

EFFECT OF ZrO_2 AND EVALUATION OF MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE OF BRAKE LINING MATERIAL

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

by

ADARSH KUMAR (Reg. No. 37150004)

ANSHUL (Reg. No. 37150012)



**DEPARTMENT OF MECHANICAL ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI,
CHENNAI – 600 119**

APRIL - 2021



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY



(DEEMED TO BE UNIVERSITY)

Accredited with "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ADARSHKUMAR (Reg.No. 37150004)** and **ANSHUL (Reg.No. 37150012)** who have done the Project work in entitled **"EXPERIMENT INVESTIGATION OF ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS BY USING TiO₂ NANO ADDITIVE AND BIODIESEL BLEND WITH DIESEL "** as a team under my supervision from December 2020 to April 2021.

Internal Guide

Mrs.P.Sivashankari, M.E., (Ph.D)

Head of the Department

Dr.G.Arun Kumar, M.E., Ph.D.

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

I **ADARSH KUMAR (37150004)** and **ANSHUL (37150012)** hereby declare that the Project Report entitled “**EFFECT OF ZrO₂ AND EVALUATION OF MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE OF BRAKE LINING MATERIAL**” is done by me under the guidance of **Mrs. P. SIVASHANKARI, M.E.(Ph.D.)**, Department of Mechanical Engineering at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE:

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr. S. Prakash, M.E., Ph.D., Dean, School of Mechanical Engineering** and **Dr. G. Arun Kumar, M.E., Ph.D., Head of the Department, Mechanical Engineering** for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide Mrs. P. Sivashankari, M.E., (Ph.D.), Assistant Professor, Department of Automobile Engineering for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of our project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Mechanical Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

Zirconia (ZrO_2) dispersed aluminium alloy metal matrix composites produced by compaction and sintering process. Using compaction techniques, aluminium-based composites with varying amounts of 1%, 2%, 4%, and 8% of zirconia by weight are fabricated. The prepared samples were subjected to mechanical and microstructure investigation. The extraordinary performance of Aluminium MMCs was the low density that obtained after alloying. Hardness and ductility were also increased when increase in Zirconia particle. Ultimate tensile strength, compressive strength and impact toughness were slightly increasing with the addition of zirconia particle. Microstructural characteristics shows that a homogeneous distribution of particles with reinforcement in casted composite. The investigations of the metallurgical characterization were carried using scanning electron microscope, X-ray diffraction test to understand the metallurgical properties.

Keywords: Metal-matrix composites (MMCs), Hardness testing, Compression test, Scanning electron microscopy (SEM), X-Ray Diffraction

CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	V
1	INTRODUCTION	1
	1.1 HISTORY AND BACKGROUND	1
	1.2 TYPES OF BRAKE LINING	6
	1.2.1 Asbestos Brake Linings materials	6
	1.2.2 Non-Asbestos Brake Lining material	8
	1.2.3 Semi-metallic Brake Lining materials	10
	1.2.4 Ceramic Friction Brake Lining material	12
	1.3 OBJECTIVE OF STUDY	14
	1.4 ORGANISATION OF THESIS	14
2	LITERATURE SURVEY	15
	2.1 INTRODUCTION	15
	2.2 LITERATURE SURVEY	15
3	AIM AND SCOPE	19
	3.1 AIM AND SCOPE	19
	3.2 SCOPE OF THE PROJECT	19
4	MATERIALS AND METHOD	20
	4.1 MATERIALS	20
	4.2 PREPARTION OF SAMPLES	21
	4.3 TRIBOLOGICAL TESTING	24
	4.4 MECHANICAL PROPERTIES	25
	4.4.1 Hardness	25
	4.4.2 Compressive Strength	27
	4.5 MICROSCOPIC STRUCTURES	28
5	RESULTS AND DISCUSSIONS	30
	5.1 MICROSCOPIC ANALYSIS	30
	5.1.1 SEM Analysis	30

5.1.2	XRD Analysis	32
5.2	MECHANICAL PROPERTIES	33
5.2.1	Hardness using Vickers Analysis	35
5.2.2	Density	35

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION:

