PREDICTION OF MECHANICAL PROPERTIES OF ALUMINIUM ALLOY

A PHASE II REPORT

Submitted by

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In partial fulfillment for the award of the degree of

MASTER OF ENGINEERING IN

CAD/CAM ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SIR ISSAC NEWTON COLLEGE OF ENGINEERING AND TECHNOLOGY, PAPPAKOVIL.

ANNA UNIVERSITY, CHENNAI

DECEMBER 2018

ANNA UNIVERSITY, CHENNAI

BONAFIDE CERTIFICATE

Certified that this Thesis titled **“PREDICTION OF MECHANICAL PROPERTIES OF ALUMINIUM ALLOY ”** is the bonafide work of **CHRISTOPHER S (821717402005)** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ACKNOWLEDGEMENT

At the outside I think the almighty for his showers of blessings and his divine help with enables me to complete the project successfully.

I extend my sincere thanks to **Mr.T.ANANTH M.B.A.,** Chairman, Sir Issac Newton College of Engineering and Technology, for offering the means of attending my most cherished goal.

I extend my deepest gratitude to principal **Dr.G. GIFTSON SAMUEL M.E., Ph.D.,** Sir Issac Newton College of Engineering and Technology, for giving permission to do the project work successfully.

It gives immense pleasure to extend my sincere and heartful thanks to our head of the department **Mr. P.MALAISELVARAJA M.E.,** Assistant professor, Department of mechanical engineering, for his encouragement of appreciation, untiring patience, steadfast,inspiration and valuable help for the successful completion of the project.

I record my sincere and deep sense of gratitude to my project coordinator and my supervisor, **Mr. K.VEERAPANDIAN, M.E.,**Assistant professor, Department of Mechanical Engineering for his guidance and encouragement, which has held me a lot in completing this project successfully.

I also extend my sincere thanks to staff members of mechanical engineering department. I am extremely thankful to my parents for enlighten me by providing professional education and for their prayerful support that makes me to complete the project successfully

S CHRISTOPHER

ABSTRACT

The usage of aluminum based composite is increasing day by day in the entire manufacturing sectors due to their unique properties such as high strength to weight ratio, good mechanical properties and better durability. Subsequently a lot of research has taken place in aluminum composite material with addition of carbides based particulate reinforcement. But in the present competitive market, the manufacturing sectors seek for the better properties, manufacturing easy nature and eco-friendly based materials. It's observed that there is tremendous research gap for excellent properties improvement and eco-friendly materials. This present study gives sump-up of the latest developments taken place in aluminum based composite and other particulate reinforcement effects. The tribologoical behavior of aluminum based composite has been covered. This study is focused on AA6061 and AA7075 alloy due to commercial easy available and it's widely used for structural purpose in manufacturing sectors. From this current study, it's clearly identifies that the many research has been done only on addition of RHA based reinforcements. No much adequate research on addition of RHA particulates reinforcement in aluminum alloys has been done. The properties can be improved by addition of RHA reinforcement and also by combination of oxides with A 6063. Even there is research gap in utilization of advance characterization techniques in composites characterization study.

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CHAPTER-1
INTRODUCTION

1.1 INTRODUCTION TO ALUMINIUM ALLOY

Aluminium is the world's most abundant metal and is the third most common element comprising 8% of the earth's crust. The versatility of aluminium makes it themost widely used metal after steel.Aluminium is derived from the mineral bauxite. Bauxiteis converted to aluminium oxide (alumina) via theBayer Process. The alumina is then converted toaluminium metal using electrolytic cells and the Hall-HeroultProcess.Worldwide demand for aluminium is around 29 milliontons per year. About 22 million tons is new aluminiumand 7 million tons is recycled aluminium scrap.

The use of recycled aluminium is economically andenvironmentally compelling. It takes 14,000 kWh toproduce 1 tonne of new aluminium. Conversely it takesonly 5% of this to remelt and recycle one tonne ofaluminium. There is no difference in quality betweenvirgin and recycled aluminium alloys.Pure aluminium is soft, ductile, corrosion resistant andhas a high electrical conductivity. It is widely used foroil and conductor cables, but alloying with otherelements is necessary to provide the higher strengthsneeded for other applications.

Aluminium is one of thelightest engineering metals, having a strength toweight ratio superior to steel.By utilising various combinations of its advantageousproperties such as strength, lightness, corrosionresistance, recyclability and formability, aluminium isbeing employed in an ever-increasing number ofapplications. This array of products ranges fromstructural materials through to thin packaging foils.

ALLOY DESIGNATIONS

Aluminium is most commonly alloyed with copper, zinc,magnesium, silicon, manganese and lithium. Smalladditions of chromium, titanium, zirconium, lead,bismuth and nickel are also made and iron is invariablypresent in small quantities.There are over 300 wrought alloys with 50 in commonuse. They are normally identified by a four figuresystem which originated in the USA and is nowuniversally accepted. It describes the system forwrought alloys. Cast alloys have similar designationsand use a five digit system.

1.2 PHYSICAL PROPERTIES

Density

Aluminium has a density around one third that of steel or copper making it one of the lightest commercially available metals. The resultant high strength to weight ratiomakes it an important structural material allowing increased payloads or fuel savings for transport industries in particular.

Strength

Pure aluminium doesn’t have a high tensilestrength. However, the addition of alloyingelements like manganese, silicon, copper and magnesium can increase the strength properties of aluminium and produce an alloy with properties tailored to particular applications. Aluminium is well suited to cold environments. It has the advantage over steel in that its’ tensile strength increases with decreasing temperature while retaining its toughness. Steel on the other hand becomes brittle at low temperatures.

Corrosion Resistance

When exposed to air, a layer of aluminium oxide forms almost instantaneously on the surface of aluminium. This layer has excellent resistance to corrosion. It is fairly resistant to most acids but less resistant to alkalis.

Thermal Conductivity

The thermal conductivity of aluminium is about three times greater than that ofsteel. This makes aluminium an important material for both cooling and heatingapplications such as heat-exchangers. Combined with it being non-toxic this property means aluminium is used extensively in cooking utensils and kitchenware.

