A Review Paper on Research and Analysis of Non Asbestos Composite Material

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Abstract— *Composites are combinations of two or more different metals inter metallic compound. In this review paper some of the most suitable and non hazardous material has been used instead of Non asbestos material. Agricultural wastes like banana peels, palm kernel shells, palm wastes, rock wool, aramid fibers, flax fibers etc are studied. Mainly we have tried to replace those material with agricultural waste Different alternatives for filler material.*

We have checked the density, porosity, hardness and different properties of both the material agricultural waste as well as standard non asbestos material and we found slight difference in both the reading which shows that we can use those agricultural waste instead of standard non asbestos material. In order to reduce the cost of filler material and composite rexin we have used non hazards and nature friendly material like coconut pulp, banana peels, palm kernel shells, palm waste, etc. We have about manufacturing process of brake with non asbestos material and tried to replace those material with agricultural waste. Because of high frictional force at the plane of contact of brake de gradation of brakes pad are in higher amount due to heat formation to reduce the cost of brake shoe we have studied and checked all the related parameter and we found that we can use those agricultural waste as brake shoe by some treatment.

Composite material can produce by controlling the morphologies of the constituents to achieve optimum combination of properties. Properties of the composites depend on the properties of the constituent phases, their relative amount, dispersed phase geometry including particle size, shape and orientation in the matrix.

We have also studied about metal matrix or we can say aluminum metal matrix (AMC) in which we have mainly focused on silicon carbide just because of its various important properties. such as- greater strength and high specific modulus, improved stiffness, light weight, low thermal expansion coefficient, high thermal conductivity, tailored electrical properties, increased wear resistance and improved damping capabilities.

Non asbestos materials have found wide applications in our daily life. There are some advantages in using particles reinforced Now it is used in aerospace, thermal management areas, industrial products, automotive applications such as engine piston, brake disc etc.

Keywords— Brake, Composite Material, Natural Waste, Non Asbestos.

I. INTRODUCTION

In the past few years the global need for low cost, high performance and good quality materials has caused a shift in research from monolithic to composite materials.

Asbestos was once considered to be a "miracle mineral". This naturally occurring silicate has many desirable characteristics, including resistance to fire, heat, and corrosion. It is strong, durable and flexible. Asbestos is inexpensive because it is available in abundant quantities. Its versatility has led to its use as a component of a variety of products in numerous industries

In case of MMC's, aluminum matrix composite due their high strength to weight ratio, low cost and high wear resistance are widely manufactured and used in structural applications along with aerospace, high temp applications, circuit breakers and brake pads, liners in automobile industry. Also a simple and cost effective method for manufacturing of the composites is very essential for expanding their application. Reinforcements like particulate alumina, silicon carbide, graphite, fly ash etc can easily be incorporated in the melt using cheap and widely available stir casting method.

This paper presents a review on the mechanical and tribological properties of stir cast aluminum matrix composites containing single and multiple reinforcement and rubber brake.

The main purpose of brake is to decelerate a vehicle by transforming the kinetic energy of the vehicle to heat via friction and dissipating that heat to the surroundings. During this process the break pad play important role during braking.

As we apply the brake due to friction the heat is generated and break pad wears. Due to repetitive braking process large amount of heat is generated and break pad wear more rapidly due to thermal stress and it will not working properly

A composite material is a material system composed of a suitably arranged mixture or combination of two or more nano, micro, or macro constituents with an interface separating them that differ in form and chemical composition and are essentially insoluble in each other. The discrete constituent is called the reinforcement and the continuous phase is called the matrix. According to the chemical nature of the matrix phase, composite are classified as metal matrix (MMC), polymer matrix (PMC) and ceramic matrix composites (CMC). MMC's recently are drawing interests of the researchers because of the ability to alter their physical properties like density, thermal expansion, thermal diffusivity and mechanical properties like tensile and compressive behavior , creep, tribological behavior etc. by varying the filler phase. Also the growing requirement for advanced materials in the areas of aerospace and automotive industries had led to a rapid development of MMCs.

