Technology in Mechanical Engineering of Andhra University, Visakhapatnam.

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ABSTRACT

During the last few decades, there has been a rapid increase in the utilisation of aluminium-silicon alloys, particularly in the field of automobile sector due to their high strength to weight ratio, high wear resistance, low density and low coefficient of thermal expansion. Due to the advancements in the field of automobile application, make the study to test their wear and tensile behaviour with utmost importance. In this present investigation, Aluminium based alloys containing 7%,12% and 14% weight of Silicon were synthesized using stir casting method. Compositional analysis and tensile studies of different samples of same composition have shown near uniform distribution of Silicon in the prepared alloys. Study of microstructure has showed the presence of primary silicon. Tensile tests were carried out on universal testing machine. Yield strength and ultimate tensile strength has increased with increase in silicon percentage. Wear behaviour was studied by using computerized pin on disc wear testing machine. The hardness property has been tested on Vickers hardness testing machine which shows the hardness content increases with the increase in silicon content.

Keywords: Al-Si alloy, stir casting, yield strength, tensile strength, wear behaviour, microstructure

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EVALUATION OF MECHANICAL PROPERTIES

CHAPTER 1

INTRODUCTION

1.1 ALLOY

An alloy is a metal made by combining two or more metallic elements,especially to give greater strength or resistance or corrosion. These are defined by the metallic bonding character.An alloy may be the solid solution of metal elements(a single phase) or a mixture of metallic phases(two or more solutions).

The metallic atoms must dominate in its chemical composition and the metallic bond in its crystalline structure. Commonly,all alloys have different properties from those of the component. Making of the alloy gives the material to attain more desirable properties such as increase in the values of hardness and lowering of the melting points. Some of the physical properties such as density and conductivity of an alloy element may not differ greatly from those of its component elements but engineering properties such as tensile strength and shear strength may be considerably different from those of constituent materials.

Mixing the metals together or with non-metals offers many advantages, like these combination of materials can have enhanced hardness,lowering of the melting points and also having a better tensile strength.

Generally there are two main types of alloys which are called as **subsitution alloys** and **interstitial alloys.**

Substitutional alloys are those in which the atoms of the original metal are literally replaced with atoms that have roughly the same size from another material.

Brass for example is a substitutional alloy for copper and zinc.

Interstitial alloys are those in which they mix together with atoms that have different sizes. Atoms are added to the original metal that are much smaller.

Steel for example is created by adding small amount of carbon in between the larger atoms in iron.

Alloys have been widely used tremendously in various applications from long time.

Few widely used applications of alloys are:

- Stainless steel is used in wire and ribbon forms for screening staple,belt,cable,weld and metalizing.
- Alloys of gold and silver are used in the preparation of jewellery.

- Some alloys are functioned as corrosive resistant materials and are used in moisture rich environments.
- High temperature alloys have been used in many aerospace & petrochemical applications.
- Magnetic alloys are used for making magnetic cores and dry reed switches.
- Thermocouple alloys have found a wide range of use in temperature sensing and control
- Alloys are used as thermostat metals,radio and electronic devices, precision devices, precision devices in aircraft coontrols, telecommunications
- Some of the nickel alloys have been used for high temperature sensing elements.
- Some of the alloys are used to produce the internal and external leads.

1.2 ALUMINIUM ALLOY

Aluminium alloys are the alloys in which aluminium is the predominant metal. The typical alloying elements are copper,magnesium,manganese,silicon,tin and zinc.

There are two principal classification in alloys like wrought alloys and casting alloys,both of them are further subdivided into the categories of heat treatable and non heat treatable. About 85% of the alloys is used for wrought products,for example in rolled plate and foils. Cast aluminium alloys yield cost effective products due to the low melting point,although they have high lower tensile strengths than wrought alloys.

In recent years aluminium alloys are widely used in automotive industries. This is particularly due to the real need to weight saving for more reduction of fuel consumption. The typical alloying elements are copper,magnesium,manganese,silicon and zinc. Surfaces of these aluminum alloys have a brilliant lustre in dry environment due to the formation of a shielding layer of aluminium oxide. Aluminium alloys of the 4xxx,5xxx and 6xxx series containing major element additives of Mg and Si, are now being used to replace steel panels in various automobile industries.

1.3 DESIGNATION AND PROPERTIES OF ALUMINIUM ALLOYS

The intenrnational alloy designation system accepted the naming scheme for the wrought alloys in which each alloy is given a four digit number,where the first digit indicates the major alloying elements, the second digit if different from zero indicates a variation of the alloy,and the third and fourth digit indicates the specific alloy in the series.

Alloy	Main alloying elements	Applications
1xxx	Mostly 99% pure aluminium	Electrical and chemical industries
2xxx	Copper	Aerospace applications
3xxx	Manganese	Architecture
4xxx	Silicon	Welding rods and automobile parts
5xxx	Magnesium	Marine applications
6xxx	Magnesium and silicon	Architectural extrusions
7xxx	Zinc	Aircraft components
8xxx	Some other elements like lithium,nickel,iron	Electrical wires

Table 1.1: designation of aluminium alloys

The major advantages of using aluminium is due to its remarkable properties which are listed below:

- Aluminium has a density around one third that of steel and is used advantageously in applications where high strength and low weight is required.
- When the surface of aluminium is exposed to air, a protective oxide coating is formed which is resistant to corrosion.
- Aluminium is an excellent conductor of both heat and electricity,its conductivity is around twice to that of copper.
- Aluminium is non-toxic but also does not release any odours when it is in contact.

1.4 ALUMINIUM-SILICON ALLOY:

Aluminium-Silicon alloys are of greater importance to engineering industries as they exhibit high strength to weight ratio, high wear resistance, low density, low coefficient of thermal expansion etc.