Electrical Conductivity

Along with copper, aluminium has anelectrical conductivity high enough for use as an electrical conductor. Although the conductivity of the commonly used conducting alloy (1350) is only around 62% of annealed copper, it is only one third the weight and can therefore conduct twice as much electricity when compared with copper of the same weight.

Reflectivity

From UV to infra-red, aluminium is an excellent reflector of radiant energy. Visible light reflectivity of around 80% means it is widely used in light fixtures. The same properties of reflectivity makes aluminium ideal as an insulating material to protect against the sun’s rays in summer, while insulating against heat loss in winter.

CHAPTER 2

LITERATURE REVIEW

This chapter emphasizes an overview of the earlier research work carried out in the area of aluminium metal matrix composites processing methods, tribologicalbehaviour at room and high temperatures and mechanical properties of the aluminium based nanocomposites.

2.1 INTRODUCTION

Aluminium is the most widely used metal in engineering industriesnext to iron. It is an excellent electrical and thermal conductor and goodreflector to both heat and light. It is highly corrosion resistant material under amany service conditions and is recyclable without downgrading its quality.Aluminium alloys and AMCs offer a combination of good mechanical and tribological properties with low density that makes them highly suitable for industrial applications.

2.2 MATRIX MATERIAL

Several materials and alloys have been used as matrix materials for automotive, aircraft and other industrial applications. However, mostly research and development has been concentrated on aluminium and aluminium alloys due to its unique combination of properties. It is less expensive than titanium and magnesium but also easier to fabricate.
Aluminium can be reinforced with suitable reinforcement to improve its properties such as strength, stiffness, hardness, and wear resistance. Pure aluminium has been studied extensively because of its low density, high ductility, good formability, machinability and other appropriate properties.

The use of aluminium has been growing in industry as a material for many applications. Shoroworthi et al. (2003) studied the microstructure and interface characteristics of B4C, SiC and Al2O3 reinforced aluminium matrix composites with volume fraction of ceramic reinforcement ranging from 0 to 20% manufactured by liquid melt stirring method.

They were used commercial silicon carbide particles with an average particle size of 40, alumina particles of 32 size and B4C particles of 40 sizes as reinforcement in pure aluminium (99.99%) matrix. They highlighted that B4C reinforced aluminium composites exhibit a better interfacial bonding as compared to the Al-SiC and Al-Al2O3 composites. Uthayakumar et al. (2013) developed an effective approach in achieving minimum wear in an 1100 aluminium alloy. Dry sliding wear behaviour of unreinforced aluminium and its composites with 5 wt. % of B4C and 5 wt. % of SiC particles were also experimentally investigated. It wasshown that incorporation of hard particles to 1100 aluminium alloy contributes to the improvement of the base aluminium alloy to a great extent.

Mehdi Rahimian et al. (2009) investigated the Al2O3 particle size, sintering temperature and sintering time on the properties of base aluminium matrix. They investigated the effect of different alumina particle size of 3, 12 and 48 and sintering temperature and time were in the range of 500-600 and for 30-90 *min* on density, hardness, microstructure, yield strength, compressive strength and elongation to fracture of base aluminium matrix. The experimental results showed that the highest hardness, greater compressive strength and elongation were obtained for the aluminium containing an average particle size of 3 and sintered at 600 for 45 *min*.

Topcu et al. (2009) made an attempt to improve the creep strength of pure aluminium by the presence of 10 B4C particle. In their study,density, hardness, impact and creep properties of base aluminium reinforced with 5, 10, 15 and 20 wt. % of B4C were investigated as a function of temperature and time. The hardness and impact measurement of aluminium composites revealed that impact values decreases and hardness valuesincreases with increase in weight fraction of B4C reinforcement.

2.3 FABRICATION OF METAL MATRIX COMPOSITES

It is extremely difficult to homogeneously distribute and dispersethe reinforcement phases in the matrix to achieve a defect-free microstructure. Currently, a number of techniques are available to fabricate composite such as Mechanical alloying, high energy ball milling, spray deposition, powder metallurgy, nano sintering and various casting techniques. The main problem of nanocomposites is associated with their fabrication processes. In addition, the mechanical properties of the AMNCs are sensitive to the fabrication technique used to produce nanocomposites.

However, liquid metallurgy processing appears to be the preferred process in view of its features like uniform reinforcement distribution, complex shape, better matrix-particle bonding, easier control of matrix structure, bulk production and economical. Gopalakrishnan&Murugan (2012) investigated the applicability of enhanced stir casting method for processing the Al6061-TiC composites, effect of TiC content on the wear behaviour of the prepared composites.

Defect free TiC particles reinforced aluminium matrix composites were obtained by using improved stir casting method. The distribution of TiCparticle reinforcement in matrix is improved by the superior wettabilitybetween reinforcement and matrix, with addition of 1 wt. % of Mg and reinforcement added in the form of capsule during the mechanical stirring. The composites exhibited superior tensile strength and wear resistance with more addition of TiC. Hence, this method is the most economical and efficient method to produce Al6061-TiC composites. KarbalaeiAkbari et al. (2013) used novel approach to fabricate Al2O3nanoparticlesreinforced aluminium composites to avoid agglomeration of nanoparticles in aluminium matrix.

The Al2O3 nanoparticles were separately milled with micro aluminium and copper powders with average size of 50 at different milling durations and incorporated into A356 alloy via stir casting method. A considerably uniform distribution of Al2O3nanoparticles can be found in the composites. However, the hardness, tensile and compressive strength decreased with increase in milling time due tooxidation of metallic powders during milling process and the probable presence of metallic oxide. Narasimha Murthy et al. (2012) fabricated the AA2024- fly ash (1-3 wt. %) nanocomposites using the ultrasonic method.