Novel developments and surging needs in vehicle industry ask for adjusted metal network composites. Metal Network Composites (MMCs) have developed as an vital course of materials for basic, wear, thermal, transportation and electrical applications since it offers tall quality to weight proportion, tall stiffness and great wear resistance. The aluminum-based metal framework composites are fabulous novel materials for applications in aviation, car and transportation businesses. The creation strategies of the aluminum-based composites can be categorized into three forms: solid-state strategies, semisolid state strategies and fluid state strategy. The blend casting may be a fluid state strategy of composite manufacture, in which a scattered stage is blended with a liquid lattice metal by implies of mechanical stirring. Novel developments and surging needs in vehicle industry ask for adjusted metal network composites. Metal Network Composites (MMCs) have developed as an vital course of materials for basic, wear, thermal, transportation and electrical applications since it offers tall quality to weight proportion, tall stiffness and great wear resistance. The aluminum-based metal framework composites are fabulous novel materials for applications in aviation, car and transportation businesses. The creation strategies of the aluminum-based composites can be categorized into three forms: solid-state strategies, semisolid state strategies and fluid state strategy. The blend casting may be a fluid state strategy of composite manufacture, in which a scattered stage is blended with a liquid lattice metal by implies of mechanical stirring. The addition of a ceramic reinforcement stage in solid metal amalgams altogether changes their mechanical and physical properties, as well as their distortion behavior. The Aluminum is of moo thickness and tall warm conductivity. Be that as it may, the wear resistance is destitute. In arrange to dodge this disadvantage, this LM25 amalgam fortified with ZrO₂ to create LM25- ZrO₂ composites. This composite is utilized for marine casting, motorcar, motor parts, switch boxes, water powered frameworks (Cylinder, Barrel) and food-processing businesses. The ceramic materials are by and large utilized to support aluminum amalgams like SiC, TiC, TiB₂, ZrB₂, AlN, Si₃N₄, Al₂O₃ and SiO₂. Among all the fortifications utilized in aluminum-based

composites ZrO₂ particulates alone have appeared their potential prevalence in making strides mechanical properties and microstructure assist ZrO₂ particulates gives noticeable weight saving too. In this field, Aluminum is the most popular matrix for the metal matrix composites. Most of the research works bargain with aluminum lattice since of its normal light weight. The Al amalgams are very appealing due to their moo thickness, great erosion resistance, preparing adaptability, tall warm and electrical conductivity, progressed flexible modulus, quality and their tall damping capacity. Diverse processing techniques are utilized within the generation of aluminum metal framework composites. They are crushed casting invasion, stir-casting, unconstrained penetration, gas weight penetration, vacuum, centrifugal invasion, hot squeezing, cold squeezing, powder expulsion, powder producing, dissemination holding, etc. Among these strategies Mix casting strategy is utilized to deliver the composites in temperate way, tall generation rate at the very simple way. It too increments the uniform distribution of particles and decreases the absconds such as porosity, weak holding between network and support. The support of ZrO₂ is exceptionally alluring because it shows a thickness of 8.18 gm/cm³ , softening point 1860°C, UTS-425 MPa, VHN-150, Young's modulus of 98 GPa. It was too found that ZrO₂ appears way better quality, hardness and break sturdiness with slight lessening in ductility. From the writing overview, it is recognized that MMCs play a imperative part in supplanting metals, due to its progressed mechanical and metallurgical properties. A part of analysts had concentrated in creating unused composites such as Al 6061, LM25 and LM6 strengthening with different components such as TiB₂, SiC, TiC, ZrB₂, AlN, Si₃N₄, Al₂O₃ and their mechanical and metallurgical properties were analyzed in prior investigates. Exceptionally few works were recognized in analyzing the impact of ZrO₂ on mechanical and metallurgical properties. No works have been recognized in analyzing the impact of ZrO₂ on LM25 base fabric whereas subjected to mechanical and metallurgical properties. Subsequently the works primarily concentrated in creating unused composite fabric by taking LM25 as the base fabric and shifting rate of ZrO₂ to distinguish the impact of ZrO₂ on the mechanical and metallurgical properties. In Vehicle segment brake lining materials are for the most part utilized in arrange to produce the friction. Brake lining could be a contact causing fabric which is utilized in most of the mechanical braking frameworks. For diminish speed of the vehicles. To begin with brake lining

fabric was designed in Eminent 1888 by BERTHA BENZ. She was a German car pioneer and creator. She was spouse of KARL BENZ who is an Vehicle innovator. She is additionally a trade accomplice of Karl Benz. She designed brake lining in arrange to illuminate a few specific issues amid her to begin with travel of 105KM (65Miles).