Aluminum-based Metal Matrix Composites (MMCs) have received increasing attention in recent decades as engineering materials. The introduction of a ceramic material into a metal matrix produces a composite material that results in an attractive combination of physical and mechanical properties which cannot be obtained with monolithic alloys. The various reinforcements that have been tried out to develop aluminum matrix composites(AMCs) are graphite, silicon carbide, titanium carbide, tungsten, boron, Al203, fly ash, Zr, TiB2. Addition of hard reinforcements such as silicon carbide, alumina, and titanium carbide improves hardness, strength and wear resistance of the composites [1, 2-4].

Aluminum alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These alloys have started to replace cast iron and bronze, to manufacture wear resistant parts. Investigation of mechanical behavior of aluminum alloys reinforced by micro hard particles such as Graphite is an interesting area of research.

AMCs can be manufactured by liquid state processing (stir casting, infiltration, squeeze casting etc.), semisolid processing and powder metallurgical route. Usually non metallic and ceramic particles like silicon carbide (SiC), alumina (Al_2O_3), boron carbide (B_4C), graphite etc. are used as reinforcements in AMCs. When loads are applied externally to the composites, metal matrix transmits loads to reinforcements and then loads are carried by dispersed reinforcements bonded with the matrix. Strong interface bond between reinforcements and matrix is required to obtain high strength of composites. Interface bond is formed by reaction or mutual dissolution during casting. Therefore, good wetting of the reinforcements is necessary during casting.

The disadvantage of producing AMC's usually lies in the relatively high cost of fabrication and of the reinforcement materials. The cost effective method for manufacturing composites is very important for expanding their application. Particulate-reinforced aluminum-metal matrix composites (AMCs) because of their isotropic properties and relatively low cost are attracting researchers. With the evolution of new processing techniques stir casting process has proved to be relatively economical and easy to use method.

II. PROBLEM DEFINATION

- The braking system of passenger vehicles consist of brake pad made up of semi-metallic lining material & brake disc of grey cast iron.
- During braking action brake pad comes in contact with disc & with increase in braking action leads to maximum wear of semi-metallic lining material & there is increase in temperature of brake pad affecting braking performance
- Also at high temperature there is generation of surface cracks & large amount of plastic deformation in brake rotor.

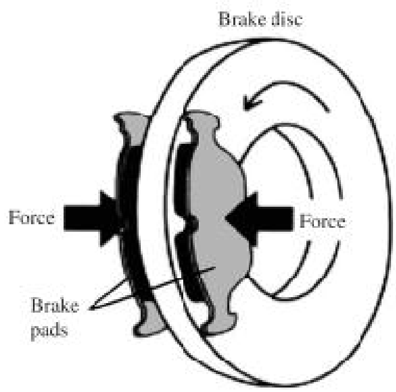


Fig.1: Brake system (Brake disc & Brake pad)

- This all discussion shows that mechanical properties and tribological properties of the non asbestos material is affected by manufacturing processes. So it is essential to find optimized constituents and best suitable manufacturing process for metal matrix composite and also there effects on properties.

- This problem gives out a way for development of composite by different manufacturing processes & evaluation of its mechanical characteristics.

III. FABRICATION PROCESS

Casting is probably one of the most ancient processes of manufacturing metallic components. The metal matrix composite used in the present work is prepared by the stir casting method. For the preparation of the Aluminum silicon carbide composite by using stir casting mass basis ratio of 100:2.5, 100:5, 100:7.5, and 100:10are taken. Fig. 1 illustrates the raw materials and samples of Aluminum Silicon Carbide material. Aluminium alloy in the form of ingots is used. The metal ingots are cleaned and melted to the desired super heating temperature of 75°C in graphite crucibles. Fig.2 shows schematic set up for stir casting technique. A three-phase electrical resistance furnace with temperature controlling device is used for melting. For each melting 300 - 400 gof alloy is used. The super heated molten metal is degassed at a temperature of 780°C. SiC particulates, preheated to around 500°C, are then added to the molten metal and stirred continuously by a mechanical stirrer at 720°C.The stirring time is between 5 and 8 minutes. During stirring, Borax powder was added in small quantities to increase the wettability of SiC particles.