In their fabrication, they made an attempt to modify the micro sized fly ash into nano structured fly ash using high energy ball mill. It was seen that the homogeneous distribution of the nano fly ash particles in the matrix without any additional contamination. It was found that increasing nano fly ash content in aluminium alloy matrix resulted in improvement in the hardness and compressive strength of the composites. Sajjadi et al. (2012) made a comparison of microstructure and mechanical properties of nano and micro-composites (A356 aluminium alloy Al2O3)with different weight percent of particles fabricated by stir and compocastingprocesses. The experimental results showed that type of fabricationprocess and particle size were the effective factors influencing on the mechanical properties. The microstructure results showed that the porosity content and grain size in compo-casting was lower than stir-casting process since wettability of particles in compo-casting was better than stir-casting process. The nano and micro-composites showed significant improvement in strength, ductility and hardness when fabricated using compo-casting than stir casting.

HafeezAhamed& Senthilkumar (2012) used powder metallurgy technique to fabricate monolithic Al6063 alloy, Al6063/1.5 Al2O3, Al6063/1.5 Y2O3 and Al6063/

1.5 Al2O3/1.5 Y2O3 nanocomposites. The Al6063 powder, alumina and yttria (Y2O3) nano-particulates were blended in planetary ball mill at 200 *rpm* for 2 *h*. The milled powder mixtures wereconsolidated by cold compacting and sintering and then hot extruded to produce nano-composites with more uniform distribution of particles in the material. The effects of nano-size reinforcement particles, weight percentage of reinforcements and also hot extrusion on the hardness and mechanical strength of the composites were investigated. The results indicated that hybrid nano-composites exhibited superior properties over monolithic Al6063 alloy and Al6063/1.5 Al2O3, Al6063/1.5 Y2O3 nanocomposites.

CHAPTER 3
PROBLEM IDENTIFICATION

Recent studies have used micro-sized B4C particles to improve the mechanical and tribological properties of AMCs. However, the poor ductility and reduced fracture toughness have limited the application of micro-sized B4C particle-reinforced AMCs. The use of nano-sized B4C particles to improve the mechanical and tribological properties of the AMCs is attractive because this approach could maintain good ductility, machinability and improved fracture toughness. Based on the literatures discussion, it can be found that the ultrasonic cavitation assisted solidification process is an effective process to fabricate the metal matrix nanocomposites.

It offers advantages compared with powder metallurgy and squeeze casting because of its low cost, better matrix-particle bonding, easier control of matrix structure, flexibility and applicability to complex shape and large quantity production. An additional advantage of the ultrasonic cavitation assisted casting is to distribute and 56 disperse boron based nano-sized particles in an aluminium melt, which enhances their wettability, the degassing of liquid metals and the dispersive effects for homogenizing.

This uniformity not only improves the structural properties but also the mechanical strength as well as imparts good wear resistance. In general ultrasonic cavitation assisted solidification processexhibit good levels of mechanical and wear properties compared with thosefrom other alternative fabrication process. Reasonably fewer studies are found on the self lubricatedmechanical and wear characteristics of light weight aluminium-based composites. However, studies on the self lubricated aluminium hybrid composites are scarce in the literature.

Moreover, no systematic attempt has been made to study the influence of the hybridization of B4C on the mechanical and wear properties of aluminium based composites prepared by ultrasonic cavitation assisted solidification casting. Furthermore, it is evident from these studies that the majority of the matrix chosen are 2XXX, A356, LM13, 6XXX and 7XXX series alloys.

Although some studies have been reported on the 1XXX series alloys reinforced with both boron carbide particulates, much less attention has been given to the 1030 alloy matrix composites, which, has the highest ductility and machinability among all Al alloys. Therefore, in the present study, aluminium hybrid composites on the mechanical properties and tribologicalbehaviour at room and high temperatures are investigated. Some of the research gap identified based on the literature surveyof the topics are listed as below.

From the literature review, it is observed that boron carbide nanoparticles reinforced aluminium composites are prepared using different routes such as powder metallurgy, squeeze casting, etc. However, ultrasonic cavitation assisted solidification casting route is rarely found in the literature.

Limited study has been made on aluminium hybrid composites involving both hard boron carbide and soft self lubricating reinforcements even though it is very interesting and provides scope to overcome some of the challenges posedby use of single hard ceramic particle.

From the literature study, it is observed that the majority of the aluminium composite chose graphite as self lubricantreinforcement as graphite. The main drawback of the graphite reinforced aluminium composites is the formation of brittle interfacial phases leading to a decrease in composites strength and wear properties as graphite materials can react with aluminium at elevated temperature during liquid processing.

Most of the reported research focuses on the effect of micro sized B4C particles on the mechanical and dry sliding wear behaviour of the composites. But no systematic attempt has been made to study the influence of the hybridization of both nano B4C and h-BN particles on the mechanical and tribological properties of aluminium-based composites.

High temperature tribologicalbehaviour of boron carbide nanoparticle reinforced aluminium composites has not been investigated so far at different loads and temperatures. Therefore in the present investigation,tribological properties of both nano-sized and micro sized B4C and h-BN solid nano lubricant reinforced aluminium composites are analyzed at high temperatures.

Based on the literatures discussion, it can be found that the ultrasonic cavitation assisted solidification process is an effective process to fabricate the metal matrix nanocomposites. It offers advantages compared with powder metallurgy and squeeze casting because of its low cost, better matrix-particle bonding, easier control of matrix structure, flexibility and applicability to complex shape and large quantity production. An additional advantage of the ultrasonic cavitation assisted casting is to distribute and 56 disperse boron based nano-sized particles in an aluminium melt, which enhances their wettability, the degassing of liquid metals and the dispersive effects for homogenizing.

This uniformity not only improves the structural properties but also the mechanical strength as well as imparts good wear resistance. In general ultrasonic cavitation assisted solidification process exhibit good levels of mechanical and wear properties compared with those from other alternative fabrication process. Reasonably fewer studies are found on the self lubricatedmechanical and wear characteristics of light weight aluminium-based composites.

However, studies on the self lubricated aluminium hybrid composites are scarce in the literature. Moreover, no systematic attempt has been made to study the influence of the hybridization of B4C on the mechanical and wear properties of aluminium based composites prepared by ultrasonic cavitation assisted solidification casting. Furthermore, much less attention has been given to the 1030 alloy matrix composites, which, has the highest ductility and machinability among all Al alloys.