Almost all vehicles use different types of brake lining materials. Brake lining are consumable surfaces in brake frameworks such as drum brakes and plate brakes utilized in nearly all vehicles Friction materials are heterogeneous and made up of some distinctive components that are utilized to illustrate contact properties at moo and tall temperatures, make strides life span, mechanical properties, and reduce porosity and noise. The study of tribological behaviour focuses on wear resistance, grinding, and grease between interrelated surfaces. After you apply the brakes, weight between the brake cushions and the turning circle powers the car to halt. Due to which the motor vitality changed over into warm vitality. As a result, contact materials must retain warm effectively whereas still persevering tall temperatures with negligible wear rate loss. The braking mechanism is made up of many components, counting tire limitations, brake barrels, wheel cylinders, and a pressure driven framework. In numerous braking frameworks, distinctive sorts of brake materials are utilized. There are four distinctive sorts of divisions. Folios, fillers, grinding modifiers, and fortifications are all examples. Asbestos filaments are typically embedded in a polymeric framework, in conjunction with numerous other materials, within the confinement. Numerous thinks about have been conducted within the field of creating asbestos-free brake linings over the final few a long time. To substitute asbestos-free brake pad material, palm nut shell and vegetable oil clinker are being examined. The utilize of mechanical or rural squanders as a source of crude materials for composite generation may be a current slant within the investigate division. By repurposing normal fiber squander, this would offer a more cost-effective arrangement whereas still protecting the forest. Furthermore, a few contemplations ought to be considered when creating brake materials within the car businesses, such as a steady contact coefficient and a lower wear rate at distinctive working rates, temperatures, stresses, and natural conditions. It is vital to get the correct mix of materials in arrange to meet such details at a reasonable taken a toll. Texture determination may be a luxurious operation instead of a direct errand. In any utilize, counting brake cushion

substance, the constituents are regularly helped by hone or a trial-and-error approach to deliver a replacement definition.

Brake lining is a component of the braking mechanism that's located between the drum and the shoe. A brake may be a component that's utilized to moderate or halt a moving protest. When the speed of plunge is controlled, dependable brakes are required to retain the motor vitality of the moving parts or the P.E. of the thing being brought down by the have. Brakes assimilate steam, which is at that point scattered within the shape of warm. To bring the motor to a end, the warm is scattered within the encompassing atmosphere. A bended lean strip of asbestos-based fabric bolted to a shoe to have a renewable board. The brake filler is the component that brings a moving body to a halt or moderates it down. When the speed of plunge is directed, solid brakes are required to assimilate the active vitality of the moving parts or the P.E. of the thing being lowered by the host.

The tribological properties of the brake system's grinding couple (circle (or drum) and cushion contact fabric) are the essential determinants of a vehicle's braking proficiency. In common, required productivity is abridged on a comparatively higher and reliable grinding level at a wide extend of braking conditions, such as temperature, mugginess, and the nearness of a third body interior the pad-disc interface, a way molecule from the exterior, and so on. Security determinations, long brake component lifetimes, and tall consolation (especially energetic and acoustic viewpoints) all provoke intrigued. Producers and analysts are asking total vehicle street and laboratory-scale testing beneath different pressing, sliding speed, temperature, and weight conditions in arrange to deliver brake pads with the best possible results. In reality, a variety of test methods, extending from "little coupon rub tests" to "full-sized car, on street tests," were anticipated to back laboratory progresses and commission control within the brake cushion plan. In reality, a few criteria and braking conditions counting grinding materials properties, brakes innovation, and braking sales influence the blur, i.e. adequacy diminish at raised temperatures, and the recuperation, i.e. return to sensible levels of grinding at lower temperatures after braking operation (especially mechanical, warm, and tribological sales). These factors connected in a synergistic way, expanding the study's difficulty. Brake linings are fundamental components of all sorts of braking frameworks. Grinding interior the touch locale converts the car's K.E. to thermal energy. Several researchers have considered the occasions that happen inside

the contact locale, which play an imperative part within the tribological conduct of brake lining items, over a long period of time. Different contemplations, such as driving conditions, lining definition, generation necessities, and consequently the properties of the grinding film that gathers at the interface between the rotor and grinding materials, impact the frictional strengths and wear conduct of the lining amid braking. . As a result, a few research facility tests on diverse brake lining formulations have been conducted within the final decade to supply steady grinding, unwavering quality, palatable wear resistance, moo commotion and vibration for both braking, and appropriate natural conditions. Whereas the sort of brake liner composition is most imperative in terms of tribological productivity and production fetched, it is largely influenced by manufacturing conditions, as the ingredients in linings can lose their properties when uncovered to tall temperatures amid make. Made strides fabricating details make strides tribological properties whereas bringing down brake lining fabricating costs. It is well caught on that diverse vehicles put diverse conditions on the grinding fabric as a braking system's neighborhood, which each contact fabric has its claim set of appropriate manufacturing criteria for the leading effectiveness. In spite of this, investigate into the lining's generation parameters is uncommon. Brake linings are made utilizing metallurgy (P/M), which includes two steps: first, hot forming of a blend at tall temperatures, and after that warm treatment (post-curing). Forming is one of the foremost vital and controlled stages within the P/M strategy since it determines item density and uniformity. Initial moulding, elastic–plastic deformation, and particle breaking or fracture are all stages of the forming prepare. The molecule estimate and frame are regularly a issue within the early stages. Densification starts with the modification of powder precious stones, coming about within the filling of expansive voids and, as a result, the hacking of molecule bridges. The flexible distortion of the particles contributes to the strategy of densification within the elastic–plastic organize. Plastic misshapening happens locally at the antiparticle touch focuses as the connected weight is expanded, and here the mechanical properties and consequently the composition of the particles are basic contemplations, as they impact the compressibility conduct of powder. Plastic misshapening gets to be common at the conclusion of the forming handle, due to shearing, the era of unused oxide-free surfaces, and cold welding of touching surfaces, as well as a decrease in porosity. Heat treatment, one of the most