Silicon imparts high fluidity and low shrinkage, which result in good castability and weldability. Al-Si alloys are designated 4xxx alloys according to the Aluminium Association Wrought Alloy Designation System.

The major features of the 4xxx series are:

a. Heat treatable

b. Good flow characteristics, medium strength

c. Easily joined, especially by brazing and soldering

There are two major uses of the 4xxx series for forging and weld filler alloy. These both applications are due to the excellent flow characteristics provided by relatively high silicon content.

Effects of silicon in the Al-Si alloys are as follows:

1. Thermal expansion is reduced substantially by silicon
2. Magnetic susceptibility is only slightly decreased by silicon
3. The lattice parameter is decreased slightly by silicon
4. Machinability is poor because of the hardness of the silicon

Although many investigations exist in literature and based on the above discussion, it is evident that there is enough scope for further research of Al-Si alloys especially their mechanical properties. Therefore the objectives of this study are:

1. Preparation of Al-Si alloys of hypo and hyper eutectic compositions.
2. To study of their microstructure.
3. To study of their mechanical properties.

4. To evaluate their wear behaviour.

1.5 BEARING

A bearing is a machine element that constraints relative motion to only the desired motion,and reduces friction between moving parts. The design of the bearing may,for example,provide for free rotation around a fixed axis or it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts.

These bearings are classified into two types **ball bearing** and **roller bearing** according to their occurrence. Lubrication is often provided to reduce the friction between the moving parts. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency,reliability,durability and performance.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE 1

ALUMINIUM[1]

Alumimium has contributed very significantly as a versatile material in the development of technology. Because of some unique chaarcteristics, aluminium has substituted much older and established materials like wood,copper,iron and steel. On volumetric basis, more aluminium is consumed than all the other non-ferrous materials including copper and its alloys as well as lead,tin and zinc.

The best known characteristic of aluminium is its light weight,the density being about one third that of the steeel or copper alloys. Certain aluminium alloys have a better stregth to weight ratio than that of high strength steels. Aluminium has good malleability and formability,high corrosion resistance and high electrical conductivity.

Aluminium is nontoxic nonmagnetic and non sparking. The nonmagnetic characteristic makes aluminium useful for electrical shielding purposes such as bus-bar housings or enclosures for other electrical equipment.

Due to the exciting range of physical properties of aluminium and aluminium alloy, this group of metals is extensively used for wide range of industrial applications. The important sectors include transportation,building and architecture,containers and packing, household,aerospace etc.

2.2 LITERATURE 2

ALUMINIUM ALLOYS AND THEIR USES[2][3][4]

Aluminium alloys are distinguished according to their major alloying elements. The 4xxx group contains silicon as the main alloying element for ease of casting. Silicon is good in metallic alloys.

This is because it increases the fluidity of the melt, reduces the melting temperature, decreases the shrinkage during solidification and is very inexpensive as a raw material.

Silicon also has a low density (3.24 g cm^{-3}), which may be an advantage in reducing the total weight of the cast component. Silicon has a very low solubility in aluminium it therefore precipitates as virtually pure silicon, which is hard and hence improves the abrasion resistance.

Aluminium-silicon alloys form a eutectic at 12.6 wt% silicon, the eutectic temperature being 577°C. This denotes a typical composition for a casting alloy because it has the lowest possible melting temperature. Once high Si content is alloyed into Al, it adds a large amount of heat capacity that must be removed from the alloy to solidify it during the casting operation.

USES:

- Recent examples of aluminium applications in vehicles cover, power trains, chassis, body structure and air conditioning.
- The material for engine blocks, which is one of the heavier parts, is being switched from cast iron to aluminium resulting in significant weight reduction.
- Aluminium castings find the most widespread use in automobile. In automotive power train, aluminium castings have been used for almost 100% of pistons, about 75% of cylinder heads, 85% of intake manifolds and transmission(shafts).
- For chassis applications, aluminium castings are used for about 40% of wheels, and for brackets, brake components, suspension, steering components and instrument panels.

2.3 LITERATURE 3

MICROSTRUCTURE[5][6]

Binary Al-Si alloys, in the unmodified state, near to the eutectic composition exhibit a circular or lamellar eutectic silicon which is in the form of large plates with sharp sides and edges. Al-Si alloys containing more than about 12% Si exhibit a hypereutectic microstructure normally containing primary silicon phase in a eutectic matrix. Cast eutectic alloys with coarse circular silicon show low strength and ductility because of the coarse plate-like nature of the Si phase that leads to premature crack initiation and fracture in tension. Similarly, the primary silicon in normal hypereutectic alloys is usually very coarse and imparts poor properties to these alloys. Therefore, alloys with a predominantly eutectic structure must be modified to ensure adequate mechanical strength and ductility. It is widely recognized that the Group IA and IIA elements (Na, Mg, Ca, Sr) are effective modifiers of Al-Si eutectic; only sodium and strontium, however, have been used extensively in the commercial production of these alloys. Refinement of primary silicon is usually achieved by the addition of phosphor to the melt. It is also reported that rare earth metals are also capable of modifying the eutectic structure of cast aluminium-silicon alloy. Fig shown below are the microstructures of different Al-Si alloys.

2.4 LITERATURE 4

EFFECT OF GRAIN REFINER[7][8]

Hyper–eutectic alloys containing aluminium and silica have a huge portion of primary α-Al in their microstructure. An unmodified Al-Si alloy has a large,brittle flakes of silicon ,which result in poor ductility to the casting. Modifiers are added to eutectic and hypo-eutectic Al-Si alloys to refine the eutectic Si phase from angular platelets to fine fibres. This change in microstructure results in an additional development in the mechanical properties.