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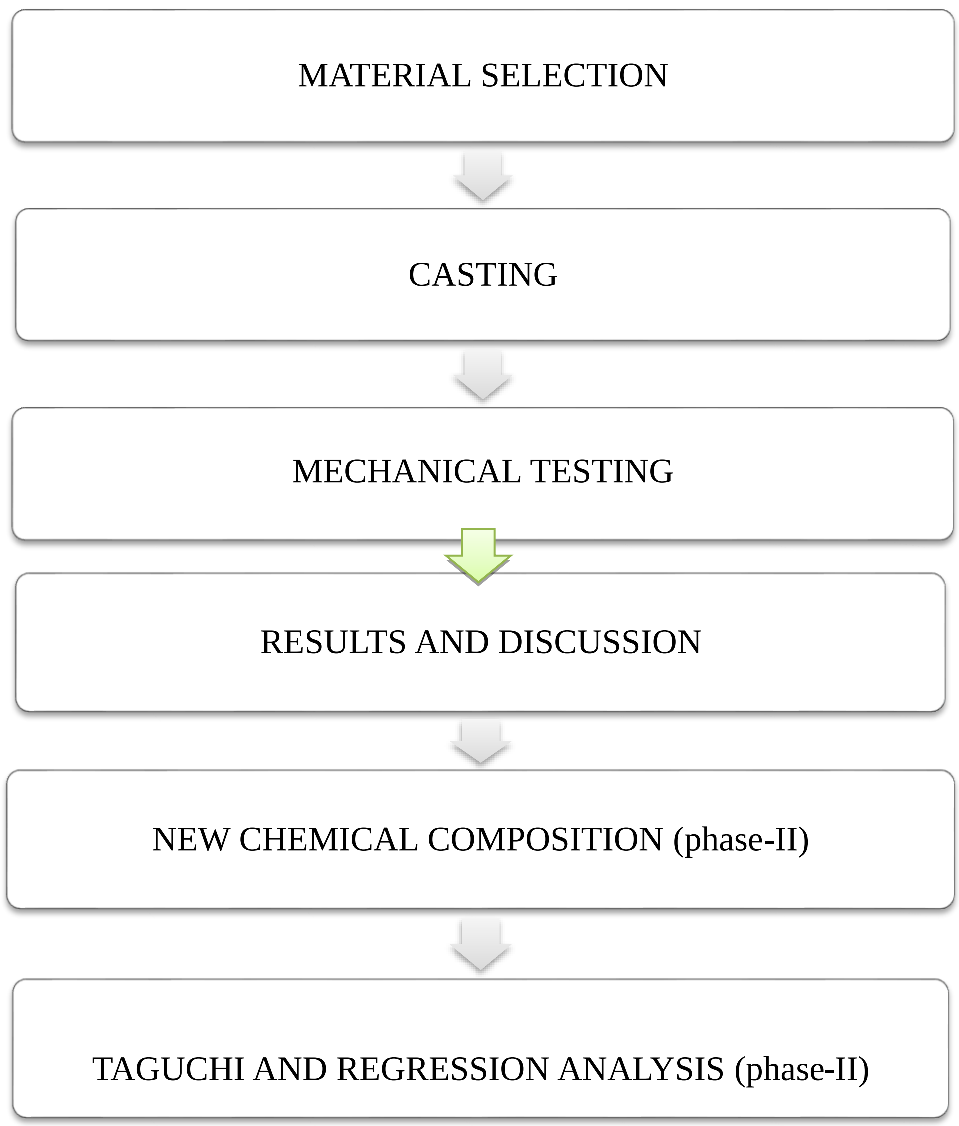
CHAPTER 4
DESIGN OF ALUMINIUM COMPOSITE

4.1 DESIGN AND ANALYSIS



4.2 COMPOSITE MIXING RATIO

In this work, Aluminium alloy 6063, Al203 and Rice husk ash are mixed below mentioned categories:

MATERIAL	COMPOSITION
AA6063	85%
AL_2O_3	10%
RHA	5%

Table 4.1 Chemical composition of aluminium composite.

4.3 ALUMINIUM

Aluminium or aluminum is a chemical element with symbol Al and atomic number 13. It is a silvery-white, soft, nonmagnetic and ductile metal in the boron group. By mass, aluminium makes up about 8% of the Earth's crust; it is the third most abundant element after oxygen and silicon and the most abundant metal in the crust, though it is less common in the mantle below. The chief ore of aluminium is bauxite. Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals.

Aluminium is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in transportation and building industries, such as building facades and window frames.[9] The oxides and sulfates are the most useful compounds of aluminium.

Despite its prevalence in the environment, no known form of life uses aluminium salts metabolically, but aluminium is well tolerated by plants and animals. Because of these salts' abundance, the potential for a biological role for them is of continuing interest, and studies continues.

CHEMICAL COMPOSITION OF ALUMINIUM

Element	**%**
Silicon	0.6%
Iron	0.35%
Copper	0.10%
Manganese	0.10%
Magnesium	0.9%
Chromium	0.10%
Zinc	0.10%
Titanium	0.10%
Aluminium	Balance

Table 4.2 Chemical composition of aluminium composite.

4.4 RICE HUSK

Rice milling industry generates a lot of rice husk during milling of paddy which comes from the fields. This rice husk is mostly used as a fuel in the boilers for processing of paddy. Rice husk is also used as a fuel for power generation. Rice husk ash (RHA) is about 25% by weight of rice husk when burnt in boilers. It is estimated that about 70 million tones of RHA is produced annually worldwide. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped.

During milling of paddy about 78 % of weight is received as rice , broken rice and bran .Rest 22 % of the weight of paddy is received as husk . This husk is used as fuel in the rice mills to generate steam for the parboiling process . This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process , is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica. So for every 1000 kgs of paddy milled , about 220 kgs (22 %) of husk is produced , and when this husk is burnt in the boilers , about 55 kgs (25 %) of RHA is generated.