fundamental and compelling forms in lining production, allows texture particles to stay together, inevitably diminishing the sum of pore space between them, moves forward curing consistency, diminishes warm development during operation, and can play a basic part within the properties and taken a toll of final goods. Temperature, time, and heater environment are the foremost basic impacts within the warmth treatment prepare. In the event that warm treatment is connected for a delayed period of time, the pores can be expelled, and the fabric may ended up thick. In spite of the truth that the degree of warming treatment increments over time, the impact is minor as contradicted to temperature reliance. The sum of warm treatment is decided by the temperature, activation vitality, dissemination coefficient, and particle estimate at the begin. Due to upkeep costs and vitality request, an exertion might be made to get it the specified properties of the components by shorter processing cycles and, as a result, lower temperatures.

A multiphase composite incorporating more than ten additives could be used as a brake friction agent for automobile braking. During the past 20 years, the ingredients in commercial friction materials have been increased to such a large number to satisfy a variety of demands in safe and comfortable brake efficiency. Approximately 200 materials are used to manufacture industrial brake friction materials, and they are typically categorised as binders, fibrous reinforcements, non-fibrous reinforcements, and property modifiers based on their intended functions of brake efficiency.

Friction braking systems in bikes, trucks, aircraft, race cars, and other vehicles commonly utilize polymer-based plastic grinding materials. These materials are multi-ingredient composite materials that must meet a assortment of criteria, counting a solid and strong grinding coefficient, better than average wear resistance, restricted wear to partners, no or moo vibration and commotion, satisfactory weight, and reliable execution over a wide run of temperatures, speeds, weights, and situations. The coefficient of grinding of brake cushions utilized in North America is as a rule 0.35–0.45, while it is higher than 0.45 in Europe and Asia (Tang and Lu (6)). The added substances have a noteworthy impact on the contact materials' productivity. Within the grinding materials advertise, there are approximately 100 ingredients.

Current friction materials (non-asbestos organic— NAO) utilized in brake cushions, linings, shoes, bricks, clutch facings, and other applications are given by

exceedingly complex definitions consolidating added substances of distinctive shapes, natures, and amounts. Current contact materials (non-asbestos organic—NAO) utilized in brake cushions, linings, shoes, bricks, clutch facings, and other applications are given by exceedingly complex definitions joining added substances of diverse shapes, natures, and amounts. Tribotesting such materials may be a troublesome errand since brake materials are utilized in a assortment of ways (cushions, shoes, linings, pieces against different rotors such as plates, drums, wheels, and so on) and under a variety of working conditions.

1.2. Types of brake lining materials

There are several types of brake lining materials among which are mostly used materials are

- 1) Non-Asbestos Brake Lining material
- 2) Semi-metallic Brake Lining materials
- 3) Ceramic Friction Brake Linings materials
- 4) Asbestos Brake Linings materials

1.2.1 Asbestos brake lining material:

Because of its durable physical, chemical, and tribological qualities, asbestos has been used as a friction material since Herbert Frood patented brake linings in 1908. Until asbestos was used as brake linings, different fibres were checked for heat releasing properties, which is the most desirable property a brake lining material should have, by a number of scientists, including Dr. Gwilym, a well-known physicist. Asbestos is checked and analysed for heat dissipation, thermal, and tribological properties since its initial usage as a brake lining content.

Some researchers suggested an unusual scenario in which an organic brake pad slides over a grey iron. When this worn-out cast iron disc is replaced on the pad, a dissimilar structure with elevated surface plateaus appears on the surface. Using various techniques such as SEM, the researchers investigated the formation of physical, mechanical, and tribological composition of the brake pad surfaces.

A paper on friction lining content research is presented by an analyst from the United States Department of Energy's Assistant Secretary for Energy Efficiency and Renewable Energy's Office of Transportation Technology. Most brake materials, he claims, are made up of various constituents in order to achieve the properties expected of brakes, which is why they are called composite materials. Thousands of various materials with differing constituents are now used in industrial brake parts. The first brake filler was a cotton-based material infused with bitumen solution that was used on waggon wheels and early cars. The Ferodo Company was established as a result of the discovery, and it continues to supply brake materials to the market today. Later, woven brake lining fabrics were used, but in the 1920s, moulded materials with chrysotile asbestos fibres and ample mineral content were used instead.