The quality of the castings can be enhanced by grain refinement which decreases the size of primary α-Al grains in the castings, which else solidifies with a coarse,columnar grain structure. A fine equiaxed structure has many advantages like improved mechanical properties,better feeding during solidification, reduced and more evenly distributed shrinkage porosity. Better dispersion of second phase particles, better surface finish and other desired properties. Al-Ti master alloys such as Al-3Ti and Al-5Ti-1B alloys can be used for grain refinementof aluminium-silicon alloy.

2.5 LITERATURE 5:

PHASE DIAGRAM[9][10]

Aluminium-Silicon (Al-Si) casting alloys are the most useful of all common foundry cast alloys in the fabrication of pistons for automotive engines.

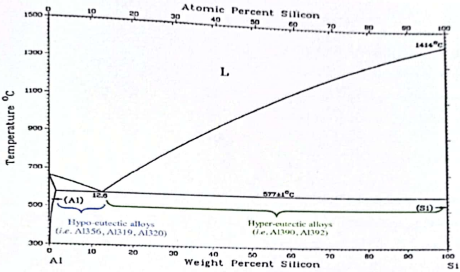


Fig2.1: Al-Si phase diagram

Depending on the Si concentration in weight percentage, the Al-Si alloy systems are divided into three major categories:

1. Hypoeutectic (<12 wt %Si)
2. Eutectic (12-13 wt % Si)
3. Hypereutectic (14-25 wt% Si)

CHAPTER 3

DESCRIPTION OF MATERIALS

The aluminium material is first placed in a crucible and then it is placed in the stir casting setup. Then after sometime aluminium starts to melt since it reaches its melting point. Then the amount of silica in the form of percentages should be added to the aluminium metal to form aluminium alloy. The percentages of silicon are 7%,12%,14% which was added to 250gms of aluminium.

3.1 STIRCASTING:

The setup consists of a long hollow furnace in which the material with the crucible is placed and this furnace allows uniform heating to the crucible. The material is heated in the crucible and starts to change its phase from solid to liquid. In this setup stirring is done with the help of the motor. The motor which is connected to the stirrer starts to rotate the stirrer. Once the entire process is ready the material is removed from the furnace and pour into the mould in order to obtain the desired shape.

It is the economical process for the fabrication of aluminium matrix alloys. There are many parameters which will effect the final, microstructure and mechanical properties of the alloy

Fig 3.1: stir casting setup

The materials which can be taken will be of the following form

Sl no	Material	Aluminium(gms)	Silicon(gms)
1	Al - 7% Si	250	18.8
2	Al - 12% Si	250	34.1
3	Al - 14% Si	250	40.7

Table 3.1: Material description

After pouring the metal into the mould, then they are subjected to cooling to become solid and then they are taken for the following tensile, hardness tests and by using the mathematical formulas the following properties like hardness, ultimate tensile and yield strength for the material is considered. The same process is done for all the three specimens and their values are noted.

CHAPTER 4

TESTS PERFORMED ON SPECIMENS

4.1 TENSILE TEST:

Tensile test is a standard engineering procedure to characterize properties related to mechanical behavior of materials. It gives the response of properties of material during loading conditions.

The engineering tensile test is also known as tension test which is widely used for providing base of the design information on strength of material. Under the pulling type of load, its strength and elongation can be found out. A good tensile profile is obtained until the material breaks and this curve is known as stress-strain curve.

The machine used for conducting the tensile test is Universal Testing Machine. It is a hydraulic testing machine provides bath load controlled and displacement control machine. In UTM top cross head can be adjusted to three positions for extended tensions tests. There are two main hand wheel controls, one for applying and other for releasing the load.

Fig4.1: Universal testing machine

The loading valve is designed in a manner that at any setting, needed for applying incremental loads quickly, for holding loads steady and for removing the loads. Specimens are attached to a movable grip and to a fixed side of the

The test specimens can be manufactured in various ways to mate to various grips in testing machine. The load is gradually increased to a certain value until the specimen undergoes fracture. During this process, ultimate point, yield point and breaking point is noted. As the process is going on ,the elongation of gauge section is recorded against applied force. The elongation measurement is used to calculate the engineering strain(ἑ). The applied force measurement is used to calculate the engineering stress(σ). For most materials, the initial portion of the test will exhibit a linear relationship between the applied force or load and the elongation exhibited by the specimen. In this linear region, the line obeys the relationship defined as "Hooke's Law" where the ratio of stress to strain is a constant. E is the slope of the line in this region where stress is directly proportional to the strain and is called "Modulus of Elasticity" or "Young's Modulus".

$$E = \sigma/\acute{\varepsilon}$$

σ = Engineering stress in N/mm^2(ratio of force and area)

ἑ = Engineering strain (ratio of change in length and original length)

E = Youngs modulus in N/mm^2

Major applications of tensile testing in various sections like Aerospace,automotive,medical device,pharmaceuticals,textile industry and so on.

4.2 HARDNESS TEST:

The hardness test is a mechanical test for material properties which are used in engineering design, analysis of structures, and materials development. The main purpose of hardness test is to determine the suitability of a material for a given application.

Hardness is defined as the resistance of a material to permanent deformation such as indentation, wear, abrasion, scratch. Generally, the importance of hardness testing has to do with the relationship between hardness and other properties of material. This is, because both the tensile test and hardness test measure the resistance of a metal to plastic flow, and results of these tests may closely parallel each other.

Hardness testing currently classified into two categories:

1. macro hardness
2. micro hardness

The macro hardness refers to testing with applied loads on the indenter of more than 1kg whereas the micro hardness refers applied loads of 1kg and below.

We are performing the Vickers hardness test which belongs to the macro hardness test. The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with square base and an angle of 136 degrees. The maximum load applied is between the ranges of 1 to 100kgf.