APPLICATION OF RICE HUSK ASH

RHA is a carbon neutral green product. Lots of ways are being thought of for disposing them by making commercial use of this RHA. RHA is a good super-pozzolan . This super-pozzolan can be used in a big way to make special concrete mixes . There is a growing demand for fine amorphous silica in the production of special cement and concrete mixes ,high performance concrete , high strength, low permeability concrete, for use in bridges, marine environments , nuclear power plants etc. This market is currently filled by silica fume or micro silica , being imported from Norway, China and also from Burma .

This product can be used in a variety of applications like:

- Green concrete
- high performance concrete
- refractory
- ceramic glaze
- insulator

- roofing shingles
- waterproofing chemicals
- oil spill absorbent
- specialty paints
- flame retardants
- carrier for pesticides
- insecticides and bio fertilizers

CHEMICAL COMPOSITION OF RICE HUSK ASH

MATERIAL	COMPOSITION
Sio2	97.095
AL_2O_3	1.135
FE203	0.316
CaO	0.073
MgO	0.825
SO3	0.146
K2O	0.181
Na2O	0.092
Others	Balance
LOI	0.965

Table 4.3 Chemical composition of rice husk ash.

4.5 ALUMINIUM OXIDE

Aluminium oxide (IUPAC name) or aluminum oxide (American English) is a chemical compound of aluminium and oxygen with the chemical formula Al2O3. It is the most commonly occurring of several aluminium oxides, and specifically identified as aluminium(III) oxide. It is commonly called alumina (regardless of whether the element is spelled aluminum or aluminium), and may also be called aloxide, aloxite, or alundum depending on particular forms or applications.

CHAPTER 5
CASTING

5.1 STIR CASTING

Stir casting is an economical process for the fabrication of aluminum matrix composites. There are many parameters in this process, which affect the final microstructure and mechanical properties of the composites. In this study, micron-sized SiC particles were used as reinforcement to fabricate Al-3 wt% SiC composites at two casting temperatures (680 and 850 °C) and stirring periods (2 and 6 min).

Factors of reaction at matrix/ceramic interface, porosity, ceramic incorporation, and agglomeration of the particles were evaluated by scanning electron microscope (SEM) and high-resolution transition electron microscope (HRTEM) studies. From microstructural characterizations, it is concluded that the shorter stirring period is required for ceramic incorporation to achieve metal/ceramic bonding at the interface.

The higher stirring temperature (850 °C) also leads to improved ceramic incorporation. In some cases, shrinkage porosity and intensive formation of Al_4C_3 at the metal/ceramic interface are also observed. Finally, the mechanical properties of the composites were evaluated, and their relation with the corresponding microstructure and processing parameters of the composites was discussed.

It occurs naturally in its crystalline polymorphic phase α-Al2O3 as the mineralcorundum, varieties of which form theprecious gemstones ruby and sapphire. Al2O3 is significant in its use to produce aluminium metal, as an abrasive owing to its hardness, and as a refractory material owing to its high melting point

5.2 MATERIAL SPECIMEN

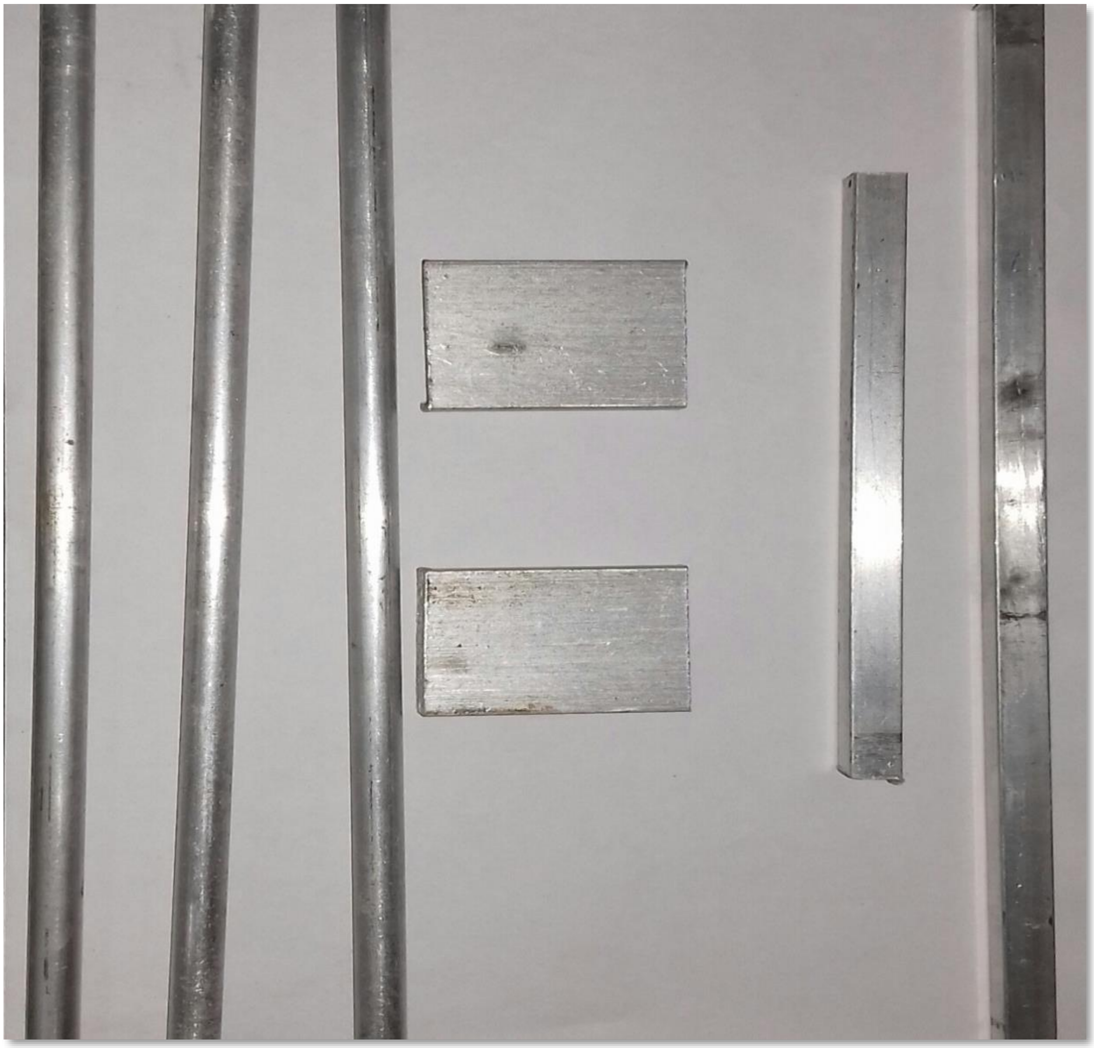


Fig 5.1 Material specimen

CHAPTER 6
MECHANICAL PROPERTIES TESTING

6.1 IMPACT TEST

6.1.1 IMPACT TEST (IZOD)

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of un notched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads. Of all types of impact tests, the notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature

PROCEDURE :

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machine?s vice in such a way that the notch face the hammer and is half inside and half above the top surface of the vice.