The melt, with the reinforced particulates, is poured into the dried, coated, cylindrical permanent sand mould. The pouring temperature is maintained at 680oC. The same molten metal and SiC particle mixture was poured into strip. The melt was allowed to solidify in the moulds. The mould has been prepared (Fig.3)for casting specimen for various mechanical tests. The sand mould is prepared approximately 10cm in diameter and 8cm to 10cm in height

The powder metallurgical method can also be used for the same component .In this technique powder were ball milled using a horizontal attritor (CM01, Zoz GmbH).The milling atmosphere was helium. The very reactive ball-milled powders were discharged in a purified argon glove box (Jacomex)to prevent oxidation. In order to prepare the bulk material, theas-milled powders were introduced into a mold, which was out gassed and then sealed into the glove box. Hydrostatic pressure(0.2 GPa) was then applied to the rod. After removing the mold, the green compact was heated for a few minutes at 1000°C in a protective atmosphere leading to the formation of the Al–SiC nano-composite. Finally, a fully dense material was obtained by means of a hot extrusion process using a 13 kbar vertical hydraulic press.

3.1 Powder Metallurgy:

Powder metallurgy is the process of blending fine powdered materials, pressing them into a desired shape (compacted), and then heating the compressed material in a controlled atmosphere to bond the material (sintering). The powder metallurgy process generally consists of following basic steps:

1) Powder manufacture,
2) Powder mixing and blending
3) Compacting
4) Sintering
5) Extrusion

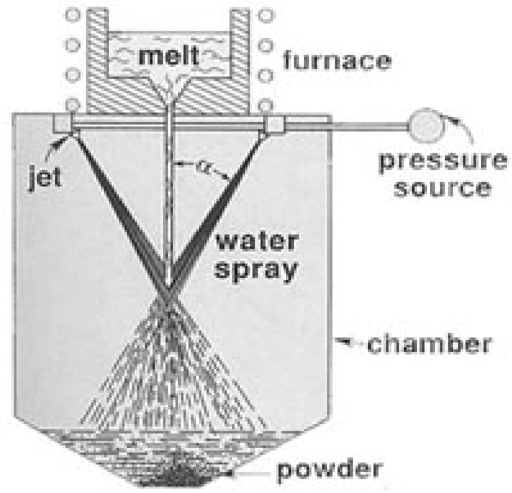


Fig.2: Schematic of Powder Metallurgy processes

Blending

- Blending is homogenous mixing of powder particles and Reinforcement material.
- Which is carried out by milling process with the help of Milling M/Cwhich is shown in fig
- This contains cylindrical vessel rotating horizontally along the axis.
- Length of the cylinder is more or less equal to diameter.
- The vessel is charged with the grinding media.
- The grinding media/balls may be made of hardened steel, or tungsten carbide,ceramics like agate, porcelain, alumina and zirconium.
- During rolling of vessel, the grinding media & powder particles roll fromsome height.
- This process grinds the powder materials by impact/collision & attrition.

Fig.4: Ball Milling M/C.

- During milling, impact, attrition, shear and compression forces are actedupon particles.
- During impact, striking of one powder particle against another occurs.
- Attrition refers to the production of wear debris due to the rubbing action between two particles. Shear refers to cutting of particles resulting in fracture.
- The particles are broken into fine particles by squeezing action in compression force type which is shown in fig. 4.2.3
- Main objective of milling: Particle size reduction (main purpose), Particle size growth, shape change, agglomeration (joining of particles together),solid state alloying,

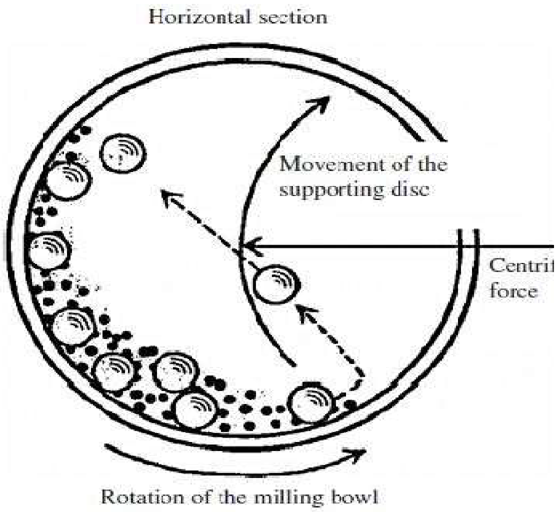


Fig.5: Horizontal section of Ball Mill container

Compaction:

- Compaction is an important step in powder processing as it enables the forming of loose metal powders into required shapes with sufficient strength to withstand till sintering is completed.
- Die compaction: In this process, loose powder is shaped in a die using a mechanical or hydraulic press giving rise to densification shown in fig 3.7and fig 3.6 respectively.
- The mechanisms of densification depend on the material and structural characteristics of powder particles.