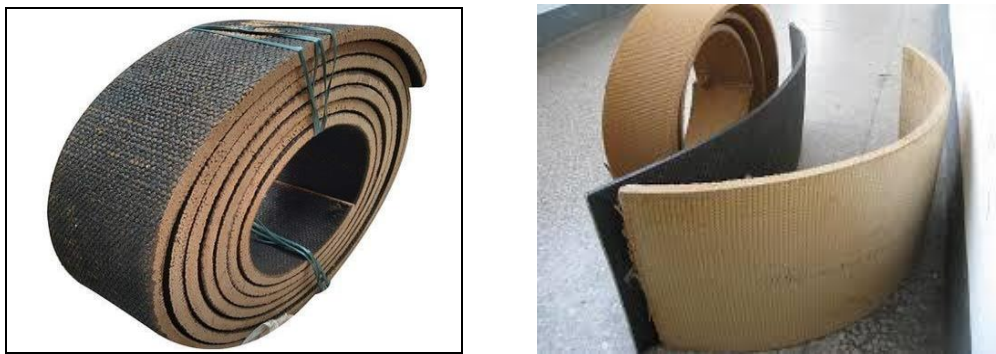


Fig: 1.1: Asbestos brake lining material

In the field of sliding and environmental scenarios researchers develop a brake test system which can quantify drum brake output. The dry and damp brake pad condition influenced the forces and the slipping speed of the car. The findings were that the friction coefficients between drum and brake line with increasing pressure or speed in dry and wet environments were slightly higher. All of those variables and the entry parameters were designed, to define all of them, for the time the braking form and the geometric structure of the disc and the material used for the distribution of the temperature of the disc brake. Numerical ANSYS foundation simulation is integrated in the sequent thermal-structural analysis, to carry out the assessment of stress field and deformations that are attached to the disc and the contact pressure on the pads for coupled transient heat and stress fields.

Some analysts are also considered to maximise the Tribological mechanical and physical properties of the brake lined material in manufacturing parameters, such as moulding strain, temperature, time, and heat treatment period. The parametric pattern, such as Taguchi, was used in the evaluation of 16 different materials in the brake lining, developed by manufacturing and for physical characteristics such as surface hardness and porosity, tribological properties of the friction coefficient and wear.

In the case of asbestos, the diameter is less than 3 inches in diameter and the aspect ratio 3:1 or higher, the International Labour Organization (ILO) is likely to suspend it in air. Asbestos fibre with a length greater than 5µm, diameter less than 3 µm and aspect ratio more than 3:1 was considered by the US Occupational Safety and Health Administration (OSHA) as the respirable asbestos fibres and the potentially hazardous dust.

Later in many countries banned usage of asbestos fibre has brake lining materials has it causes health problems to humankind. Sure has Mesothelioma and lung cancer, appearance of scarred Alveoli etc.

1.2.2 Non-asbestos brake lining material

The properties of asbestos as a basic substance for frost liners are ideal but are dangerous to health. It's inherently carcinogenic. There is therefore space for its substitution, and some researchers have suggested asbestos material as base material for brake fittings. The substance of a brake lining should have strong mechanical properties, such as compressive strength and tensile strength, for high loading applications. However, these alternate materials can be routinely examined by varying composition for their tribological and mechanical properties.

A researcher checked the friction wear characteristics for $ZrSiO_4$. For this purpose, samples were tested for density, durability, coefficient of friction and wear. Scanning electron microscopy (SEM) was also used to micro-structural studies of materials before and after sintering and used surfaces and the types of wear and connection were calculated between parameters. A broad variety of slipping conditions of the pin on disc testing tester often analyse the tribological response of Al/SiC. The methodology of powder metallurgy is used to instigate trios regimes of specimens ' tribological behaviour. Few analysts proposed and tested several phenolic composites for the use of automotive braking.. Some

analysts have also studied a wide range of phenolic materials, Cu powder, BaSO₄, Al₂O₃, and used a wear testing pad-on-disk form to analyse many sample compositions of the components in manufacturing.

In the experimental area, the pin on a disc style test is very familiar type of instrument. The frictional and wearing characteristics of the specimens were examined very near the pad contact point with a cast iron disc. The properties of a SEM were studied as well as the temperature effect on the behaviour of the pads, in temperatures around degrees and the pressure of several bars. Some explorers have suggested a derived replacement substance for asbestos that consists of a palm kernel shell. A non - asbestos friction substance with agro-waste material – Palm Kernel Shaft (PKS) - was formed in conjunction with other ingredients. Taguchi optimization technology has been employed to obtain the best composition of friction materials and optimal parameters of production. Palm kernel shell material is examined for a disc brake. Any literature develops asbestos-free car brake pads with periwinkle shell fragments as the filler. The periwinkle shell is an organic farm waste that uses its properties as an antidote to dangerous asbestos. Various collections of specimens and friction coefficients were developed and tested. Periwinkle exhibits similar asbestos properties, but at high temperature it loses its properties.