2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.
5. Again bring back the hammer to its idle position and back

Specimen : 75 mm X 10mm X 10mm

OBESERVATIONS:-

Energy absorbed (A)	Energy spend to break (J)	Impact strength (J/mm^2)
10 X 8 =80	125	1.5

Table 6.1 Impact test (izoid) tabulation.

$$\text{Impact strength} = \frac{\text{Energy absorbed}}{\text{Area}}$$

$$= \frac{125}{80}$$

$$= 1.5$$

Impact value of Aluminum = 1.5 J/mm^2

6.1.2 IMPACT TEST (CHARPY)

PROCEDURE :

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces s the hammer and is half inside and half above the top surface of the vice.
2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen..
5. The specimen is placed on supports or anvil so that the blow of hammer is opposite to the notch.

Specimen :10 mm x 10 mm X 55mm

OBESERVATIONS:

Energy absorbed (A)	Energy spend to break (J)	Impact strength (J/mm^2)
10 X 8 =80	114	1.

Table 6.2 Impact test (charpy) tabulation.

$$\text{Impact strength} = \frac{\text{Energy spend}}{\text{Area}}$$

$$= \frac{114}{80}$$

= 1.425

Impact value of Aluminum = 1.425 J/mm^2

6.2 HARDNESS TEST

The hardness of a material is resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation. There are three general types of hardness measurements depending upon the manner in which the test is conducted:

A. Scratch hardness measurement,
B. Rebound hardness measurement
C. Indention hardness measurement.

In scratch hardness method the material are rated on their ability to scratch one another and it is usually used by mineralogists only. In rebound hardness measurement, a standard body is usually dropped on to the material surface and the hardness is measured in terms of the height of its rebound. The general means of judging the hardness is measuring the resistance of a material to indentation.

The indenters usually a ball cone or pyramid of a material much harder than that being used. Hardened steel, sintered tungsten carbide or diamond indenters are generally used in indentation tests; a load is applied by pressing the indenter at right angles to the surface being tested. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or plastic. The resistance depends on friction, elasticity, viscosity and the intensity and distribution of plastic strain produced by a given tool during indentation.

6.2.1 BRINELL'S HARDNESS TEST

Hardness of a material is generally defined as Resistance to permanent indentation under static or dynamic loads. However it also refers to stiffness or to resistance to scratching, abrasion or cutting. Indentation hardness maybe measured by various hardness tests, such as Rockwell, Vickers, Brinnells hardness etc. In Brinell?s hardness test, a hard steel ball, under specified conditions of load and time, is forced into the surface of the material under test and the diameter of the impression is measured. Hardness number is defined as the load in kilograms per square millimeters of the surface area of indentation. This number depends on the magnitude of the load applied, material and geometry of the indentor.

PROCEDURE:

1. Select the proper diameter of the indentor and load.
2. Start the machine by pushing the green button of starter and allow oil to circulate for few minutes.
3. Keep the hand lever in position A.
4. Place the specimen securely on the testing table. Turn the hand wheel in clockwise direction, so that the specimen will push the indentor and will show a reading on dial gauge.
5. The movement will continue until the long pointer will stop at "0? and small pointer at red dot when the initial load of 250kg is applied. If little error exists the same can be adjusted by rotating the outer ring dial gauge.
6. Turn the handle from position "A? to "B? so that the total system is brought into action.
7. When the long pointer of dial gauge reaches a steady position, the load may be released by taking back the lever to position "A?.
8. Turn back the hand wheel and remove the specimen.
9. The diameter of the impression can be found by using optical microscope.

10. Read the hardness number from the tables.

OBESERVATIONS:

Brinell's hardness number (HB) is given by

HB = Load on ball in kg

Surface area of indentation in sq.mm 2P

Where:

P=load in kg, D=diameter of indentor in mm

d=average diameter of impression in mm

Sl No	Diameter of indentor	Load (Kg)	Diameter of impression (mm)
1	10	3000	8

Table 6.3 Brinell’s hardness tabulation.

$$BHNb = \frac{2P}{\pi D(\sqrt{D^2} - d^2)}$$

$$= 2 \times 3000 / \pi \times 10(\sqrt{10^2} - 8^2)$$

= 95.49 Kg/mm^2

6.2.2 ROCKWELL'S HARDNESS TEST

PROCEDURE:

1. Adjust the weights on the plunger of dash pot according to Rockwell scale as shown in chart.
2. Keep the lever in position A.
3. Place the specimen on testing table.
4. Turn the hand wheel clockwise, on that specimen will push the indentor and the small pointer moves to the red spot (Do not turn the wheel in a way to cross the red spot). The long pointer automatically stops at zero on black scare. If there is any resistance, unload and check the weights, indentor and the gap between inner faces of hanger and Turn the lever from position A to B slowly so that the total load into brought in to action without any jerks.
5. The long pointer of dial gauge reaches a study position when indentation is complete. Take back the lever to position A slowly.
6. Read the figure against the long pointer. That is direct reading of the hardness of specimen.
7. Turn back the hand wheel and remove the specimen.
8. Repeat the procedure 3 to 4 times.

