

PREPARATION AND PROPERTY
ANALYSIS OF A
METAL MATRIX COMPOSITE
PROJECT REPORT

Submitted by

P-362

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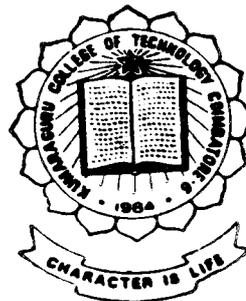
Department of Mechanical Engineering

Submitted in partial fulfilment of the requirements

for the degree of

**BACHELOR OF ENGINEERING IN
MECHANICAL ENGINEERING**

Bharathiyar University

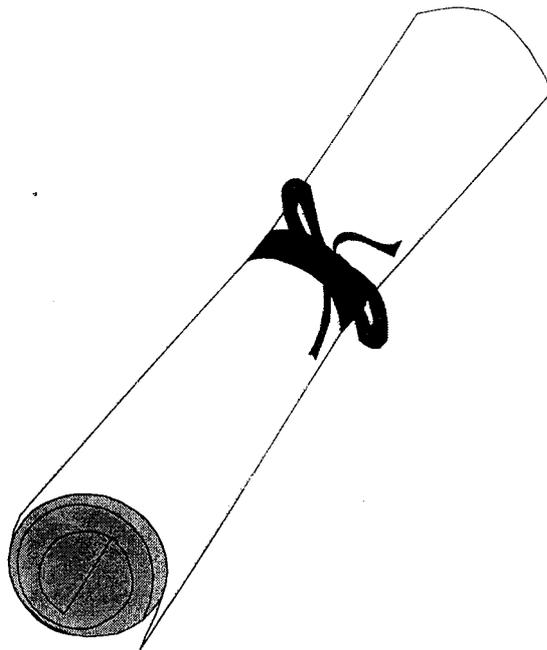


1998 - 1999

Department of Mechanical Engineering

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE - 641 006



CERTIFICATE

DEPARTMENT OF MECHANICAL ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
(Affiliated to Bharathiyar University)
Coimbatore – 641 006.

PROJECT WORK
CERTIFICATE

This is to certify that the project work entitled

PREPARATION AND PROPERTY ANALYSIS OF A
METAL MATRIX COMPOSITE

is a bonafide record of work carried out by

..... Reg.No

during the year 1998 - 1999 in partial fulfillment of
the requirements for the degree of Bachelor of Engineering in
Mechanical Engineering of the Bharathiyar University

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PROJECT GUIDE

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PRINCIPAL

Submitted for the University Examination held on

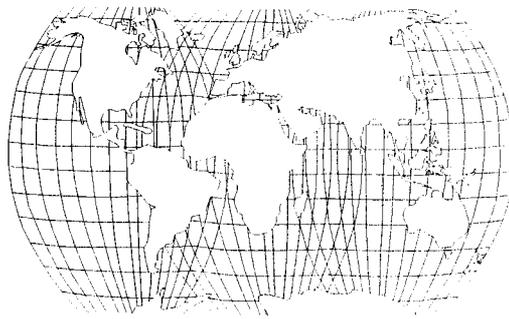
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**DEDICATED
TO OUR BELOVED
PARENTS**





ACKNOWLEDGEMENT

information's & illustrations about the composite materials and motivated & to do the project in metal matrix composite

We wish to thank **Mr. Mohandoss, B.E.**, Delta Copper Alloys, Ganapathy ,Coimbatore who helped us in fabrication by giving valuable suggestions and we also thank Srinivasa Machine Works, Ganapathy, Coimbatore ,who gave us a helping hand in machining our specimens.

We especially wish to acknowledge SITARC & SISI, Government of India testing Centers allowing us to perform various tests (Mechanical, Chemical & Photomicrograph).

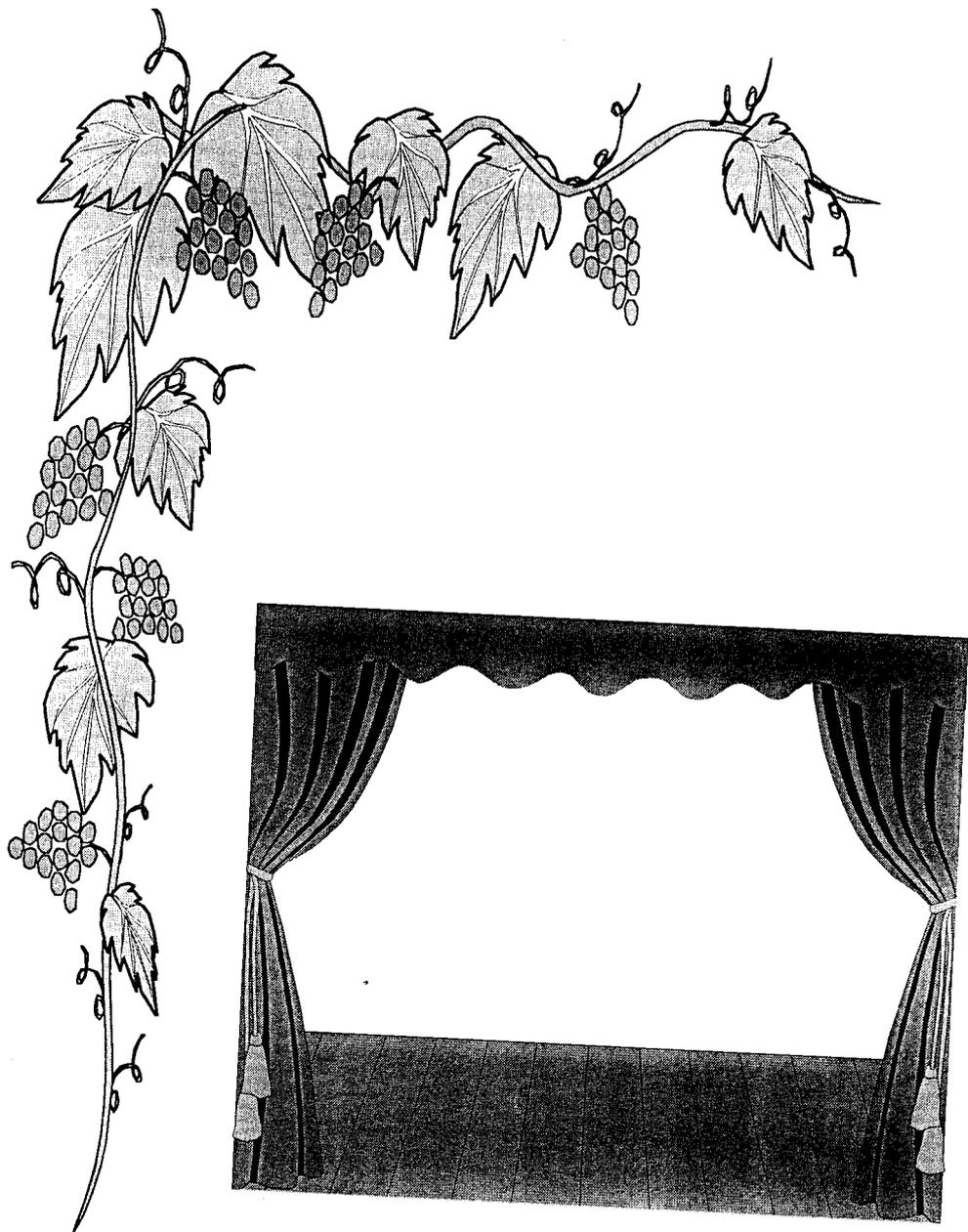
We are obliged to all Mechanical Engineering teaching and non teaching staff who rendered their kind help during time of project work. Last but certainly not the least, we appreciate the role played by our beloved friends.



SYNOPSIS



CONTENTS



INTRODUCTION



INTRODUCTION

1.1 DEFINITION OF COMPOSITE MATERIALS

A **composite material** or composite is a complex solid material composed of two or more materials that, on a macroscopic scale, form a useful material. The composite is designed to exhibit the best properties or qualities of its constituents or some properties possessed by neither.

The combining of the two or more existing materials is done by physical means as opposed to the chemical bonding that takes place in the alloys of monolithic solid materials. A true composite might be considered to have a matrix material completely surrounding its reinforcing material in which the two phases act together to either constituent acting alone.

EXAMPLES :

Plywood, Fiberglass, Laminated timber, Graphite epoxy, Premex, Reinforced concrete, tungsten carbide, reinforced glass, are a few examples of composites.

A recent example of the development of composites in the medical field is cited. A mineral paste composed of monocalcium phosphate monohydrate, α - tricalcium phosphate, and calcium carbonate, dry mixed, to which a sodium phosphate solution is added to form a paste, is surgically

implanted into acute bones fractures and hardens within ten minutes of injection. This process causes the in – situ formation of mineral phase of bone, Heavy and uncomfortable casts are eliminated.