Non-asbestos is an environmentally safe and robust organic furnace. In these brakes are rubber, glass, resin forms, and also Kevlar. This kind of lining consists of just a small amount of metal.

The durability of non-asbestos liner is less than its counterparts. This kind of brake causes dust in operation, but is not a pollutant. They are much quieter than asbestos and half-metal brakes too.

Non-asbestos are not so durable but are environmentally friendly which is less pollution and not affect mankind whereas asbestos brake lining materials will affect the health of not only humans and also animals and birds. In most of the countries use asbestos materials is banned. Which gave a way for development of new material which is useful in preparing of brake lining materials.



Fig 1.2: Non asbestos brake lining/pads (Organic brake pads)

1.2.3. Semi metallic lining materials

The second form is called "semi-metallic" as brake pad friction material. This is because they have between 30 and 65 % by weight of aluminium. Many kinds of metal from copper and iron to steel are included. The remainder of the friction surface consists of fillers, modifications, and other materials necessary to improve performance and ensure reliability.

This style of brake pad friction is very common with automakers and is the most flexible form of brake pad on the market. They obviously have their drawbacks, but others think it's best to get semi metallic brake pads. All depends on the requirement

Semi-metallic pads used to be the best selling pads on the market, until ceramic brake pads appeared. Obviously with modern technologies, some of this benefits are gone, but from certain points of view it can still catch up with its top rivals.

Where pottery excels in the comfort zone, semi-metallic products are produced for performance. They are made of steel, iron, copper and other metals with a high percentage that increases their stopping strength. Semi-metallic brake pads are more resistant and robust than other pads, working at the widest possible range of temperatures compared to all three here. It doesn't last as long as ceramics, but is longer than biological pads. Regarding other brake system parts, especially your break rotors, they generate some brake dust and are much more offensive. They're much more noisy, shrinking than most pads.



Fig : 1.3 : Semi metallic brake lining materials (Semi metallic brake pads)

This brake pads are somewhat more costly, but they last longer than organic brake pads. However, on the rotors, they are not as soft as organic brake pads and can rate rotors if they are not replaced immediately when used. This brake pads are excellent for a wide range of driving types, from cold to dry, from light to moderate to hilly areas due to their excellent heat resistance and range. The stigma of being a little loud and creating more dust than the two other styles of pads involves a lot of their downsides.

Semi-metallic brake pads are designed for performance in extreme driving conditions and are highly versatile. They have a better braking response than their organic counterparts. They have longer brake pad durability, excellent cold bite, and function well over a wide range of brake temperatures.

The semi metallic pad contains more brake particles, meaning that the rotors get more debris quicker. One of the other downsides that, since they are metallic, they're more rough on the breaking rotor, so you need to make the rotors thinner more frequently.

1.2.4. Ceramic friction brake linings materials:

Since ceramics were long commended for their thermal strength and longevity, they have become an essential option for manufacturers of brake pads. These non-metallic compounds are enhanced by their extreme hardness, temperature and wear resistance, high rigidity, resistance to chemical corrosion and compressive strength. Both commercial and industrial ceramic brake pads are used for the automotive, agriculture and transit sectors. Ceramics start as granular powder, which is filtered and sometimes mixed with other ceramics or materials like metal shavings before they are weighed.

The friction material is then joined together with the techniques of processing, including sintering, firing, hot pressing, hiping, extrusion, fusing, slip casting or

pressure casting, and injection moulding, as well as deposition. These composites may be unique to a particular industrial or commercial application since they maintain the positive quality of each element they contain. The most general of advanced, scientific and engineering ceramics used in the manufacturing of brake pads are alumina or aluminium oxides, boron carbides and silicone carbide.

The simple braking mechanism is highly dependent on brake pad functionality and performance. If a hebel or pedal is pushed on, it starts with the release of brake fluid, and it passes to the stopping system on each wheel where the shoe or calliper is fitted with a small hydraulic pump. Therefore, ceramic brake pads, fixed to the rotating surface of the wheel or disc with a solid adhesive glue or rivet, are pressed. The friction caused by interaction between the two materials leads to a slowdown of the wheel in proportion to the pressure level.