In general, compaction is done without the application of heat.

- Loose powders are converted into required shape with sufficient strength withstand ejection from the tools and subsequent sintering process.
- In cases like cemented carbide, hot compaction is done followed bysintering.

Different steps in compaction:

1. Die Filling: Charging of Die with Powder Mixture by mechanical arrangement.

2. Compaction: Applying load using a punch (uni-axial) or double punch (Bidirectional) to compact powders.

3. Ejection: Removal of green compact by removing load i.e Top Punch

Fig.6: Hydraulic press

Sintering:

- It is the process of consolidating either loose aggregate of powder or a green compact of the desired composition under controlled conditions of temperature and time. (fig 3.8)

Fig.8: Tubular Sintering Furnace

- Sintering is nothing but heating of compacted samples up to 75% of Melting point of material under controlled condition.

Stages in solid state sintering:

In general, solid state sintering can be divided into three stages

- **1st stage:** Necks are formed at the contact points between the particles, which continue to grow. During this rapid neck growth takes place. Also the pores are interconnected and the pore shapes are irregular.
- **2nd stage**: In this stage, with sufficient neck growth, the pore channels become more cylindrical in nature. The curvature gradient is high for small neck size leading to faster sintering. With sufficient time at the sintering temperature, the pore eventually becomes rounded. As the neck grows, the curvature gradient decreases and sintering also decreases. This means there is no change in pore volume but with change in pore shape. Pores may become spherical and isolated. With continued sintering, a network of poresand a skeleton of solid particles is formed. The pores continue to form a connected phase throughout the compact.
- **3rd stage:** In this stage, pore channel closure occurs and the pores become isolated and no longer interconnected. Porosity does not change and small pores remain even after long sintering times.

3.4 Hot extrusion process:

- Extrusion is a plastic deformation process in which a block of metal(billet) is forced to flow by compression through the die opening of a smaller cross-sectional area.(fig 3.10)

Fig.9: Hot Extrusion

- Extrusion is an indirect-compression process.
- Indirect-compressive forces are developed by the reaction of the workpiece (billet) with the container and die; these forces reach high values.
- The reaction of the billet with the container and die results in high compressive stresses that is effective in reducing the cracking of the billet Material during primary breakdown from the billet.
- Extrusion is the best method for breaking down the cast structure of the billet because the billet is subjected to compressive forces only.
- Extrusion can be cold or hot, depending on the alloy and the method used.
- The two basic types of extrusion are direct and indirect, which are commonly used in aluminum industries.
- Solid and hollow shapes are designed and extruded for a wide range of programs: Solid sections, bars, and rods extruded from solid billets by direct extrusion.

- Tubes and hollow sections extruded from solid billets through porthole or bridge-type dies (for certain alloys) by direct extrusion.
- Tubes and hollow sections extruded from hollow or solid billets (latter pierced in the press via floating mandrel) by direct extrusion.
- Tubes and hollow sections extruded from hollow or solid billets (latter pierced in the press via stationary mandrel) by direct extrusion.
- Critical solid sections, bars, and rods extruded from solid billets with sealed container through the die mounted on the stem by indirect extrusion.

For the preparation of composite, stir casting technique is to be selected because in this technique due to stirring action in molten metal vortex is created & there is well distribution of SiC particles in matrix phase and also desired shape can be given to the composite by varying mould dimensions. Powder metallurgy technique is also selected for sample preparation. There is well distribution of SiC particles in matrix phase and also desired shape can be given to the composite by different processes. For the evaluation of mechanical characteristic of materials under study is to be carried out on different mechanical testing methods.