1.2 WHY USE COMPOSITES ?

In answer to this question, the reply in part is as follows,

1. To increase stiffness, strength or dimensional Stability
2. To increase toughness (impact strength)
3. To increase heat – deflection temperature
4. To increase mechanical damping
5. To reduce permeability to gases and liquids.
6. To modify electrical properties
7. To reduce costs
8. To decrease water absorption
9. To decrease thermal expansion.
10. To increase chemical wear and corrosion resistance
11. To reduce weight
12. To maintain strength / stiffness at high temperatures while under strain conditions in a corrosive environment.
13. To increase secondary uses and recyclability and to reduce any negative impact on the environment.

14. To improve design flexibility.

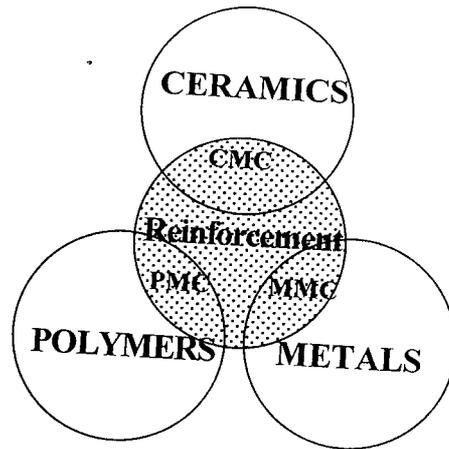
1.3 FAMILY OF MATERIALS

- ❖ Metallics
- ❖ Polymers
- ❖ Ceramics
- ❖ Composites

Group	Sub – Group	Examples
Composites	Polymer – based	Plywood Laminated timber fiberglass
	Metallic – based	Boron aluminium Primex
	Ceramic – based	Reinforced concrete CFCC
	Cermets Other	Tungsten Carbide Reinforced glass

1.4 DEVELOPMENT OF COMPOSITES

Many developments of composites made through collective effort of NASA, industries and universities gave rise to advanced composites. The following **venn diagram** shows how ceramics, metals and polymers are integrated into sets and subsets of advanced composites. The sets of based on the form of reinforcement and general structural arrangement.



This also represents the continual search for materials systems that can withstand even greater loads under hostile environments. These composite materials are being developed and tested for use in many high temperature applications such as High Speed Civil Transport (**HSCT**). The National Aero Space Plane (**NASP**) program in U.S. is developing and beginning production of advanced materials for the x – 30 hypersonic research vehicle.

1.5 TYPES OF COMPOSITES

Ever increasing variety of composites are divided into fiber, laminated sandwich, particulate, flake, and filled composites

1.5.1 Fiber– Reniforced Composites

1.5.1.1.Polymer Matrix Composites (PMCs) Fiber Glass Reinforced Plastic (GRPs)

GRPs represent the earliest and the most widely used fiber – resin composites. With glass fibers in various forms coupled with either a thermosetting or thermoplastic resin. These composites can be produced without the need for high curing temperatures or pressures. Using 20 % to 40 % fiber loadings, the composites in general, double the strength and stiffness of the plastic resin used alone.

1.5.1.2 Metal Matrix Composites (MMCs) & Ceramic Matrix Composites (CMCs)

The major rational for the development of Metal Matrix Composites and Ceramic Matrix Composites is to satisfy the important need for tough, strong materials capable of maintaining their special properties under high operating conditions.

Metal Matrix Composites consist of a base (matrix) that is reinforced with continuous fiber or discontinuous materials in particulate form. They are mainly used in aerospace industry and industries. They are synthesized using standard metalworking practice such as extrusion, hot forging, hot molding, superplastic forming, squeeze casting, powered metallurgy, liquid metal filtration and rolling. Whisker reinforced Metal Matrix

Composites have distinct advantages over conventional alloys. Typical fibers are SiC , Al_2O_3 , and Si_3N_4 which are combined with some common metal matrices, such as Al, Mg, Ti and Cu.

Egs :Fiber glass,Hard board,Graphite epoxy, reinforcedglass.etc.,

1.5.2. Laminar Composites

These consists of layers (lamina) of at least two different solid materials bounded together so the fiber orientation runs at different angles. Laminations allow the designer of this composite material to use the best layer to achieve a more useful material. Adhesives properties such as wear resistance, strength, stiffness, can be achieved bound the laminations.

Egs :- Plywood, laminated boards, thermocouples, safety glass, alclad.

1.5.3. Sandwich (stressed – skin) composites

Their outer surfaces or facings are made of some material higher in density than the inner material or core that supports the facings. The primary purpose is to achieve high strength with less weight. Facing materials are aluminum, wood, vinyl paper, GRPs , & stainless steel. Core materials represent all families of materials taken on the configurations known as honeycomb, waffle, corrugated tubes & cones

Eg :- Nomex.

1.5.4. Particulate composites

(They contain reinforcing particles of one or more materials suspended in a matrix of a different material. The particles, either metallic or non – metallic, by definition do not chemically combine with the matrix material.) The size, shape and spacing of particles, their volume fraction, and their distribution all contributes to the properties of these materials.

Eg:- Concrete, Particle board.

1.5.5. Flake composites

(Flakes of mica or glass in a glass or plastic matrix form a composite material that has primarily two – dimensional geometry with corresponding strength and stiffness in two dimensions. Flakes tend to pack parallel to and overlap each other, They provide properties such as decreasing wear, low coefficient of thermal expansion , increased thermal and electrical conductivity.

1.5.6. Filled composites

A filler is a material added to another material to alter its physical and mechanical properties significantly or to decrease its costs. filler when added to polymer materials improve their strength by reducing the mobility of the polymers chains, as gravel increases the strength of concrete. The size shape and distribution all play an important role in determining the desired properties of the filled composite.

1.5.7. Hybrid composites

It combines two or more different fibers in a common matrix, greatly expand the range of properties that can be achieved with advanced composites. The matrix can be either a thermoset or a thermoplastic.

1.5.8. Smart composite materials

The infinite variety of structures possible with hybrid composites to fulfill many of the goals sought for smart materials. Hybrid Polymer Matrix Composites (PMCs) incorporating shape memory alloys (SMAs) such as nitinol, improves low-velocity impact and perforation resistance. Imbedded particles allow in service motioning of the host composite structure.

1.6. APPLICATIONS OF COMPOSITES

1. Aerospace / Aircraft Industry :-

Light weight composites have replaced aluminium in the structure and body building of aircrafts. Toughened graphite which is seven times tougher than Carbon Fiber Reinforced Plastics (**CFRP**) is used in the rudder, fin and stabilizer torque boxes.

2. Auto Industry :-

Glass fibers are used in auto bumper beams. Reinforced – plastic composite technology is made by ford Taurus chassis saves about 30% of car weight. Ceramic Matrix Composites (**CMCs**) are used in cam roller followers. Aluminum Metal Matrix Composites (**MMCs**) can be used in engine components such as connecting rods, piston pins, brackets, and stiffness.

3. Medical field (Bioengineering)

Composite prosthetic devices are used to replace defective joints in knees, hips, humers, etc., Mineral bone paste used in orthopedic surgery is a composite.

4. Electronics Industry

High ductile and low flash grades high performance connectors are used in electronics surface mount technology.

5. Chemical Industry

Impellers made of thermo plastic composite have an extended life in acid environment.