OBESERVATIONS:

Rockwell's hardness number (HR) is 58 HRB

6.3 TENSION TEST

The tensile test is most applied one, of all mechanical tests. In this test ends of test piece are fixed into grips connected to a straining device and to a load measuring device. If the applied load is small enough, the deformation of any solid body is entirely elastic. An elastically deformed solid will return to its original form as soon as load is removed. However, if the load is too large, the material can be deformed permanently. The initial part of the tension curve which is recoverable immediately after unloading is termed. As elastic and the rest of the curve which represents the manner in which solid undergoes plastic deformation is termed plastic.

The stress below which the deformations essentially entirely elastic is known as the yield strength of material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and a lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through a maximum and then begins to decrease. This stage the "ultimate strength"?which is defined as the ratio of the load on the specimen to original cross-sectional area, reaches a maximum value. Further loading will eventually cause "neck? formation and rupture.

PROCEDURE:-

1. Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen
2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.

4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

DESCRIPTION OF UTM AND EXTENSOMETER:

LOADING UNIT:-

It consists of main hydraulic cylinder with robust base inside. The piston which moves up and down. The chain driven by electric motor which is fitted on left hand side. The screw column maintained in the base can be rotated using above arrangement of chain. Each column passes through the main nut which is fitted in the lower cross head. The lower table connected to main piston through a ball & the ball seat is joined to ensure axial loading. There is a connection between lower table and upper head assembly that moves up and down with main piston. The measurement of this assembly is carried out by number of bearings which slides over the columns. The test specimen each fixed in the job is known as "Jack Job?. To fix up the pecimen tightly, the movement of jack job is achieved helically by handle.

CONTROL PANEL:-

It consists of oil tank having a hydraulic oil level sight glass for checking the oil level. The pump is displacement type piston pump having free plungers those ensure for continuation of high pressure. The pump is fixed to the tank from bottom. The suction & delivery valve are fitted to the pump near tan Electric motor driven the pump is mounted on four studs which is fitted on the right side of the tank. There is an arrangement for loosing or tightening of the valve. The four valves on control panel control the oil stroke in the hydraulic system. The loading system works as described below. The return valve is close, oil delivered by the pump through the flow control valves to the cylinder & the piston goes up.Pressure starts developing & either the specimen breaks or the load having maximum value is controlled with the base dynameters consisting in a cylinder in which the piston reciprocates. The switches have upper and lower push at the control panel for the downward & upward movement of the movable head. The on & off switch provided on the control panel & the pilot lamp shows the transmission of main supply

METHOD OF TESTING:

Initial Adjustment: - before testing adjust the pendulum with respect to capacity of the test i.e. 8 Tones; 10 Tones; 20 Tones; 40 Tones etc. For ex: - A specimen of 6 tones capacity gives more accurate result of 10 Tones capacity range instead of 20 Tones capacity range. These ranges of capacity are adjusted on the dial with the help of range selector knob. The control weights of the pendulum are adjusted correctly. The ink should be inserted in pen holder of recording paper around the drum & the testing process is started depending upon the types of tests.

EXTENSOMETER:-

This instrument is an attachment to Universal / Tensile Testing Machines. This measures the elongation of a test place on load for the set gauge length. The least count of measurement being 0.01 mm, and maximum elongation measurement up to 3 mm. This elongation measurement helps in finding out the proof stress at the required percentage elongation.

Curve A shows a brittle material. This material is also strong because there is little strain for a high stress. The fracture of a brittle material is sudden and catastrophic, with little or no plastic deformation. Brittle materials crack under tension and the stress

increases around the cracks. Cracks propagate less under compression. Curve B is a strong material which is not ductile. Steel wires stretch very little, and break suddenly. There can be a lot of elastic strain energy in a steel wire under tension and it
will "whiplash" if it breaks. The ends are razor sharp and such a failure is very dangerous indeed. Curve C is a ductile material. Curve D is a plastic material. Notice a very large strain for a small stress.The material will not go back to its original length.

OBESERVATIONS:

A) Original dimensions Gauge Length = 300mm

B) Final Dimensions Gauge Length = 358 mm

% Elongation = $\frac{final\ length}{original\ length}$

$= \frac{358}{300}$

% Elongation = 1.193

Tensile strength of aluminium is 13.84 KN.

6.4 TORSION TEST

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force is applied tangentially and in the plane of transverse cross section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion and it will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

Torsion equation:

Torsion equation is given by below

$T/J = \tau/R = G\theta/L$

$G = T L/J \theta$ N/mm2

T= maximum twisting torque (N mm)

J = polar moment of inertia (mm4) = ?d4/32

G = modulus of rigidity (N/mm2)

L= length of shaft under torsion (mm)

Assumptions made for getting torsion equation:

1. The material of the shaft is uniform throughout.
2. The shaft, circular in section remain circular after loading.
3. Plane sections of shaft normal to its axis before loading remain plane after the torque have been applied.
4. The twist along the length of the shaft is uniform throughout.
5. The distance between any two normal-sections remains the same after the application of torque.
6. Maximum shear stress induced in the shaft due to application of torque does not exceed its elastic limit.

PROCEDURE:-

1. Select the driving dogs to suit the size of the specimen and clamp it in the machine by adjusting the length of the specimen by means of a sliding spindle.
2. Measure the diameter at about three places and take the average value.
3. Choose the appropriate range by capacity change lever
4. Set the maximum load pointer to zero.
5. Set the protractor to zero for convenience and clamp it by means of knurled screw.
6. Carry out straining by rotating the hand wheel in either direction.
7. Load the machine in suitable increments.
8. Then load out to failure as to cause equal increments of strain reading.
9. Plot a torque- twist (T- ?) graph.
10. Read off co-ordinates of a convenient point from the straight line portion of the torque twist (T-?) graph and calculate the value of G by using relation.

OBESERVATIONS:-

Gauge length of the specimen, L

Diameter of the specimen ,d, j is Polar moment of inertia,

Torque,	Torque,	Angle of twist	
Kg-cm	N - mm	Degree	Radians
900	90000	30	0.349

Table 6.4 Torsion test tabulation

T/J = τ/R= Gθ/L

G = T L/J θ N/mm2

$$= \frac{900\times30}{\frac{(\pi\times10^4)\times0.3490}{32}}$$

Moment of inertia = 78.45 Gpa

CHAPTER 7

CONCLUSION AND FUTURE ENHANCEMENT

The test report which clearly shows that the addition of Rice husk ash in to the aluminium alloy 6063 improve its mechanical properties.