Example 1

Preparation of the Brake pad composite:

Once the chemical treatment and mechanical treatment for raw materials is over, the final composition is made with other ingredients like filler, fiber, binder, frictional additives etc in different formulations. Each formulation is mixed to obtain a homogeneous mixture of ingredients. Then, the mixtures are compacted at a pressure of 15-17 MPa using a unaxial, hydraulic hand press machine for the green body of the brake pad composite Then, the green body was compacted further and cured using a hot press at 150 °C with 60 tons of compressive molding pressure for five minutes. At the end of the hot-pressing process, samples were taken out of the molds, allowed to cool to room temperature, and cured further at a constant temperature of 150 °C in air oven for four hours.

Testing and Analysis:

The mechanical properties of phenolic resin based brake pad composites were determined by a universal testing machine (UTM) at room temperature. Each sample, consisting of an initial cross-sectional area of 86.6 mm^2, was placed between the lower cross member and lower friction composite samples were obtained using a digital Rockwell hardness tester. A sample with a diameter of 10 mm was used to carry out the test at different filler. The test was conducted using a 1/8-inch-diameter steel ball indenter with a load of 100 kgf. Brake pad test rig was used to determine the pads wear, disk temperature rise and disk stopping time. Figure 2 shows the schematic diagram of the brake pad test rig. It has a 2.2kW motor with a provision for speed variation by using a stepped pulley. The motor provides the energy required to set the flywheel weights and the brake disc in angular motion. When a set of brake pad is fixed into the brake caliper assembly of the test rig, the system is switch-on and the drive shaft begins to rotate, it is then allowed to attain a desired speed. Thereafter, a manual force is applied on the brake pedal which is similar to that of a motor car. Subsequently the stopping time, temperature of the disc and brake pad material lost are recorded. The speed and brake line pressure ranges were: 6.66 m/s to 13.82 m/s and 0.2 – 0.6 MPa respectively for the test conditions

IV. EXPERIMENTAL PROCEDURE

Experimental procedure is followed as per the methodology discussed above. Detail explanations are as follows.

4.1 Compositions details:

- In this research Aluminum is used as base material i.e. matrix of metal matrix composite.
- Silicon carbide is used as reinforcement material in metal matrix composite.
- Three different compositions are formed by varying the wt% of Silicon carbide 15wt%, 20 wt%, 25wt%.

Table.3: Compositions of samples

Samples	Manufacturing process	
	Stir casting	Powder metallurgy
Sample 1	15% Sic	15% Sic
Sample 2	20% Sic	20% Sic
Sample 3	25% Sic	25% Sic

4.2 SAMPLE PREPARATION BY POWDER METALLURGY:

4.2.1 Blending:

Experimental condition:

Blending operation is used to get homogenous mixture of Al and Sic powder. Planetary ball milling machine is used for blending. There is one container in which Al and sic powder taken with 30 steel balls which is shown in fig 4.1. Steel balls are used for the size reduction of Al powder and proper dispersion of sic in Al particles. Container was rotating with 250 rpm for a 120 minute eccentrically.

Fig. Ball milling container

4.2.2 Compaction:

Experimental condition:

Blended mixture of Al and Sic powder compacted in billets. For that 100 tonnage hydraulic press was used. Mixture of Al and Sic powder filled in the die cavity by hand method and punch inserted in to die. Whole set up is placed under press and gradual 400 KN load is applied on the mixture. Powder mixture is converted in green billets of 30 mm O D which is shown in fig 6.2.

4.2.3 Sintering:

Experimental condition:

Compacted green billets are converted in to hard billets through sintering operation. Sintering operation performed by using Tubular sintering furnace. Arrangement of billets is shown in fig 4. Sintering is done at 500 to 6000c which is 90% of its melting point. Sintering was a 120 minutes for the each composition.

Fig.10: Samples

4.2.4 Extrusion:

Experimental condition:

After sintering operation extrusion operation performed, Extrusion was done through the extrusion set up which is specially designed for this research work. Extrusion performed at 500ºC. After achieving the 5000C temperature, we provided the 120 minutes soaking period to the billets. After completing the soaking period punch is pressed with help of Universal testing machine. Extruded samples are shown.

V. CALCULATIONS

For this research two types of densities are calculated those are as follows.

5.1 Density measurement:

Theoretical Density:

This density is calculated directly by using the formula i.e. mass per unit volume.