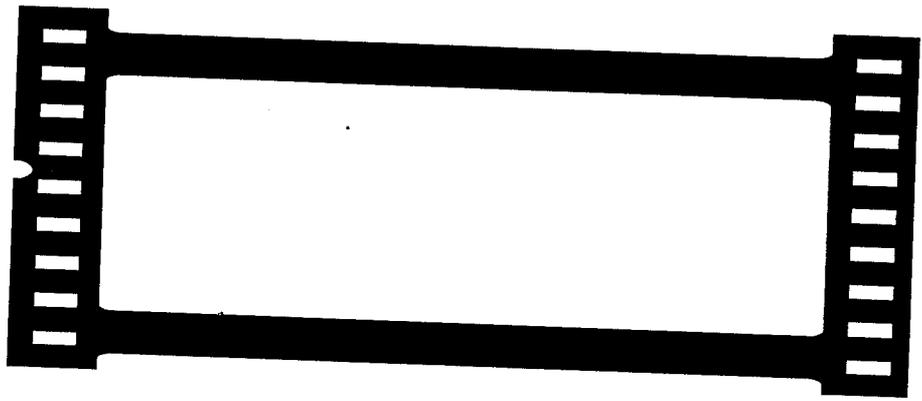
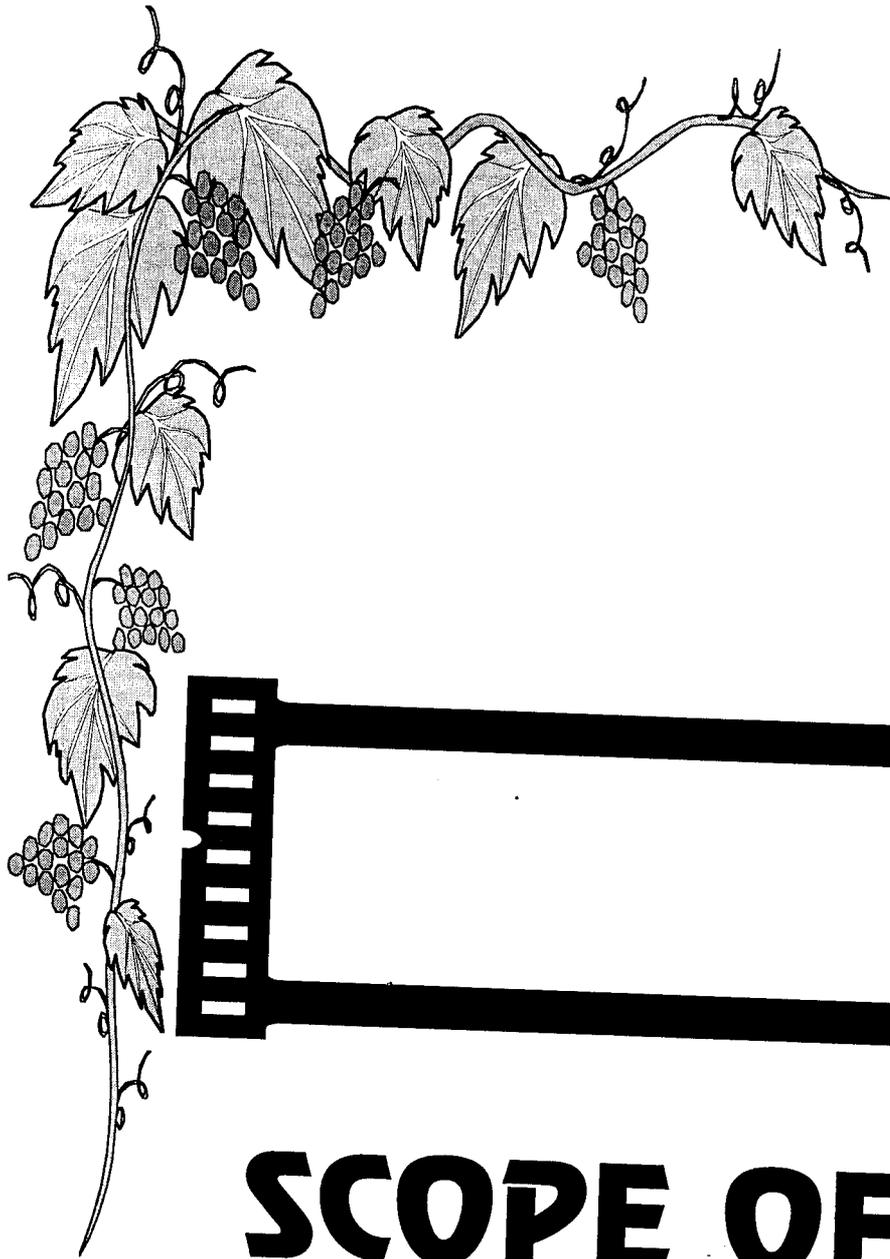
6. Building construction

Concrete laminated boards, plywood's etc., are used in construction works.



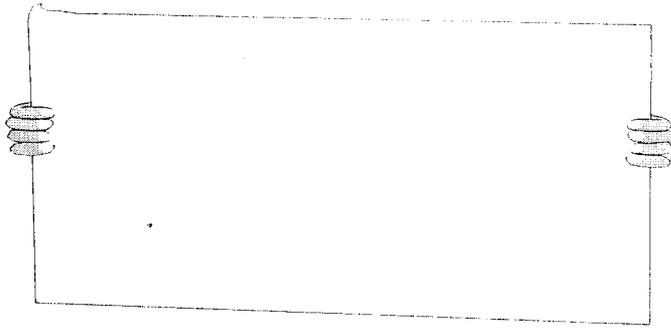
AIM OF OUR PROJECT





SCOPE OF PRESENT INVESTIGATION





LITERATURE STUDY



4.1.4.3. Quality and Performance.

The usage of aluminum gives assurance that parts will not rust. It can withstand repeated stress. Also it is easily extricable.

4.2 PROPERTIES OF ALUMINIUM & QUARTZ

4.2.1 ALUMINIUM STUDY

- ❖ White metal, Bluish Tinge
- ❖ Atomic Weight - 26.97
- ❖ Atomic number - **13**
- ❖ Specific Gravity - 2.70
- ❖ Melting point - 658.7 °C
- ❖ Non-magnetic
- ❖ F.C.C structure crystal
- ❖ Thermal conductivity - 60 % of copper
- ❖ Brinell hardness number - 30
- ❖ Easily extrudable, Resistant to corrosion
- ❖ Yield strength declines after 350 ° F
- ❖ Occurrence in earth - 8% (O2 -47%, Si - 28%)
- ❖ Avg% in igneous rods - 8.13%
- ❖ Modulus of Elasticity (Tension) - 10×10^6 Kgf/ cm²

- ❖ Linear Expansion - unit length increase per degree centigrade rise in temp - 0.24×10^{-4}
- ❖ Relative electric conductivity - 63.00

4.2.1.1 APPLICATIONS

- ❖ Ornamental architecture work
- ❖ Containers
- ❖ Cooling utensils
- ❖ Chemical equipment
- ❖ Electric conductors
- ❖ Refrigeration tubing
- ❖ Panelling & Moulding
- ❖ Sheet metal work

4.2.1.2 COMMERCIAL DETAILS

- ❖ Designation - 19,000
- ❖ Characteristics - Commercially pure Aluminium
- ❖ Very ductile or extruded condition
- ❖ Resistance to corrosion
- ❖ Available forms - Sheet, plate, tube, wire, forgings
- ❖ Compositions - Al - 99%

4.2.2.1 Applications

- ❖ abrasive
- ❖ filler
- ❖ flux

4.2.2.2 Family of Quartz

- ❖ Low temp Quartz (hexagonal)
- ❖ High temp Quartz (hexagonal)
- ❖ Tridymite (hexagonal)
- ❖ Cristobalite (cubic)
- ❖ Coesite (monoclinic)
- ❖ Stishovite (tetragonal)
- ❖ Opal .n.H₂O



FABRICATION OF COMPOSITES



5.0 FABRICATION OF COMPOSITES

5.1 Preparation of Pattern and Mould

5.1.1 Pattern:

Pattern is the principle tool during the casting process. It may be defined as a model of anything, so constructed that, it may be used for forming an impression called mould, in damp sand or other suitable material. The process of making a pattern is known as pattern making.

Reasons For Selecting Wood As A Pattern

5.1.2 Material :

Wood is the most common material for pattern as it satisfies many of the aforesaid requirements. It is easy to work and readily available, woods can be cut and fabricated into numerous forms by gluing, bending and curving. Wood used for pattern making should be properly dried, before it is used. It should be straight grained, free from knots, and free from excessive sap wood. The most common wood used for pattern is teak wood.

5.1.2 Different Allowances considered in pattern making

Patterns are not made to the exact same size as the desired casting for several reasons. Such a pattern would produce castings which are undersized, allowances must therefore be made for shrinkage, draft, finish, distortion and rapping.

5.1.2.1 Shrinkage allowance

As metal solidifies and cools, it shrinks and contracts in size, to compensate for this a pattern is made larger than the finished casting by means of shrinkage or contraction allowance. The shrinkage allowance considered for the present pattern is 13 mm/m from the standard table.

5.1.2.2 Machine allowance

Rough surfaces of casting that have to be machined are made to dimensions some what over, those indicated on the finished working drawing, the extra amount of metal provided on the surface to be machined is called machine finish allowance.

The machining allowance considered is 2mm as given in the table of standard machining allowance.

5.1.2.3 Rapping allowance

When a pattern is rapped in the mould before it is with drawn the cavity in the mould is slightly increased in every cases where casting must be uniform and true to pattern. Rapping or shake allowance is provided for by making the pattern slightly smaller than the actual size, to compensate for the rapping of the mould.

5.1.3 Dimensions of the pattern

Length = 300 mm + 5 mm = 305 mm

Diameter = Maximum dia of the specimen required + shrinkage allowance +

Machine finish allowance - Rapping allowance

= 30 + (30 * 13/1000) + 2mm- 0.5 mm

= 35 mm

5.1.4 Pattern making procedure

Teak wood piece of size 40*40 cross section and of length 400mm was turned on the wood turning lathe machine to produce a pattern of diameter 35 mm, by using a rough chisel tool and by using a fine finishing chisel. The diameter is brought down, to 32 mm and still fine surface was obtained by rubbing sand paper in it.

5.1.5 Moulding process

The sand used in the Moulding process was green and hand Moulding procedure was adopted. The mould produced is known as green sand mould. The procedure used in making mould for the required casting is as follows

1. Drag was placed on the mould board, graphite powder was sprinkled inside the drag.
2. One fourth portion of drag was filled with green sand and rammed.