Due to the fact that ceramics retain their structural stability even though the heat is enormous, they deliver higher power than metals that are thermal expanded. Although this agitation creates a grinding or squealing effect, ceramics are not only frequent but are less of an inconvenience to customers. Another important advantage of ceramic brake pads is reduced dust. The intrinsic friction in the braking process grinds the rotor and the pad, producing small pieces of pads that break down and lose traction or vibration.

Ceramics have a substantial reduction in their longevity and heat strength in terms of break-stab generation. Shimmers, chamfered brake pads and slots further eliminate cracks and noises due to heat expansion.



Fig :1.4 : Ceramics brake lining.

Different mainly used brake lining materials.

Type	Best Performance	Lowest Noise	Least System Wear	Least Mess	Price
Organic/ Non asbestos	Low	Medium Noise	Medium	Medium	Low
Ceramic	Medium	Low Noise	High	High	High
Semi-metallic	High	High Noise	Low	Low	Medium

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION:

A considerable amount of research has been done on the braking lining materials in order to do research on the new materials. There are more number of research documents regarding brake lining materials. A good amount of literature study was made and as an outcome, the methodology was designed and experiments were performed. There are several researches that have been done both internationally and nationally by several journals.

2.2 LITERATURE SURVEY:

1. K. Ravikumar (2017); deals with the investigation on mechanical properties of aluminium alloy (AA 6082) composites reinforced with tungsten carbide particles. Stir casting process was employed to fabricate the aluminum composite example by shifting tungsten carbide in 2, 4, 6, 8 and 10% by weight. The composites were uncovered to thickness, hardness, malleable and affect ponders. Filtering electron magnifying instrument was utilized to examine the instrument of the broken malleable and affect test example. The thickness, affect quality and stretching of the composites diminished with increment in expansion of tungsten carbide, whereas the hardness of composites expanded with increment in tungsten carbide. The ductile quality of the composites increased at first and then tends to diminish. Break of the composites is characterized by dimples, voids, breaks, ridges, pits and molecule break. Brittle break of composites within the shape of breaks and molecule break are due to the solid interfacial holding between the tungsten carbide and aluminum framework at high strain rate. Tall affect quality of composites are due to pliable failure within the form of dimples, while low impact strength are due to brittle and plastic deformation characterized by micro and macro cracks, particle fracture.
2. H.G. Prashantha Kumar (2016); In the later years, enormous research has been carried out and reported on ceramic and carbon based reinforcement. Graphene, no ponder has pulled in critical investigate intrigued due to its broad physical properties at its single atomic thickness and 2-D

morphology. The current considers center on the part of Graphene in lessening the wear and frictional coefficient of Al 2024- SiC - Graphene reinforced half breed composites. Reinforcement chosen is 4, 8 and 12 wt. % of SiC with 0.5 wt. % of Graphene to explore the lubricating property beneath dry wear conditions and prepared through the ultrasonication and ball processing. The handled blends are hot compacted and microwave sintered. Hardness, thickness, X-ray diffraction and flexural quality analysis were done on developed composites. The dry frictional wear test were carried out using pin-on-disc tribometer to assess the impact of Graphene and SiC substance within the composite beneath different ordinary stack and plate speed conditions. Further, wear resistance and a decrease within the coefficient of grinding (μ) values compared to pure combinations were watched. Surface unpleasantness values (R_a) and infinitesimal thinks about on wear tracks were carried out. The conceivable tribological potential coupled with moved forward mechanical properties and surface harshness of Al 2024- SiC - Graphene crossover composite handled through powder metallurgy were discussed.

3. Jaswinder Singh(2016); Hybrid aluminum matrix composites (HAMCs) are the second generation of composites that have potential to substitute single fortified composites due to moved forward properties. This paper investigates the achievability and practicality of creating moo cost-high execution half breed composites for car and aviation applications. Encourage, the manufacture characteristics and mechanical behavior of HAMCs manufactured by blend casting course have too been surveyed. The optical micrographs of the HAMCs show that the fortifying particles are decently disseminated within the framework combination and the porosity levels have been found to be acceptable for the casted composites. The density, hardness, tensile behavior and break toughness of these composites have been found to be either comparable or prevalent to the ceramic fortified composites. It has been watched from the writing that the coordinate strengthening of composites happens due to the nearness of difficult ceramic stage, whereas the indirect reinforcing arises from the warm jumble between the network alloy and reinforcing stage amid hardening. Based on the database for fabric properties, the application

region of HAMCs has been proposed within the show survey. It has been concluded that the half breed composites offer more flexibility and unwavering quality within the plan of conceivable components depending upon the reinforcement's combination and composition.