Mass of Billet is measured by using the Weighing balance m/c and volume is determined by geometry of billets

Density is measured for three different billets and average is taken for these three readings.

Experimental Density:

Experimental density is calculated by using the Archimedes's Principle.

When an objects float in liquid there is an upward force produced by the liquid bon the object.

This force exists because of pressure in the surrounding liquid increase with depth below the surface.

Fig.11: Density Measurement

For this experiment we required the weighing balance, stand, glasswith water, weightless string etc.

For calculating the density we used Archimedes"s formula of densityas follows,

$$\text{Density} = \mathbf{(W_a * \rho_w - W_w * \rho_a)/(W_a - W_w)}$$

Here, W_a= Weight of sample in air.

ρ_w = Density of water.

W_w= Weight of sample in water.

ρ_a = Density of air.

5.2 Porosity measurement:

□□Porosity is calculated on the volume basis.

□□Density is nothing but volume occupied by powder out of 100%volume of geometry.

□□Remaining volume is nothing but porosity which is formed through thepowder metallurgy process.

Porosity = $((\rho_{th}- \rho_{exp})/(\rho_{th}- \rho_a))*100$

Here, ρ_{th}- Theoretical density

ρ_{exp}- Experimentall density

ρ_a - Air density

5.3 Hardness measurement:

Experimental condition:

Hardness is measured by using the BrinellHardness Tester (B scale)**.**Hardness is measured before and after the extrusion process. It is measuredat three different places on the billets and average value is taken for finalreadings.

Observation Table

Table.6: Hardness of samples

Method of manufacturing	Material	Hardness (BHN)
By powder metallurgy	Pure LM 25	74
	LM25-Alloy-15%	111.36
	LM25-Alloy-20%	114.33
	LM25-Alloy-25%	127.38

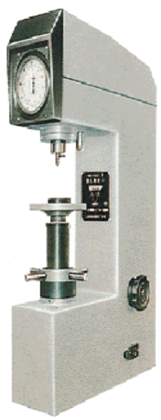


Fig.12: Hardness Measurement Machine

5.4 Compression test:

Compression test is performed by using hydraulic press machine whose capacity is 100 Tonnage. Billets specifications were 12 mm in O D and 15 mm length. Peak load sustain by billets is nothing but the compression test reading.

5.5 Tensile strength test:

For tensile strength we have used the ISO-6892-1:2009 standard inindustrial laboratory. According to the standard gauge length of specimenis 30 mm. Gauge diameter is 6 mm and holding diameter is 12mm.samples after tensile strength shown in fig.4.8.