3. Pattern was placed vertically in a drag part and then filled by green sand and rammed.
4. After the sand is rammed a stickle was used to scrape off the excess sand level with the top of the drag. The mould was then vented by striking it with a fine stiff wire at the numerous places.
5. The cope portion was placed on the drag. And parting sand was sprinkled in it. Which was used to prevent the joints between the halves of the mould from adhering to one another, when the two parts of the Moulding box are separated.
6. By placing runner and rises at a proper place cope portion was filled with the sand, ramming and venting of cope proceed in the same manner, as in the drag.
7. Wooden pegs are (ie. Runner and rises) with drawn form the cope and a funnel shaped opening is scooped out at the top of sprue to form the pouring basing. Next the cope is lifted off and placed on the board with the parting line up ward.
8. Pattern was drawn out and gate were cut in the drag form the pattern to the sprue.
9. Finally, the mould was assembled, the cope being carefully placed on the drag, so that flask pins fit into the bushes.

5.2 Melting and mixing of materials

5.2.1 Melting

A weighed quantity of aluminium was melted in a crucible; the melt was then superheated to a temperature range of about 750⁰C

5.2.2 Mixing of materials

The melt temperature was maintained at 750⁰C and the surface skin on the liquid Aluminium was skimmed off stirring was initiated using a stainless steel impeller was rotated at about 200 rpm.

The weighed quantity of Quartz powder was added at the periphery of the vertex through the nozzle of the powder feeder. Stirring was continued while adding Quartz powdered particles for uniform distribution of it.

It was then stirred at a lower speed for about one to two minutes. Subsequently the stirring was stopped and the impeller was quickly with drawn.

5.3 Production of Casting

5.3.1 Casting

Casting is a process of forming metallic products by melting metal pouring it into the cavity known as the mould and allowing it to solidify. When it was removed from the mould it was of the same shape as the mould.

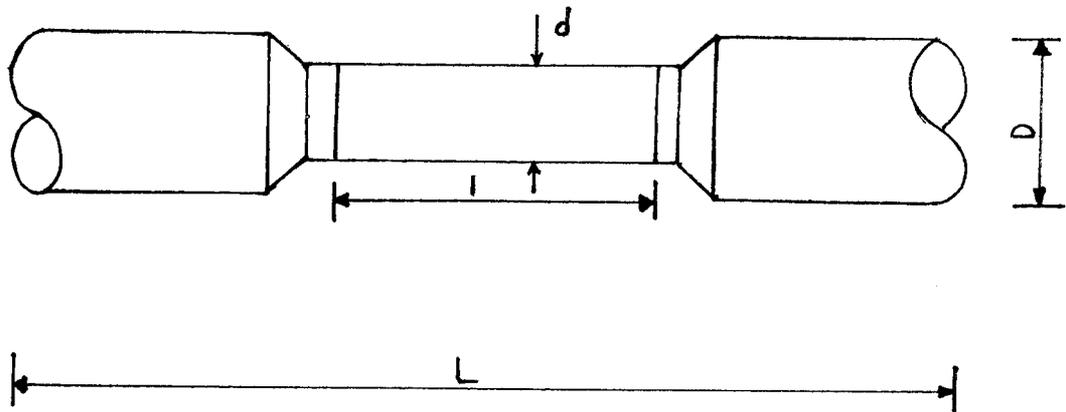
5.3.1.1 Procedure

The temperature at the end of stirring operation was maintained at about 700°C.

1. The melt was poured at 690°C into permanent moulds & while pouring floating slag was skimmed by Skimming bar.
2. It was observed that molten metal was rising into the riser, then pouring was stopped.
3. It is then permitted to cool and solidify. When the casting had solidified it was removed from the sand in the moulding box. This operation is called shake out.
4. Casting when taken out of the mould was not in the same condition, in which they are desired, since they have sprue, risers, gates etc. attached to them. Besides they are not completely free of sand particles.
5. The cutting of the unwanted parts, cleaning & finishing the casting was done, which is known as fettling which includes the following:
 - ❖ Removal gates, risers, runners etc from the casting.
 - ❖ Removal of fins and other unwanted projections
 - ❖ Removal of adhering and oxide scale from the surface of casting.
 - ❖ Repairing casting to fill up blow holes, straightening wrapped or deformed castings.

5.4 Turning & machining to the standard dimensions

5.4.1 Machining procedure



The high speed steel (H.S.S) tool a steel of high molybdenum variety, ground and polished type was used, because of its ability to retain cutting edge hardness up to 600 C and more importantly due to wear resistance, which inturn reduces the number of regrinding needed. Because of complex conditions of machine shop, the results of this analysis should not be used uncritically as in these complex conditions. There can be relatively few statements, which apply universally.

The castings were first faced to 305 mm in length and using ball bearing centre tool the casting was fixed between the two centres of the centre lathe did centering also. The rough turning of the casting with the depth of cut of 0.5 mm and fine turning of the casting was done by giving a depth of cut in step of 0.3 mm with the feed of 0.4 mm rev to get the diameter of 30 mm. The diameter of the specimen at the centre for the length of 112 mm was reduced by turning with a depth of cut of 2 mm and the feed of 0.6mm/rev and lastly with the depth of cut of 1mm and feed of 0.2mm/rev, the dia of 22 mm was obtained. The taper at the both side of the centre part of the specimen as shown in the figure was obtained by offset method of taper turning operation. After this finishing was done.



PROPERTY ANALYSIS



6 PROPERTY ANALYSIS OF MMC

6.1 Tensile test

The test is performed on machines such as houns field tensometer, universal testing machine (UTM), in stron or material testing system (MTS). The tensometer is used for testing of this section and low tensile strength materials such as leathers, rubber, thin wire, nylon, plastics and plywood etc. a **typical houns** field tensometer consist of several load scales, its loading capacity rages between 0-31 Kgf on the smallest load scale 0-200 Kgf respectively. The VTMS have large load capacity. Generally ranging from 0-40 tonne materials with large section and high tensile strength such as steel and aluminium bars are tested on them. Tensometer is generally machnically operated while VTMS all hydraulically operated. They can be controlled by computers or can be operate manually.

While conducting the experiment a specimen is prepared in accordance to a standard such as ASTM (American Society of Testing Materials) ASM(American Society if Metals). Japanese standard (JIS), British Standard (BS), German Standard (DIN), Indian standard (IS).

We shall follow Indian Standard. The tensile test specimen is confromatic with IS. The grip are circular and cross section also in circular. According to the IS system the gauge length L for a circular seclur specimen is taken equal to

$$l = 5.65 \sqrt{A}$$

where A - cross sectional area.

The diameter considered $d = 22.52$ mm

$$A = \Pi d^2 / 4 = \Pi (22.52)^2 / 4 = 398.31 \text{ mm}^2$$

The initial gauge length (l) = 112.76 mm

The test performance is judged for gauge length 'l' and not the full length 'L' of specimen. The two ends of the large cross section are gripped by the machine jaws.,

6.1.1 Object

- (a) To perform tensile test on Al-Quartz metal matrix composite specimen and to draw stress strain curve.
- (b) to calculate the following.
 - 1. Ultimate stress
 - 2. Breaking stress
 - 3. Elongation on gauge length
 - 4. Young's modulus.

Ultimate tensile strength (ultimate stress):

It is the maximum stress that a test specimen can bear before based on original cross sectional area

$$F = \text{ultimate load} / \text{c/s area}$$

Breaking stress (Fracture stress) :

It is the stress at fracture based on original cross sectional area.

6.1.2 Test procedure

1. Measure the diameter of the given test specimen at 3 different places, along its length
2. Mark off the gauge length on the specimen.
3. Adjust the load measuring range of the machine
4. Adjust the pointer of the load gauge to zero
5. clamp the specimen between lower and upper grip heads.
6. Fix the dial gauge between upper and lower jaw.
7. Switch on and load the specimen only.
8. Take the readings of dial gauge at suitable load intervals 500kg
9. Note down the Ultimate load.
10. When the specimen breaks take the breaking load.



11. Remove the specimen and join the two broken pieces and measure the length between gauge marks and the reduced diameter at the place of fracture.

6.1.3 Observation & calculation

6.1.3.1 Specimen No.1

1. Material composition (99% Aluminium –0% Quartz)
2. L.C of vernier calipers =0.02 mm
3. L.C of extensometer = 1/100 mm
4. Initial gauge length = 112.76 mm
5. Initial diameter $d_1 = 22.52$ mm
6. Original cross sectional area $A_1 = 398.3$ mm²

Tabular column for specimen - 1 has been attached

7. ultimate load - $p_u = 1840$ Kg
8. Breaking load = 1840 Kg
9. Ultimate stress = 4.62 Kg/mm²
10. Breaking stress = 4.62 Kg/mm²
11. % Elongation = 2.27%
12. Modulus of Elasticity from graph = 15.625 Kg/mm²

6.1.3.2 Specimen No 2

- 1 Material Composition (97 % Aluminium –2% Quartz)
- 2 Initial length $l_1 = 112.76$ mm
- 3 Initial diameter $d_1 = 22.52$ mm
- 4 original cross - sectional area $A_1 = 398.31$ mm²

Tabular column for specimen No 2 has been attached.