Fig 4.2: Vickers hardness test

The full load is applied for 10 to 15 seconds. The two diagonals of the indentation left on the surface of the material after removal of the load are measured using microscope and their average calculated. The area of the sloping surface of the indentation is calculated. The Vickers hardness is the quotient obtained by dividing the load by the square mm area of indentation.

$$HV = \frac{1.854 * F}{D^2}$$

F = Load =5kgf

D = Arithmetic mean of the two diagonals, D1 and D2 in mm

HV= Vickers hardness

The advantages of the Vickers hardness test are that extremely accurate readings can be taken, and just one type of indenter is used for all types of metals and surface treatments. Very precise for testing the softest and hardest of materials, under varying loads, but it is more expensive than the other hardness testing machines.

4.3 WEAR TEST:

Computerized Ducom friction and wear monitor pin on disc wear test machine was used for the wear test. The rotating disc was made of carbon steel of diameter 50 mm and hardness of 64 HRC. The Al-7%Si, Al-12%Si and Al-14%Si samples were held stationary and a required normal load was applied through a lever mechanism. The tests were carried out by varying one of the following three parameters and keeping other two constants:

1. applied load (20 N, when constant)
2. sliding speed (20 rpm, when constant)
3. sliding distance (1256 m, when constant)

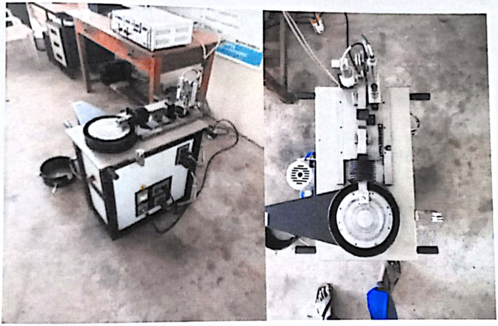


Fig 4.3: wear monitor pin disc on wear test machine

No lubricant is used as test is carried out in dry conditions. Care has been taken that the specimens under test are continuously cleaned with woollen cloth to avoid the entrapment of wear debris and to achieve uniformly in experiential procedure. Scanning electron microscopy was used to analyse the morphology of the worn surfaces of sample.

The wear tests of Al-Si alloys were carried out with varying applied load, sliding speed and sliding distance. The results are obtained from the series of tests which is done by keeping two parameters out of the three (sliding distance, sliding speed and load) constant against wear.

i. Load vs. wear

ii. Sliding speed vs wear

iii. Sliding distance vs wear

4.4 OPTICAL MICROSCOPY:

Microstructures of the alloy samples were observed under computerized optical microscope. The Al-Si samples of different weight composition were mechanically polished using standard metallographic techniques before the examination.

Characterization is done in etched conditions. Etching was done using the Keller's reagent(1 volume part of hydrofluoric acid(48%),1.5 volume part of hydrochloric acid, 2.5 volume parts of nitric acid and 95volume parts of water). The microstructures of the samples were obtained.

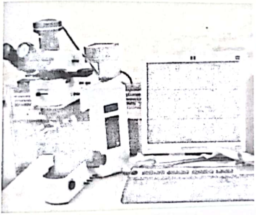


Fig 4.4: Computerised optical microscope

CHAPTER 5

EXPERIMENTAL OBSERVATIONS

5.1 TENSILE TEST:

The tensile test is done by placing the specimen in between the two jaws and certain tensile load is applied on the specimen and the readings of ultimate tensile strength and yield strength are noted.

The same experiment is carried on the three different samples and the corresponding values are noted. For high accuracy the experiment is carried out for two specimens of same sample.

SAMPLES	UTS of Sample 1 (In MPa)	UTS of Sample 2 (In MPa)	Average UTS (In MPa)
Al - 7% Si	160.97	161.87	161.42
Al 12% Si	163.21	163.71	163.46
Al 14% Si	172.13	170.38	171.255

Table 5.1: ultimate tensile strength

Samples	YS of Sample 1 (In MPa)	YS of Sample 2 (In MPa)	Average YS (In MPa)
Al - 7% Si	41.3	45.5	43.4
Al 12% Si	48.7	50.6	49.65
Al 14% Si	61	62.5	61.75

Table 5.2: yield strength

From the load and elongation values, obtained from the universal testing machine, corresponding engineering stress and engineering strain were calculated and plotted to get stress vs. strain curves for different samples of Al-7% Si, Al-12% Si and Al-14% Si alloys.

Samples	Total Elongation of Sample 1 (In %)	Total Elongation of Sample 2 (In %)	Average Total Elongation (In %)
Al - 7% Si	22.72	24.912	22.816
Al 12% Si	9.544	9.816	9.68
Al 14% Si	10.848	9.448	10.418

Table 5.3: elongation obtained

GRAPHS:

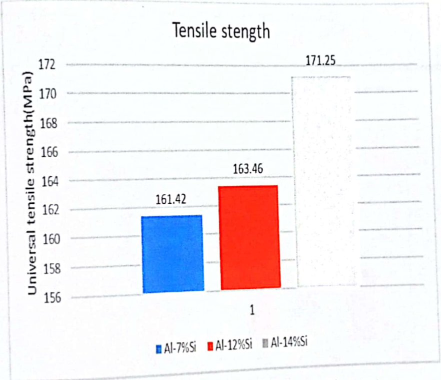


Fig 5.1: ultimate tensile strength vs Al-Si content

From the above graph we can understand that the ultimate strength of the alloy increases with the increase in the value of silicon content.

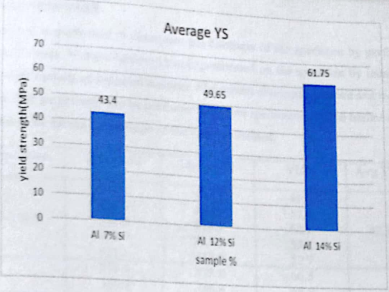


Fig 5.2: yield strength vs Al-Si content

From the above graph we can understand that the yield strength of the alloy increases same as of ultimate strength with the increase in the value of silicon content.