- The maximum hardness of composite is 58 HRB
- The maximum twisting torque of composite is 90000 N-mm and its modulus of rigidity is 78.45 Gpa.
- The maximum Tensile strength of composite is 13.84 KN.
- The maximum shear strength of composite is 13.50 KN
- There is no markable changes in impact test of the addition of RHA.

The various elements are mixed with aluminium to obtain the best results in future work and statical analysis of various aluminium alloys will be predicted and mechanical properties will be developed.

APPENDIX

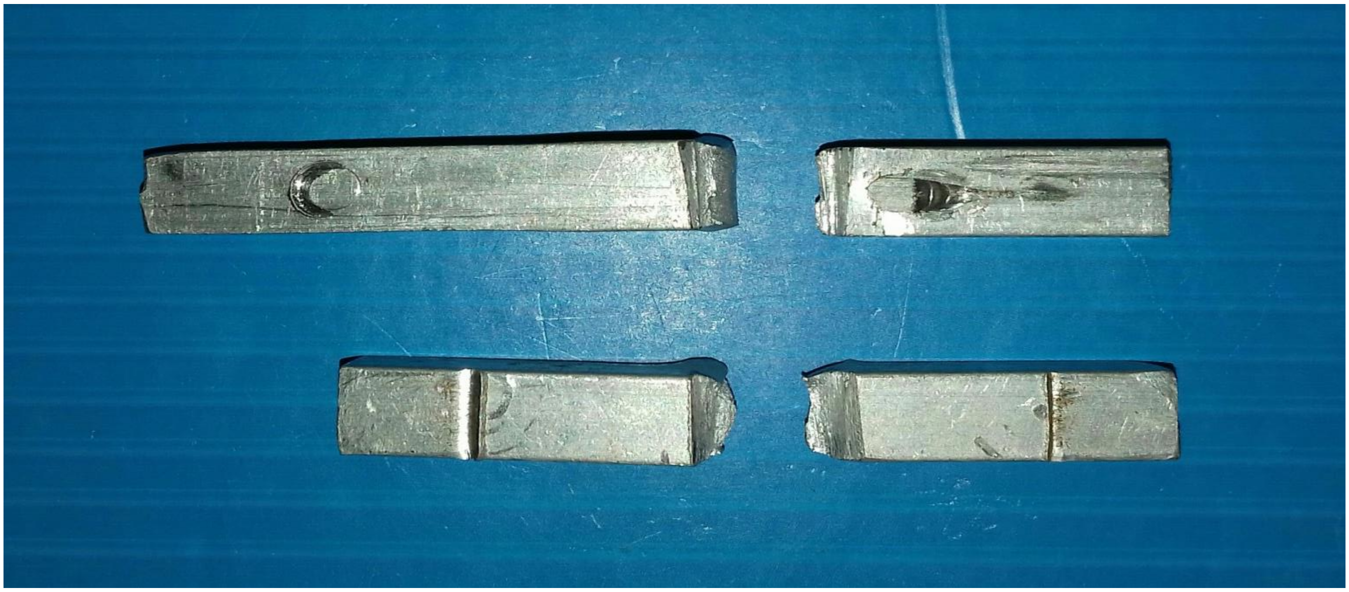


Fig A.1 Impact test

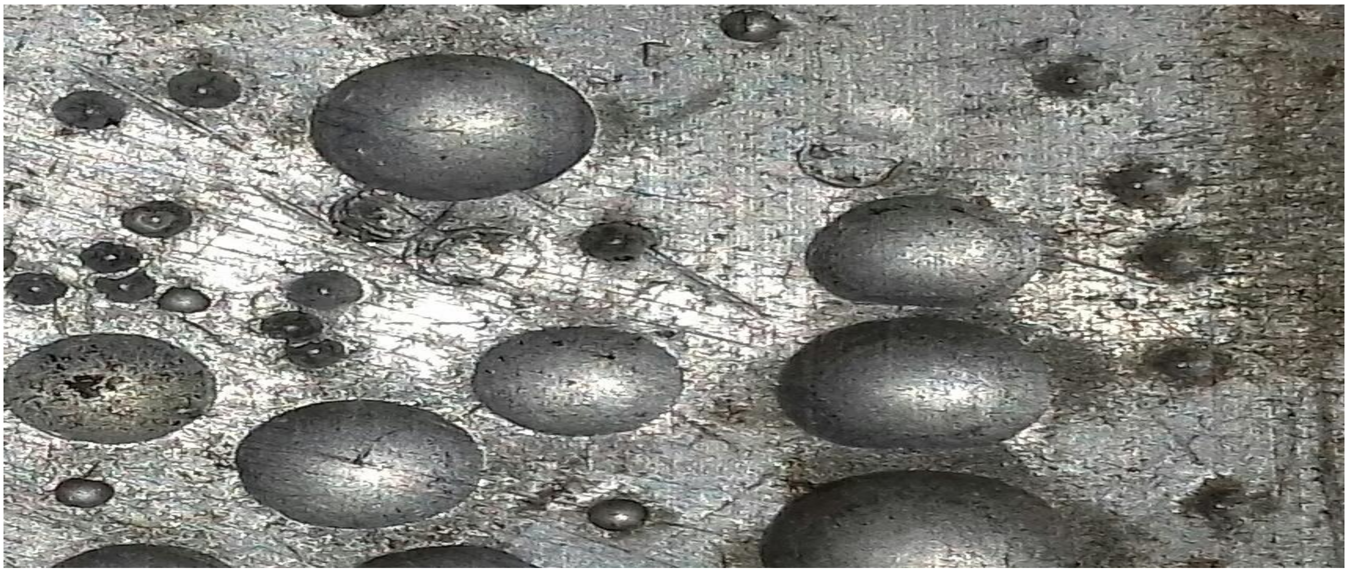


Fig A.2 Hardness test

Fig A.3 Torsion test

Fig A.4 Tension test

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