- 5 Ultimate load = 2400 Kg
- 6 Breaking load = 2400 Kg
- 7 Ultimate stress = 6.03 Kg / mm²
- 8 Breaking stress = 6.03 Kg / mm²
- 9 % Elongation = 2.52 %
- 10 Modulus of elasticity from graph = 16.07 Kg / mm²

6.1.3.3 Specimen No : 3

- 1 Material composition (95 % Aluminium – 4 %Quartz)
- 2 Initial length $l_1 = 112.96$ mm
- 3 Initial diameter $d_1 = 22.56$ mm
- 4 original cross - sectional area $A_1 = 399.73$ mm²

Tabular column for specimen No 3 has been attached.

- 5 Ultimate load = 2460 Kg
- 6 Breaking load = 2460 Kg
- 7 Ultimate stress = 6.15 Kg / mm²
- 8 Breaking stress = 6.15 Kg / mm²
- 9 % Elongation = 3.67 %
- 10 Modulus of elasticity form graph = 16.67 Kg / mm²

6.1.3.4 Specimen No : 4

1. Material composition (93 % Aluminium – 6 %Quartz)
2. Initial length $l_1 = 112.96\text{mm}$
3. Initial diameter $d_1 = 22.56 \text{ mm}$
4. original cross - sectional area $A_1 = 399.73 \text{ mm}^2$

Tabular column for specimen No 3 has been attached.

5. Ultimate load = 2640 Kg
6. Breaking load = 2640 Kg
7. Ultimate stress = 6.60 Kg / mm²
8. Breaking stress = 6.60 Kg / mm²
9. % Elongation = 3.75 %
10. Modulus of elasticity form graph = 17.825 Kg / mm²

Si'Tarc

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DATE: 99.03.09

TEST CERTIFICATE REPORT NO. M 3878

Received on: 99.03.08

No. of Samples: 1

Date: 99.03.08

AS PER IS: 1816-1979

TEST ON STEEL/ Aluminium

Code No.	Description of Sample	DIMENSIONS OF SAMPLE			YIELD		ULTIMATE		BREAKING		PERCENTAGE		Rockwell Brinel Hardness No.	Remarks
		Dia mm	Area mm ²	Gauge length in mm	Load kg or N	Stress kg/mm ² or N/mm ²	Load kg or N	Stress kg/mm ² or N/mm ²	Elongation in length %	Reduction in area %				
M 5206	Aluminium Sample marked 121	22.52	398.31	112.76	-	-	1840	4.62	1840	4.62	2.27	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Tested by

H. S. S. S.
Officer-in-charge

[Signature]
Lab-in-charge
MECH. ENGG. DIVISION

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SMALL INDUSTRIES' TESTING
AND RESEARCH CENTRE

Director

Sitarc

SMALL INDUSTRIES' TESTING AND RESEARCH CENTRE

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DATE: 99.03.09

TEST CERTIFICATE/ REPORT NO. M 3879

Received on: 99.03.08

No. of Samples: 1

Date: 99.03.08

AS PER IS: 1816-1979

TEST ON ALUMINIUM

Code No.	Description of Sample	DIMENSIONS OF SAMPLE			YIELD		ULTIMATE		BREAKING		PERCENTAGE		Rockwell Brinel Hardness No.	Remarks
		Dia mm	Area mm ²	Gauge length in mm	Load kg or N	Stress kg/mm ² or N/mm ²	Load kg or N	Stress kg/mm ² or N/mm ²	Load kg or N	Stress kg/mm ² or N/mm ²	Elongation in length %	Reduction in area %		
M 5207	Aluminium Sample Marked: 13'	22.52	398.31	112.76	-	-	2400	6.03	2400	6.03	2.52	-	-	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	

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Officer-in-charge

Lab-in-charge
MECH. DIVISION

ENGG. DIVISION

Director

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DATE: 99.03.09
 TEST CERTIFICATE REPORT NO. M 3880
 Order No.: - Date: 99.03.08 No. of Samples: 1 Received on: 99.03.08

TEST ON ALUMINIUM

AS PER IS: 1816-1979

Code No.	Description of Sample	DIMENSIONS OF SAMPLE			YIELD		ULTIMATE		BREAKING		PERCENTAGE		Rockwell Brinell Hardness No.	Remarks
		Dia mm	Area mm ²	Gauge length in mm	Load kg or N	Stress kg/mm ² or N/mm ²	Load kg or N	Stress kg/mm ² or N/mm ²	Load kg or N	Stress kg/mm ² or N/mm ²	Elongation in length %	Reduction in area %		
M 5208	Aluminium Sample Marked: 14	22.56	399.73	112.96	-	-	2640	6.60	2640	6.60	3.75	-	-	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	

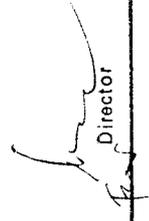
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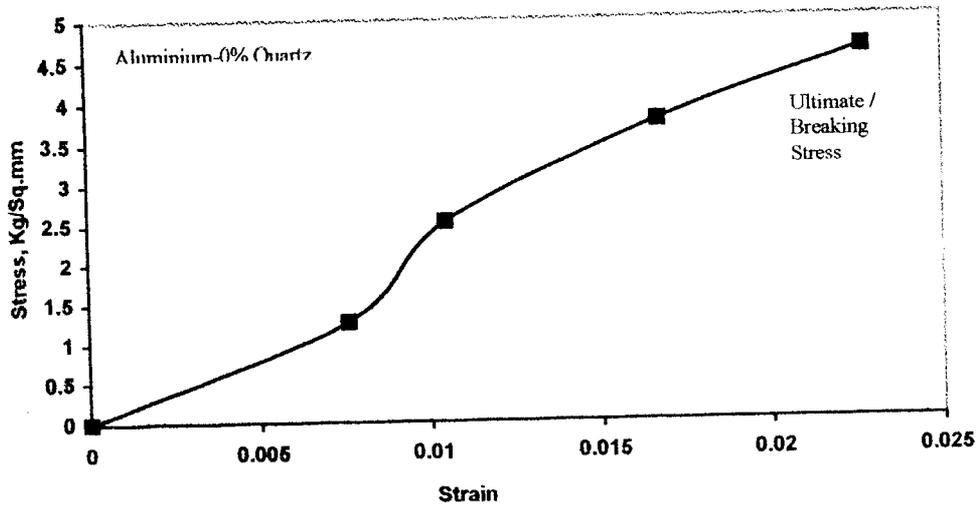

 Officer-in-charge


 Lab-in-charge
 MECH. ENGG DIVISION

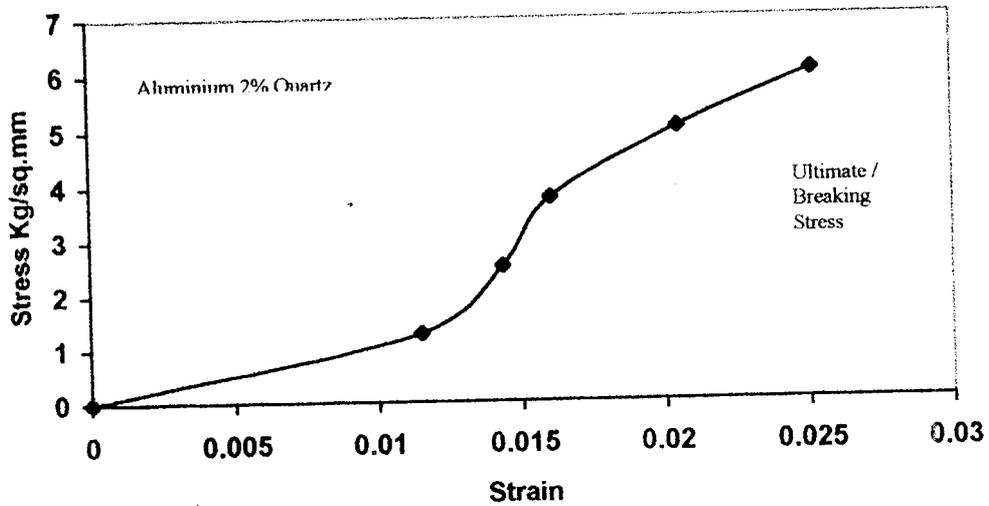
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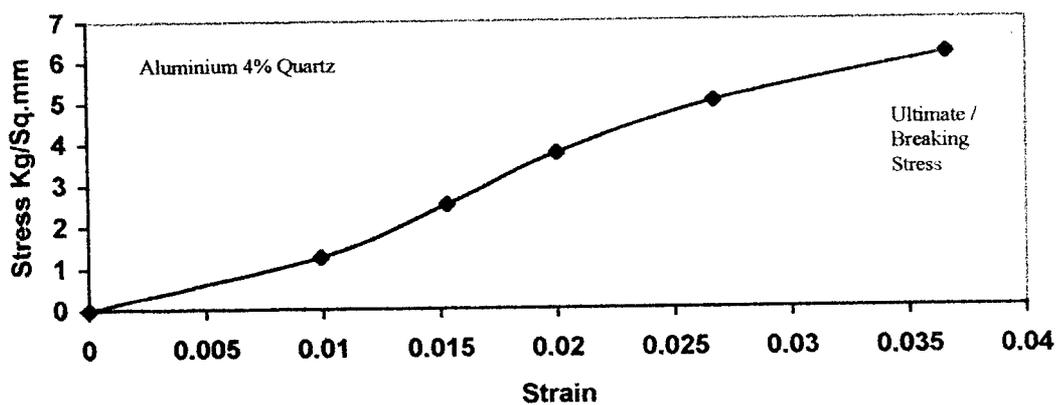
Specimen No: 1