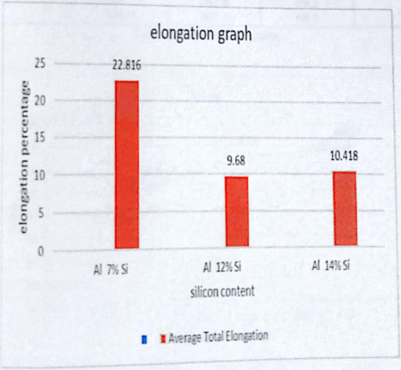


Fig 5.3: elongation vs Al-Si content

5.2 HARDNESS TEST

Hardness test is performed to determine the hardness of the specimen by performing the hardness tests. Vickers hardness test is performed on the specimen by indentation process with the help of diamond indenter. The results obtained are noted and the graph is drawn. The experiment can be performed on more specimens and the hardness value can be taken by taking the average of the values obtained.

Composition	D_1(in µm)	D_2(in µm)	VHN	Avg VHN
Al-7% Si	431.6 421.5 425.6 418.7 421.3	430.5 416.6 418.3 415.9 417.6	49.9 52.8 52.1 53.2 52.7	52.14
Al-12%Si	371.8 369.4 376.9 373.6 376.3	375.0 386.4 378.8 375.8 378.1	66.5 64.9 64.9 66.0 65.2	65.5
Al-14% Si	367.3 359.3 362.4 369.7 368.9	370.4 362.9 365.3 367.8 369.1	68.2 71.1 70.0 68.2 68.1	69.12

Table 5.4: hardness results

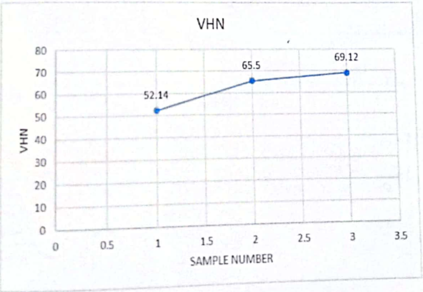


Fig 5.4: Vickers hardness number

5.3 WEAR TEST:

Samples	Load (KN)	Wear (µm)		
		Al 7% Si	Al 12% Si	Al 14% Si
Sample I	10	83.45	35.44	19.29
Sample II	20	108.79	50.5	35.13
Sample III	30	155.44	107.77	74.88

Table 5.5: Load vs wear at different loads

Samples	Sliding Speed (rpm)	Wear (µm)		
		Al 7% Si	Al 12% Si	Al 14% Si
Sample I	10	64.44	50.5	37.55
Sample II	20	86.62	69.77	60.48
Sample III	30	124.11	114.74	100.79

Table 5.6: Sliding speed vs wear at different sliding speeds

Samples	Sliding Distance (mm)	Wear (µm)		
		Al 7% Si	Al 12% Si	Al 14% Si
Sample I	1256	135.58	124.38	117.48
Sample II	1884	152	141.21	135.06
Sample III	2512	198.42	182.43	163.51

Table 5.7: Sliding dist vs wear at different sliding distance

Fig 5.5: Load vs wear

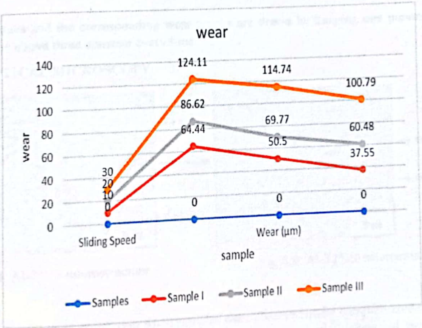


Fig 5.6: Sliding speed vs wear

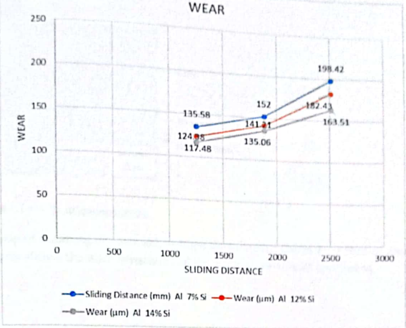


Fig 5.7: Sliding distance vs wear:

The values and the corresponding wear graphs are drawn by keeping one parameter from the above three constant every time.

5.4 OPTICAL MICROSCOPY:

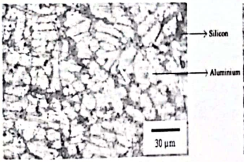


Fig 5.8: Al-7%Si microstructure

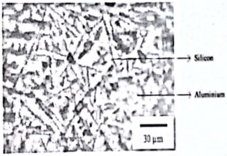


Fig 5.9: Al-12%Si microstructure

The microstructure of different Al-Si samples were observed under computerized optical microscope and the distribution of silicon and aluminium were observed and also observed the presence of primary silicon in the Al-14%Si sample

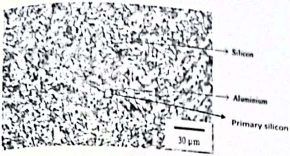


Fig 5.10: Al-14% Si microstructure

With the help of scanning electron microscope the microstructures were studied and the above figures shows the microstructures of the aluminium-silicon specimens.

DESIGN OF BEARING

CHAPTER 6

SOLID WORKS

6.1 INTRODUCTION:

The solidworks CAD software is a mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions and produce models and detailed drawings.