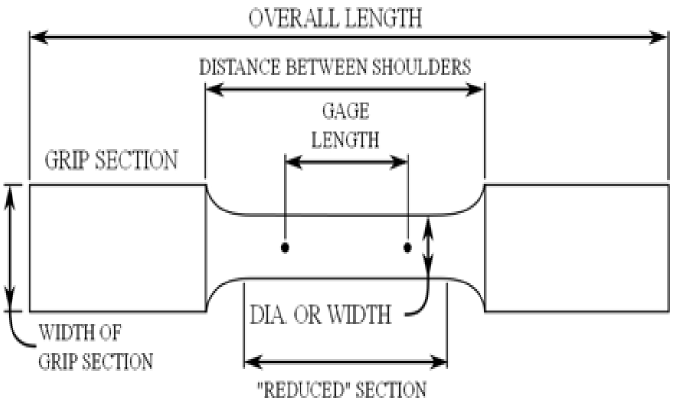


Fig.13: ASTM Standards

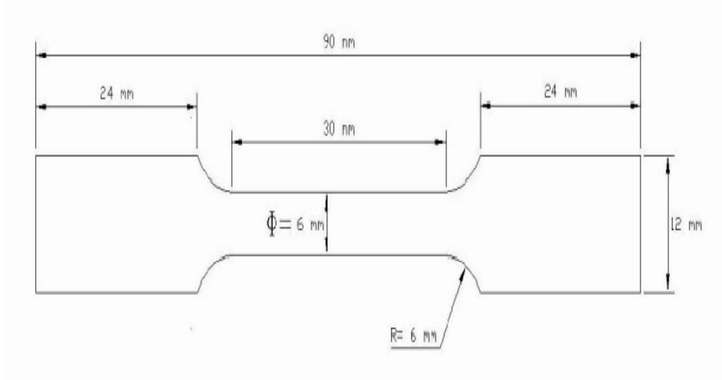


Fig.14:Dimensions of tensile test specimen

5.6 Observation Table

Al+15%SiC

Al+20%SiC

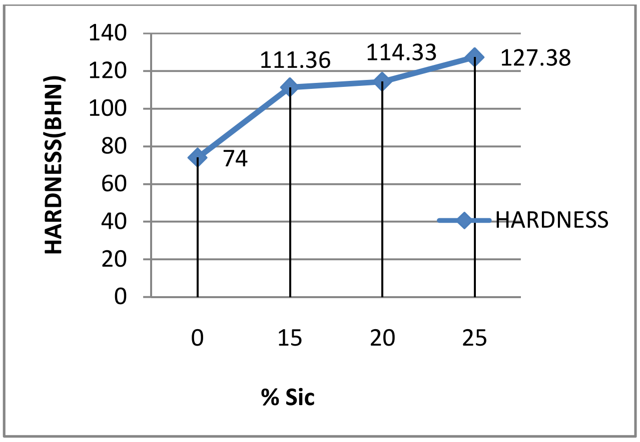
Al+25%SiC

Fig.15: Samples after Tensile test.

VI. RESULTS AND DISCUSSION

A density measurement test has been carried out on a laboratory scale to examine the density of the material after sintering. Density is depends upon the ingredients in the pad material. A metallic element will have a higher density than an organic element. Friction elements often exist in combination of various elements.

Theoretical density decreases with increasing quantity of reinforcement material. Gr 1 shows that the decrement in the theoretical density. Theoretical density is slightly greater than the experimental density.



Gr 3 Hardness variation with Sic

It has been observed that, there is no major change in the porosity by increasing amount of SiC. Because of compaction is performed at constant load. Due to less porosity we get better mechanical properties like Density, Hardness, Tensile strength, Compressive strength From Gr.3 it has been observed that, Hardness of the pure Aluminium is increasing with the increase in percentage of Sic, without an increase in density of aluminium which is desirable for light weight material. If we compare the hardness of pure Al with the MMC's there is a significant increment in the hardness.

Gr.4 Shows that there is an appreciable increment in the compressive load on adding the SiC's. Pue Al has compressive strength up to 74 MPa, There is major able increment in compressive strength without increment in density, which is a desirable property of light weight material. At low % of sic, there is perfect crack to the specimen, but at more percentage, i.e. 25 % of SiC's there is no cracks on specimens. This is due to the proper and homogeneous dispersion of sic in Al matrix.

From Gr.5 it has been observed that, with addition of Sic, tensile strength increases up to 20-22% without changing density of material which is desirable for light weight material but after exceeding certain value, it decreases.

As SiC material increases, Yield strength increase. This is due to the proper dispersion of SiC in Al matrix and strong bonding between sic particles and Al matrix.

VII. CONCLUSION

By above discussion and study we found that agricultural waste have slightly less weight density ratio with standard asbestos material so in this high modified world now we can use these agricultural waste instead of metal matrix. And asbestos material .we have checked all the parameter of both different material like agricultural waste and non asbestos material and we found slight difference in all reading. And due to less cost we can prefer agricultural waste as on priority .In this review paper different agricultural wastes are studied as alternative for asbestos brake pads. The results are shown that the performance is almost equal to asbestos brake pads without any environment and health effects.

From the research we can conclude that,

- ✓ Increment in hardness does not depend on Density Increment
- ✓ Hardness of composite Al-sic is greater than pure Aluminum and increases percentage up to 25.
- ✓ We got increment in Tensile strength by addition of SiC up to 20-22%.
- ✓ Silicon carbide is one of the most important content in non asbestos field just because of its important properties
- ✓ Increasing the percentage of phenolic resin to the composition made up of banana peels increases tribological properties but excessive addition causes poor shelf life, evolution of noxious volatiles etc. Alternatives for phenolic resins like newly developed resin, epoxy resin etc are studied

- ✓ We can make our environment more friendly by using these agricultural wastes.

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