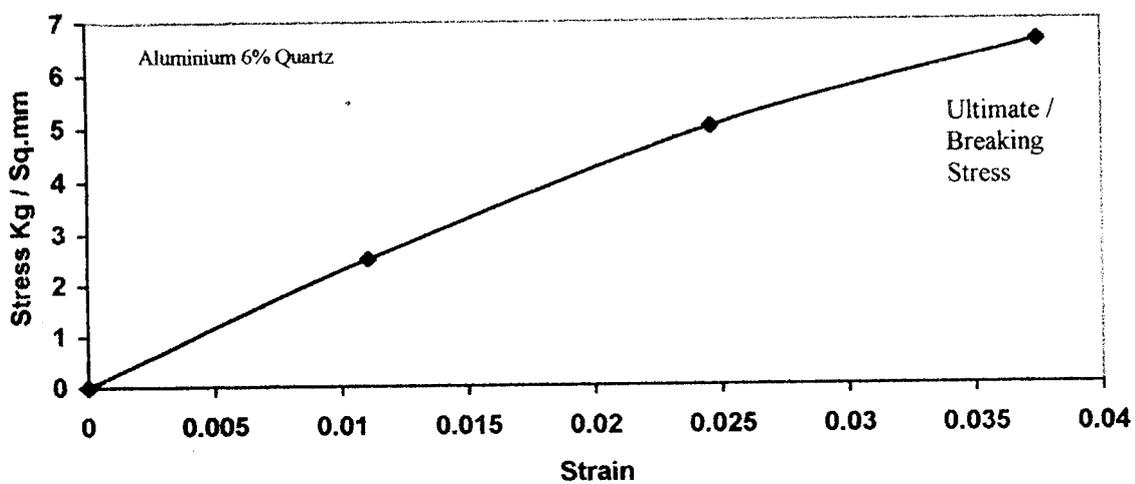
Specimen No: 2



Specimen No:3



Specimen No:4



6.1.4 Results

Specimen No.	Tensile strength Kg / mm ²	Youngs Modulus Kg / mm ²
1	4.62	15.625
2	6.03	16.07
3	6.15	16.67
4	6.60	17.825

The results of tensile test is conducted on the composites are presented in the table and it is clear that tensile strength and youngs modulus is increasing with increase in the percentage of Quartz.

6.2 Hardness Test

Hardness is a property exhibited by the material, hardness is property of a metal by virtue of which it resists scratch, wear abrasion or indentation.

6.2.1 Scope and applicability

Hardness test have a wide field of views, although as commercial tests, they are perhaps more commonly applied to metals then to any other class of material.

6.2.2 Some uses of hardness test

1. Similar materials may be graded according to hardness. The degree of hardness helps in selecting a material to a particular service based upon previous experience with material under the given service.
2. The quality level of material of production maybe checked or controlled by hardness test.

6.2.3 Brinell Hardness Test

The test consists in forcing steel ball of diameter 'D' under a load 'P' into the test piece and measuring the mean diameter 'D' of the indentation left in the surface after removal of the load.

The Brinell hardness is obtained by dividing the test load 'F' in kg by the curved surface area of the indentation (sq mm) . The curved surface is assumed to be a portion of the sphere of diameter 'D'.

For the Brinell hardness test, the surface of the specimen. On which the impression is made should be smooth, clean, dry and free from oxide scales.

For ferrous metals the load range $p=30D$ should be used for non-ferrous metals like brass, aluminium, load range $p=10D^2$, should be used

BHN = load P/spherical area of indentation

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

The Brinell hardness test makes use of a steel ball as an indenter. The hardness of the steel ball should be sufficiently higher than the material under test, otherwise the indenting the ball itself will be deformed. Thus the hardness condition cannot be determined by this method. In the other word, the Brinell hardness number are not reliable above 350. Further, depending upon the material, under test, right selection of the ball and the load should be made.

Very thin specimen should not be tested by the Brinell method, When there is not sufficient material to backup the region of indentation will become unduly large due to the least resistance offered to the ball. The thickness of the material under test, should be at least equal to the diameter of the indenter.

The hardness of the composites was measured using a Brinell hardness testing machine, with a ball indenter of 5mm diameter and 500 kg, the load was applied for 10 seconds in order to eliminate possible segregation effect a minimum of two hardness readings, were taken for each specimen.

6.2.4. Object

To find the hardness of the Al-Quartz metal matrix composite material using Brinell testing machine.

6.2.5. Procedure

1. Study the operation of the machine
2. Choose the diameter of the ball indenter depending upon thickness of the specimen.
3. Obtain the load to be applied using P/D^2 ratio.
4. Place the required counter weights on the lever.
5. Keep the specimen on the table, with its smooth clean, flat surface, towards the indenter, bring the specimen in contact with indenter by raising the table.
6. Start the machine and allow the load for 10 seconds.
7. Repeat the test on the specimen two times at different places.
8. Remove the specimen and measure the diameter of indentation.

9. Compute the hardness value using given formulae

6.2.6 Observation

1. Diameter of the indenter [D] = 5mm
2. Least count of Brinell microscope = 0.1mm
3. Time of load application = 10 Sec.

6.2.6.1 Specimen No .1

Material comp.	Indenter diameter (mm)	Load P (N)	Diameter of the Indentation (mm)			BHN	Avg. BHN
			d1	d2	davg.		
99 % Al – 0 %quartz	5	5000	4.1	4.15	4.125	292.7	297.7
			4.05	4.10	4.075	302.7	

6.2.6.2 Specimen No 2

Material comp.	Indenter diameter (mm)	Load P (N)	Diameter of the Indentation (mm)			BHN	Avg. BHN
			d1	d2	davg.		
97 % Al – 2 %quartz	5	5000	4.00	4.00	4.00	318.0	315.5
			4.00	4.05	4.025	313.0	

6.2.6.3 Specimen No 3

Material comp.	Indentor diameter (mm)	Load P (N)	Diameter of the Indentation (mm)			BHN	Avg. BHN
			d1	d2	davg.		
95 % Al – 4 %quartz	5	5000	3.9	3.95	3.925	334.6	329.1
			3.85	4.00	3.975	323.6	

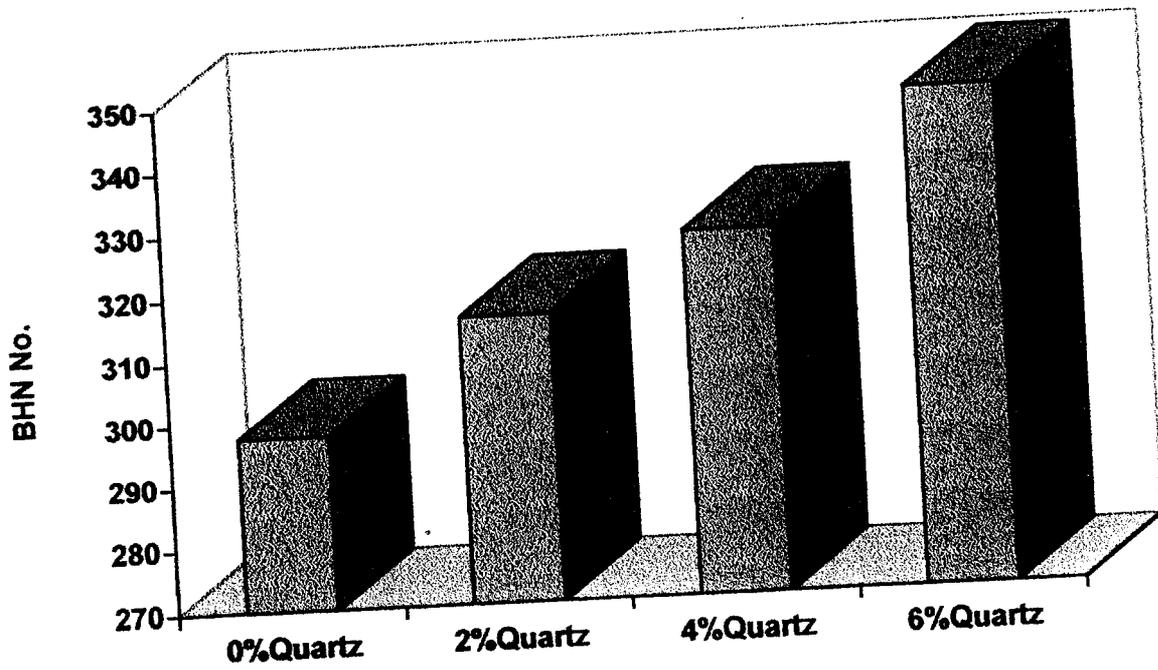
6.2.6.4 Specimen No 4

Material comp.	Indentor diameter (mm)	Load P (N)	Diameter of the Indentation (mm)			BHN	Avg. BHN
			d1	d2	davg.		
93 % Al – 6 %quartz	5	5000	3.85	3.9	3.875	345.9	348.8
			3.8	3.9	3.85	351.17	