6.2 SOLIDWORKS FUNDAMENTALS:

6.2.1 CONCEPTS:

Parts are the basic building blocks in the solidworks software. Assemblies contain parts or other assemblies, called sub-assemblies. A solidworks model consists of 3D geometry that deflects its edges ,faces, and surfaces. The solidworks software lets you design models quickly and precisely. Solidworks models are:

- Defined by 3D design
- Based on components

3D Design:

Solidworks uses a 3D design approach. As it is designed a part, from the initial sketch to the final result, it create a 3D model. From this model, it can create 2D drawings or mate components consisting of parts or sub assemblies to create 3D assemblies.

It can also create 2D drawings of 3D assemblies. When designing a model using solidworks, it can visualize it in the three dimensions, the way the model exists once it is manufactured.

Component Based:

One of the most powerful features in the solidworks application is that any change you make to a part is reflected in all associated drawings or assemblies.

- Origin: Appears as two blue arrows and represents the (0,0,0) coordinates of the model. When a sketch is active , a sketch origin appears in red and represents the (0,0,0) coordinate of the sketch.
- Plane: It can use planes for adding a 2D sketch, section view of a model, or a neutral palne in a draft feature.

- <u>Axis</u>: Straight line used to create model geometry, features or patterns. It can create an axis in different ways, including intersecting two planes. The solidworks application creates temporary axes implicitly for every conical or cylindrical face in a model.
- <u>Face:</u> Boundaries that help define the shape of a model or a surface. A face is a selectable area (planar or non-planar) of a model or surface.
- <u>Edge:</u> Location where two or more faces intersect and are joined together.
- <u>Vertex:</u> Point at which two or more lines or edges intersect. You can select vertices for sketching and dimensioning.

User Interface:

The solidworks application includes user interface tools and capabilities to help you create and edit models efficiently.

The entire solidworks modelling depends on the following processes:

1) Part model
2) Assemly
3) Drawing

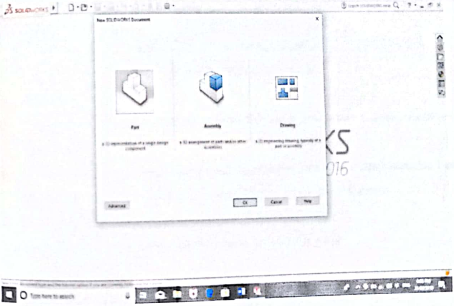


Fig 6.1: feature manager design tree

- Property manager:

  Provides settings for many functions such as sketches, fillets and also the assembly mates.

- Configuration manager:

  lets to create, select and view multiple configurations and assemblies in a document.

- Toolbars:

  It can access solidworks functions using toolbars. Toolbars are organised by functions, for example, the sketch or assembly toolbar. Each toolbar comprises individual icons for specific tools, such as rotate view, circular pattern and circle

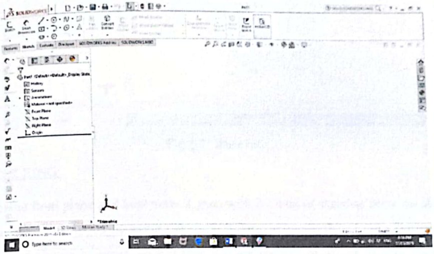


Fig 6.2: workspace of solidworks

- Sketches:

  Create the sketches and decide how to dimension and where to apply relations.

- Features:

  _Select the appropriate features,such as extrudes and fillets, determine the best features to apply, and decide in what order to apply those features.

6.2.2 PART DESIGN:

The bearing preparation involves the following four major parts :

1) Inner ring
2) Outer ring
3) cage
4) roller

INNER RING:

Select the front plane and kept normal ,then with the help of sketcher draw the sketch of the inner ring in 2D by using the circle ,fillet commands. Make sure that correct dimension should be provided and then extrude the part in 3D by exiting from the sketch then save the body as inner ring.

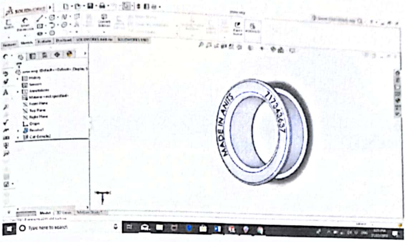


Fig 6.3: inner ring

OUTER RING:

Select the front plane and kept normal ,then with the help of sketcher draw the sketch of the outer ring in 2D by using the circle ,fillet commands. Make sure that correct dimension should be provided and then extrude the part in 3D by exiting from the sketch then save the body as outer ring.

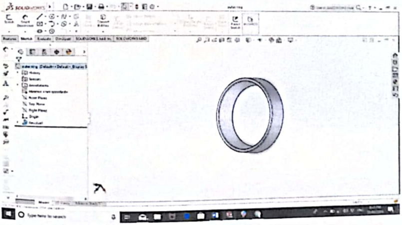


Fig 6.4: outer ring

CAGE:

Select the front plane and make it as normal. Draw the 2D view of the cage according to the dimension and then extrude it. Now with the help of extruded cut remove the place for the seating of roller

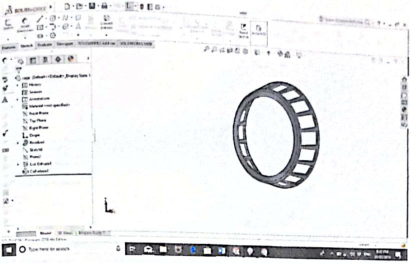


Fig 6.5: cage

ROLLER:

Select the front plane and make it as normal and then draw a circle in 2D and then extrude to obtain 3D. Then apply fillet command over the edges and name it as roller.