6.2.7 Results

Specimen No.	BHN
1	297.7
2	315.7
3	329.1
4	348.8

Bar Chart for BHN Tests

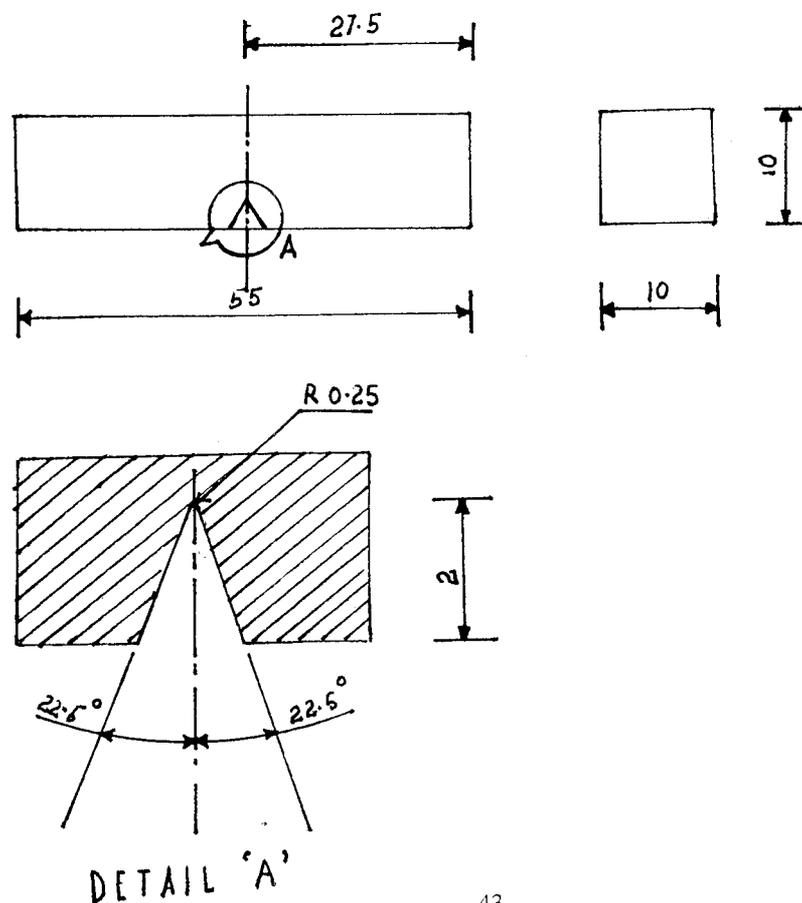


After conducting the hardness test on the specimen prepared by Al-quartz metal matrix composite, it was observed that hardness increases with the increase in the percentage of Quartz, the tensile strength of the specimen also increased with percentage increase in Quartz.

6.3 Izod Impact Test

Izod impact test is used to determine the impact value for the material of the specimen, the impact value indicates the toughness of the material of its resistance to shock.

The specimen used for this test are as follows.



6.3.1 Principle of the Test

Toughness is the ability of the material to absorb energy and deform plastically before failure. It is usually measured by the energy absorbed in a notched impact test like Izod.

The ordinary impact machine has a pendulum in fixed swinging which with reference to rise pendulum has definite arm of potential energy when it is released energy is converted into kinetic energy until it strikes the specimen and energy used to break the specimen. The needle shows the load used to break the specimen. It is expressed in Newton.

6.3.2. Uses of Impact test :

1. The result are highly is useful for comparison purpose especially in quality control.
2. The impact test is largely used for steel in welding structures, pressure vessels etc.
3. This test is used by aircraft, automobile industries, which have been found by experience high impact strength by test, generally gives satisfactory service when stock load are encountered.

6.3.3. Object

To determine the impact value of specimens & to compare the results.

6.3.4. Test Procedure

1. The pendulum is taken to the highest position and locked.
2. The test parts is gripped on the machine according to the type of test.
3. The loose pointer attached to the pendulum is set to maximum loading scale.
4. The pendulum is then released by trigger.
5. The pendulum breaks the specimen and continuous to swing. It gives direct reading if the impact value.

6.3.5 . Technical Data

1. Maximum impact energy of pendulum = 168 J
2. Angle of dropp of the pendulum = $90^{\circ} 47^{\circ 00}$
3. Striking velocity of pendulum = 3.857 m/s
4. Length of specimen = 55 mm
5. Depth below the notch = 8 mm

6.3.5.1. Specimen No 1

Loss of friction (L.F) = 0 J

Impact energy (I.E) = 18 J

Actual Impact energy = I.E - C.F

$$\begin{aligned} &= 18 \text{ J} \\ \text{Impact value} &= \frac{\text{Actual impact strength}}{\text{cross sectional area below the notch}} \\ &= 16 / 80 \\ &= 0.2 \text{ J / mm}^2 \end{aligned}$$

6.3.5.2 Specimen 2

Loss of friction = 0 J

Impact energy = 18 J

Actual Impact energy = 18 J

Impact value = $18 / 80 = 0.225$

6.3.5.3. Specimen 3

Loss of friction = 0 J

Impact energy = 20 J

Actual impact energy = 20 J

Impact value = $20 / 80 = 0.25 \text{ J / mm}^2$

6.3.5.4. Specimen 4

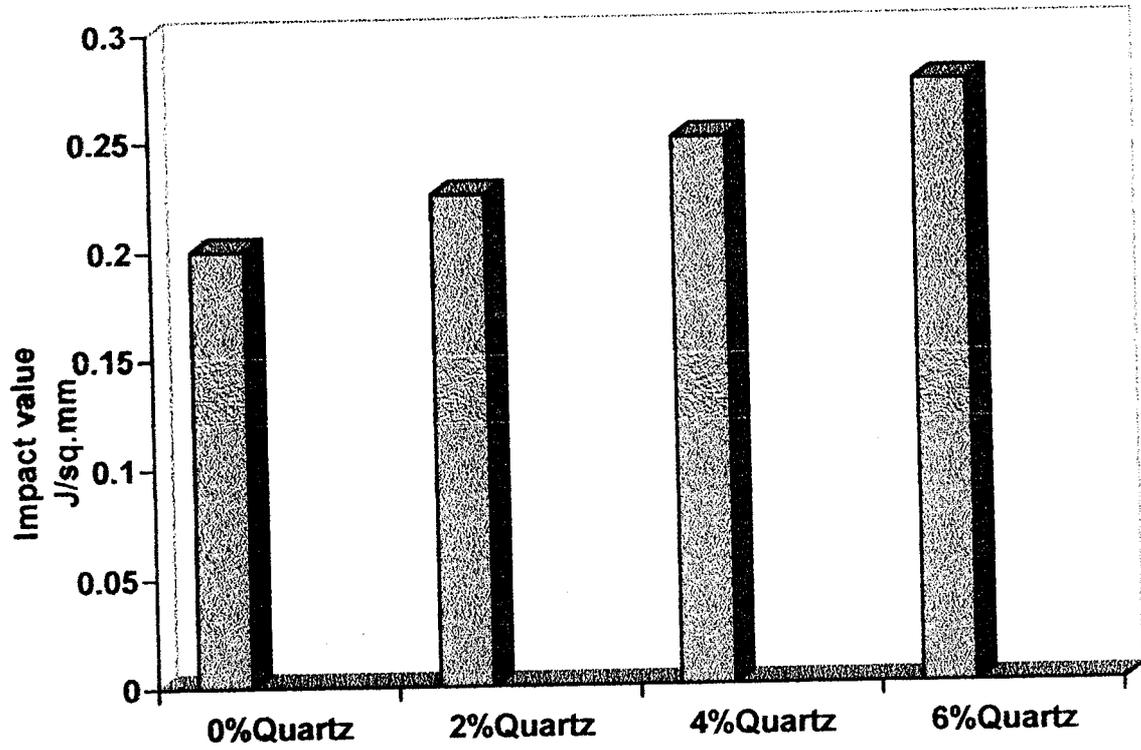
Loss of friction = 0 J

Impact energy = 22 J

Actual Impact energy = 22 J

Impact value = $22 / 80 = 0.275 \text{ J / mm}^2$

Bar Chart for Impact test



RESULTS :

Specimen No	Impact Value (J / mm ²)
1	0.2
2	0.225
3	0.25
4	0.275

After conducting the hardness test on the specimen prepared by Al-Quartz metal matrix composite, it was observed that impact value increases with the increase in the percentage of Quartz.