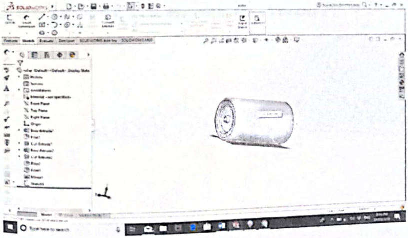


Fig 6.6: roller

6.2.3 ASSEMBLY:

The parts which were made individually is brought into assembly to obtain the final assembly of the bearing. This assembly is carried out by doing proper mates between the parts and also should use the correct mates at correct time.

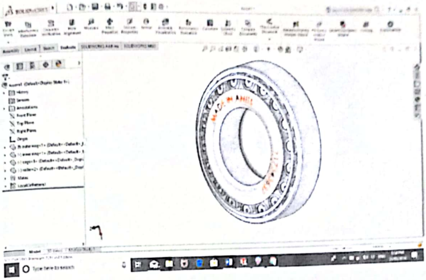


Fig 6.7: bearing

6.3 CONVERSION OF FILE:

The file of the bearing which was saved in solidworks document form should be converted to IGES form for carrying the proper analysis on the bearing. This file which was saved in IGES format can be imported to ANSYS for proper analysis.

ANALYSIS OF BEARING

CHAPTER 7

ANSYS

7.1 INTRODUCTION TO ANSYS:

ANSYS workbench is the framework upon which the industry build advanced engineering simulation technology is built. The ANSYS workbench platform automatically forms a connection to share the geometry for both the fluid and structural analysis, minimizing data storage and making it easy to study the effects of geometry changes on both analysis. In addition, a connection is formed to automatically transfer pressure loads from the fluid analysis to the structural analysis.

The ANSYS workbench interface is arranged into two primary areas: the toolbox and the project schematic. The toolbox contains the system templates that you can use to build a project. The project schematic is the area if the interface where you will manage your project. The new project schematic view shows an overall view of the entire simulation of the project. You can also use context menus, accessible via a right mouse click on schematic items, and cells. Context menus provide capabilities to add to and modify projects. The entire process is persistent. Changes can be made to any portion of the analysis and the ansys workbench platform will manage the execution of the required applications to update the project automatically, dramatically reducing the cost of performing design iterations.

ANSYS Workbench features:

- Bidirectional, parametric links with all major CAD systems.
- Integrated, analysis-focused geometry modeling, repair and simplification via ANSYS design modeller.
- Highly automated, physics-aware meshing
- Automatic contact direction
- Unequalled depth of capabilities within individual physics disciplines
- Unparalleled breadth of simulation technologies.
- Complete analysis systems that guide the user start to finish through an analysis.
- Comprehensive multi physics simulation with drag and drop ease of use.
- Complex project schematics can be saved for reuse.
- Automated what-if analyses with integrated design point capability.

STRUCTURAL ANALYSIS:

Structural analysis is probabaly the most common application of the finite element method. The term structural implies not only civil engineering structures such as bridges and buildings but also naval, aeronautical and mechanical structures such as ship hulls, aircraft bodies and machine housings as well as mechanical components such as pistons, machine parts like gears ,bearing and tools.

STATIC ANALYSIS:

Used to determine displacements, stresses etc,under static loading conditions. It comprises both linear and non linear static analysis. Non linearity can include plasticity, stress stiffening , large deflection, large strain, hyper elasticity contact stiffness and creep.

7.2 APPLYING MATERIAL:

The aluminium-silcon alloy with different percentages of silicon produces different values of mechanical properties and these values are added to the bearing and then the design analysis is carried out. The values of density, youngs modulus, poisons ratio and the tensile and compressive strengths are considered and the analysis should be carried out.

7.3 MODEL GENERATION AND MESHING:

The model which was generated in solidworks is converted into IGES file and is imported in the geometry. The body is generated and the design modeller is closed.

Then meshing is carried on the model in which the object is divided into several elements which makes the results to obtain accurately.

The mesh is generated by right clicking on the mesh and then click on generate mesh ,this provides generation of meshing on the model.

The meshing is divided into the following three types:

1. Coarse
2. Medium
3. Fine

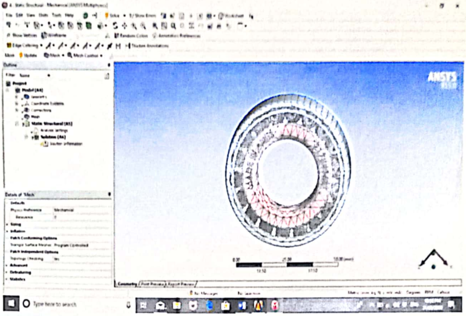


Fig 7.1: meshing

7.4 ANALYSIS:

The bearing is to provided with some fixed support and the magnitude of the load should be provided. Then the load which is acting should be given a particular direction so as to give the desired values of output.

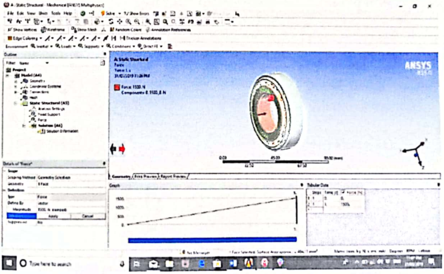


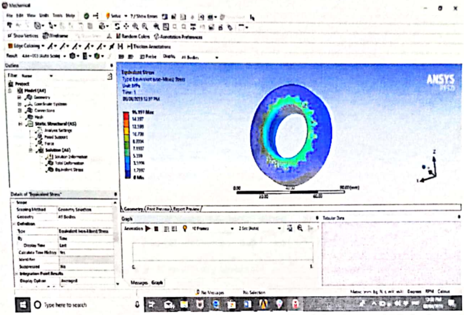
Fig 7.2: load applied

CHAPTER 8

STATIC ANALYSIS

8.1 STRESS ANALYSIS:

The bearing is evaluated for different specimens containing variable percentage of silica in Al-Si alloy and the Von-Mises stresses are calculated by solving the problem.



Details of "Equivalent Stress"

Scope

Scoping Method: Geometry Selection

Geometry: All Bodies

Definition

Type: Equivalent (von-Mises) Stress

By: Time

Display Time: Last

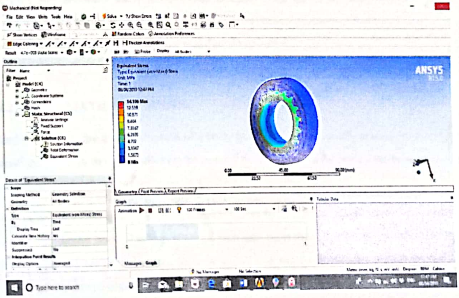
Calculate Time History: Yes

Suppressed: No

Integration Point Results

Display Option: Averaged

Fig 8.1: Von-Mises stress for Al-Si 7%sample



Details of "Equivalent Stress"

Scope

Scoping Method: Geometry Selection

Geometry: All Bodies

Definition

Type: Equivalent (von-Mises) Stress

By: Time

Display Time: Last

Calculate Time History: Yes

Suppressed: No

Integration Point Results

Display Option: Averaged

Fig 8.2: Von-Mises stress for Al-Si 12%sample

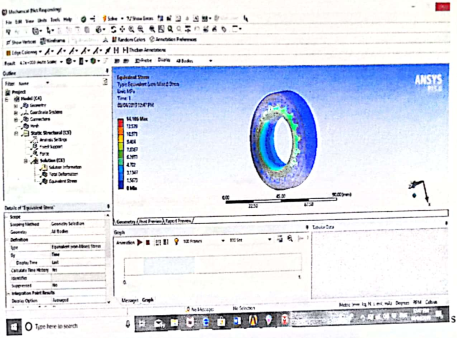


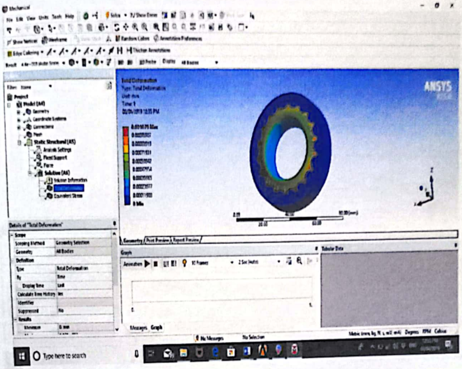
Fig 8.3: Von-Mises stress for Al-Si14% sample

Equivalent stresses are also called Von-Mises stresses used in design work because it allows any arbitrary three dimensional stresses state to be represented as a single positive stress value. Equivalent stress is a part of the maximum equivalent stress failure theory used to predict the yielding in a ductile material.

8.2 DEFORMATION RESULTS:

Deformation is the transformation of a body from a reference configuration to a current configuration. A deformation may be caused by external loads, body forces or changes in temperature, chemical reactions etc.

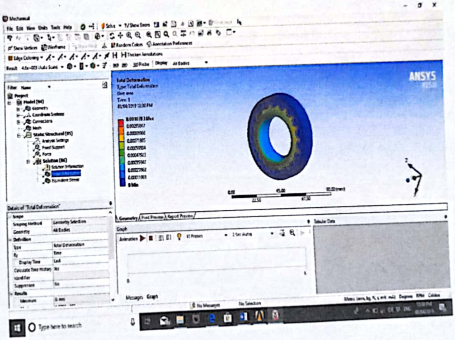
In a continuous body, a deformation field results from a stress field induced by applied forces inside the body. Deformations which can be removed after the stress field has been removed are called elastic deformations and the deformations which cannot be removed are called plastic deformations.



Details of "Total Deformation"

- Scope
  - Scoping Method: Geometry Selection
  - Geometry: All Bodies
- Definition
  - Type: Total Deformation
  - By: Time
  - Display Time: Last
  - Calculate Time History: Yes
  - Identifier:
  - Suppressed: No
- Results
  - Minimum: 0 mm

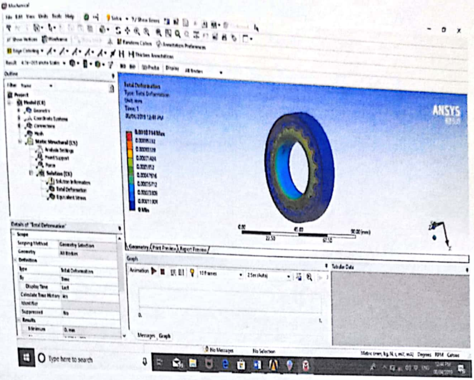
Fig 8.4: Total deformation for Al-Si7% sample



Details of "Total Deformation"

- Scope
  - Scoping Method: Geometry Selection
  - Geometry: All Bodies
- Definition
  - Type: Total Deformation
  - By: Time
  - Display Time: Last
  - Calculate Time History: Yes
  - Identifier:
  - Suppressed: No
- Results
  - Minimum: 0 mm

Fig 8.5: Total deformation for Al-Si12% sample



Details of "Total Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	0. mm

Fig 8.6: Total deformation for Al-Si14% sample

CHAPTER 9

CONCLUSIONS

The conclusions drawn from the conducted investigations are as follows:

1. Yield strength increases with the increase of weight percentage of silicon.
2. Ultimate tensile strength increases with the increase of weight percentage of silicon.
3. Total elongation decreases with the increase of weight percentage of silicon.
4. Hardness of the Al-Si composite increases with the increase in amount of silicon present.
5. The weight loss due to wear decreases when the percentage of silicon increases.
6. The maximum stress will be generated for Al-Si7% sample than the other two samples in the designed bearing.
7. The total deformation will be maximum for Al-Si7% sample than the other two samples in the designed bearing.

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