6.4 Chemical Analysis : The Chemical composition of the fabricated specimen was determined at the testing centre. The composition of quartz in the test specimen was found to be almost nearer to the mixed proportion. Thus the presence of quartz in the metal matrix composite was confirmed.

Specimen No	quartz %
1	0.2
2	2.02
3	4.14
4	6.22

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TEST CERTIFICATE/REPORT NO- C 4536

DATE: 99.03.11

TEST REPORT OF CHEMICAL ANALYSIS

1. PARTICULARS OF SAMPLE

NAME & ADDRESS OF CUSTOMER :

S.Boopalakrishnan,
S.Gowhar Ali,
P.Madhusudhana Prabhu,
Kumaraguru College of Tech.,
COIMBATORE - 6.

ORDER No. : -

Date : 99.03.09

Code No. : C 7347 to

No. of Samples : 4

Received on : 99.03.09

2. RESULTS OF CHEMICAL ANALYSIS

Sample Ref	C	S	Mn	P	Si				
Aluminium Bars									
1	-	-	-	-	0.2%	-	-	-	-
2	-	-	-	-	2.02%	-	-	-	-
3	-	-	-	-	4.14%	-	-	-	-
4	-	-	-	-	6.22%	-	-	-	-
-	-	-	-	-	--	-	-	-	-

Tests for the above results were carried out as per IS - 504

Tested by


Chemist


Officer-in-charge

CHEMISTRY LAB

SMALL INDUSTRIES' TESTING AND RESEARCH CENTRE


Director

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 3. The results reported in this certificate are valid at the time of and under the stated condition of measurement.
 4. Correction or attestation if any invalidate this certificate. This report is strictly confidential. Its use for publicity, arbitration or as evidence in legal disputes is forbidden.

6.5 Microstructure Study

6.5.1. Preparation of Specimen for Photomicrograph

Satisfactory metallographic results can be obtained only when the specimen has been carefully prepared. A properly prepared metal specimen is flat, does not contain scratches, nicely polished and is suitably etched.

6.5.2. Procedure

1. **Selection of Specimen** : when investigating the property of a metal or alloy or composite, it is essential that area which can be taken as representation of the whole mass
2. **Cutting of Specimen**: After selecting a particular area in the whole mass the specimen was removed with the help of a saw.
3. **Mounting the Specimen**: Specimen was too small to hold in hand. For further processing it was mounted in thermoplastic resin
4. **Obtaining flat Specimen Surface** : It is necessary to obtain a reasonably flat surface on the specimen. This was done by using fairly coarse file and grinding by using a motor driven energy belt.
5. **Inter mediate and fine grinding** : Fore grades of abrasive were used 220 grit, 400 grit and 600 grit the 320 grit the had particles size at about 33 microns and 600 grit that of 17 microns.

The specimens first ground on 220 grit so that scratches are produced roughly at right angle to those initially existing on the specimen and produced through preliminary grinding.

Grinding was then continued on the number 320 paper again turning the specimen through 90 degrees and polished until the previous scratch marks are removed.

The process was repeated with number 400 and number 600 paper grinding with the number 200, 320, paper had done in following way.

The specimen was hand rubbed against the abrasive paper, which has laid over a flat surface as a piece of glass plate. And some times the abrasive paper was mounted on the specimen was held in the hand against it. Also the surface of the abrasive paper was lubricated with water so as to provide a flushing action to easy away the particles cut from the surface

6. **Rough polishing** : Polishing was done by placing a very small quantity of diamond powder carried in paste that is oil-suitable on the nylon cloth covered surface of a clothing polishing wheel

The specimen was processed against the cloth of the rotating wheel with considerable pressure and was moved around the wheel in the direction opposite to rotation of the wheel to ensures a more uniform polishing action.

7. **Fine polishing** : The polishing compound used was aluminium (Al_2O_3) power (with a particle size of 0.05 microns) was placed on a cloth covered rotating wheel. Distilled water was used as a lubricant, fine polishing has removed fine scratches and very thin distorted layer remaining from the rough polishing stage.
8. **Etching** : In order to make the grain boundary visible again the fine polishing the metal specimen was etched.

6.5.3 Method

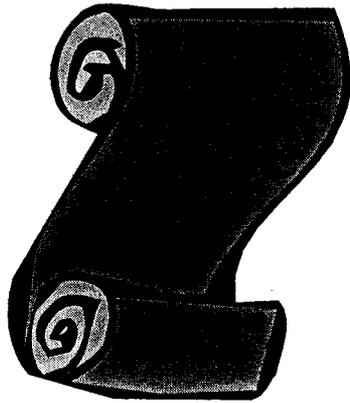
Before etching the polished specimen was thoroughly washed in running water.

Then the etching was done by rubbing the polished surface gently with a cotton swab wetted with the etching reagent.

After etching the specimen was again washed thoroughly and dried and then the specimen was studied under the microscope. The type of etchant used, Dilute Hydrofluoric acid (Hydrofluoric 0.5 cc, water 99.5 cc)

6.5.4 Photomicrograph

Photomicrographs of the aluminium-quartz Metal Matrix Composite were taken for the various percentages of quartz and detail study of the microstructure was made.



INFERENCES



APPLICATIONS



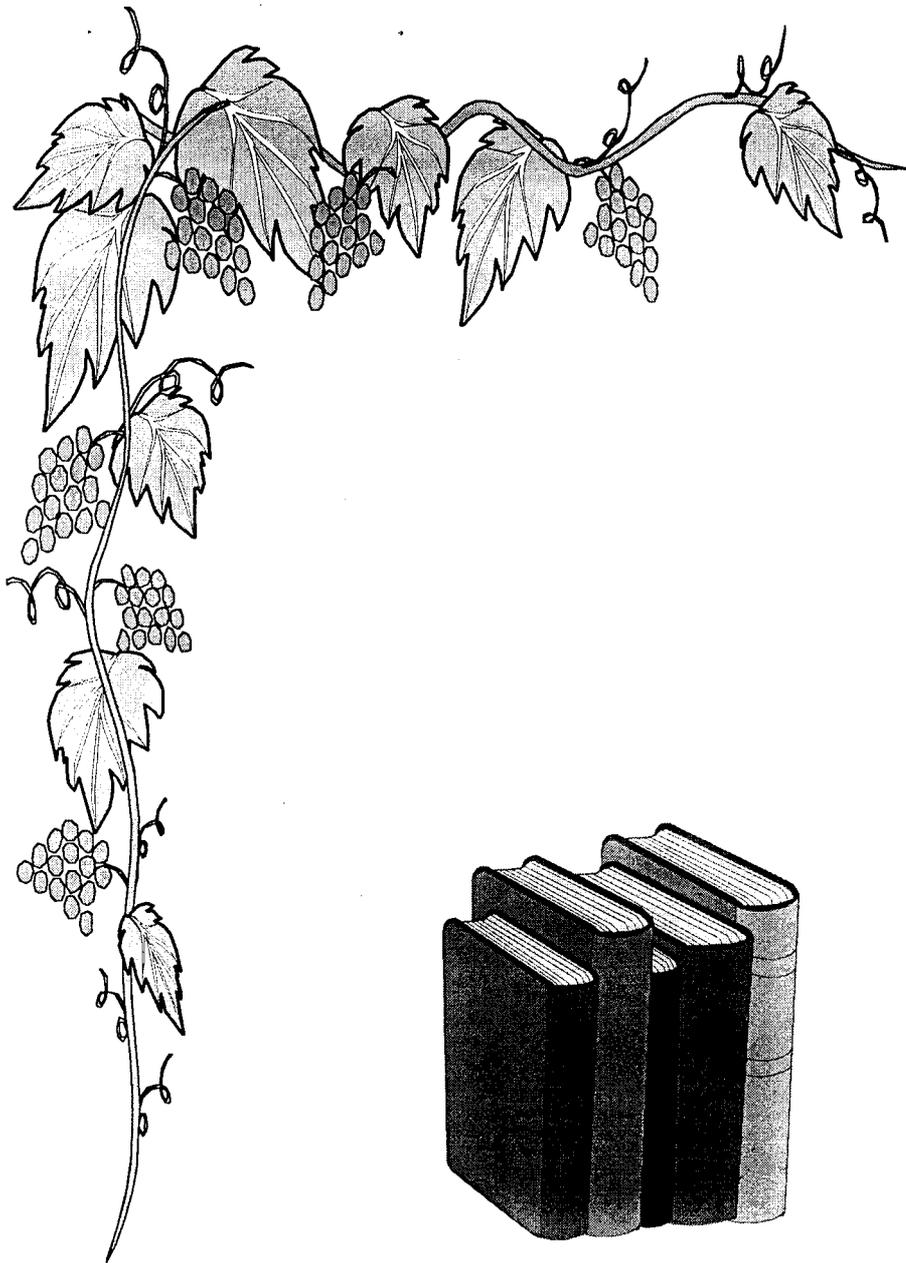


CONCLUSION



PHOTO MICROGRAPHS





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University of Mississippi
- # NASA – Conference Publications
- # NIST – National Institute of Standards and Technology, US.
- # JME – Journal of Material Education
Material Council of US.