4. T. Rajmohan (2013); Hybrid metal matrix composites are important course of engineering materials utilized in car, aerospace and other applications since of their lower thickness, higher particular quality, and better physical and mechanical properties compared to pure aluminum. The mechanical and wear properties of hybrid aluminum metal network composites were examined. Mica and SiC ceramic particles were joined into Al 356 alloy by stir-casting course. Microstructures of the tests were examined using checking electron magnifying instrument (SEM). The chemical composition was explored through vitality dispersive X-ray (EDX) locator. The comes about show that the way better quality and hardness are accomplished with Al/10SiC-3mica composites. The increment in mass division of mica improves the wear loss of the composites.
5. B Rajeshwari (2013); Metal matrix composites (MMCs) are presently picking up their usage in aviation, car and biomedical businesses since of their inborn properties like tall quality to weight proportion, moo wear rate, etc. An investigation was made on MMC-based aluminum 7075 alloy utilizing plan of experiment by Taguchi method. The essential objective is to anticipate the superior parameters that allow the highest malleable quality and hardness utilizing Taguchi strategy to the castings. The control of handling parameters is very critical in arrange to get great quality casting with negligible defect. The test tests were arranged by shifting the weight rate of reinforcement, blending speed and preparing temperature in blend casting. An orthogonal array and examination of change were utilized to explore the impact of handle parameters on the required properties. Optimum parameters were noted for attaining the maximum mechanical properties of composites by the application of Taguchi method. The most inspiration of this research work is to recognize how the parameters of impact when changed deliver defect free composite casting with required malleable quality and hardness which may be used for particular applications based on the values gotten within the tests. Confirmation test

with the ideal levels of processing parameters was carried out in arrange to demonstrate the adequacy of the Taguchi optimisation method.

6. Dora Siva Prasad (2014); A double stir casting process was utilized to fabricate aluminum composites strengthened with different volume divisions of 2, 4, 6, and 8 wt% RHA and SiC particulates in rise to extents. Properties such as hardness, thickness, porosity and mechanical behavior of the unreinforced and Al/x%RHA/x%SiC ($x = 2, 4, 6, \text{ and } 8 \text{ wt\%}$) strengthened cross breed composites were inspected. Checking electron magnifying lens (show JSM-6610LV) was utilized to consider the microstructural characterization of the composites. It was watched that the hardness and porosity of the crossover composite expanded with expanding support volume division and thickness decreased with expanding molecule substance. It was too watched that the UTS and abdicate quality increase with an increment within the percent weight division of the reinforcement particles, while prolongation decreases with the increase in reinforcement. The increase in strength of the hybrid composites is likely due to the increment in disengagement thickness. A orderly ponder of the base amalgam and composites was done utilizing the Brinell hardness estimation and the comparing age solidifying bends were gotten. It was watched that in comparison to that of the base aluminum amalgam, the precipitation energy of the composites were quickened by including the fortification. This viably decreased the time for getting the greatest hardness by the aging heat treatment.
7. G. Narasaraaju (2015); The application spectrum of moo taken a toll fabric strengthened metal framework composites is developing quickly in different building areas due to their predominant mechanical properties. In the show think about an endeavor is made to investigate the conceivable outcomes of strengthening aluminum amalgam (AlSi10Mg) with locally accessible inexpensive rice husk and fly fiery debris for creating a modern composite fabric. Hybrid Rice husk and Fly fiery debris particles are included in Aluminum Combination Lattice at 20% by weight with diverse extent utilizing Stir casting method. The fabricated cast specimens are characterized with Optical and Checking Electron Microscopes. SEM think about approves the nearness of Rice husk and Fly ash in Aluminum matrix.

The mechanical properties such as ductile quality, rate prolongation, and hardness are considered for all stir-cast examples. A significant change is watched for 10% Rice husk+10% Fly cinder fortified Aluminum Combination composite compared to as-cast examples without reinforcement additions.

8. Peter J. Blau; Brian C. Jolly (2005); the research is on study of different types of wear test of test the brake lining materials in arrange to urge the precise esteem of the materials. The materials which are utilized in this investigate is fleet which is exchange stamp enlist beneath a few established. The three tests utilized beneath the inquire about are sub scale brake testing machine, Shoe lining device tests and square on ring tests. The conclusion of the inquire about is beneath standard working conditions, materials appraised on all three measuring machines within the same arrange of wear resistance, but the relative wear variety between materials changes altogether between test motors. The choice of wear testing machine and of third-party controls will have an important affect on the amount of wear produced, on the relative evaluating evaluations of wear among the materials and on the association between the wear test comes about and the full-size vehicle brakes.
9. Senthil Kumar (2020), the research was to ponder the impact of silicon carbide over the Aluminum Matrix Composites (AMCs) on tribological characteristics utilizing taguchi procedure. The compositions consider in this research are SiC of 0, 1.5, 3, 4.5 % in AMCs at five distinctive loads are 10, 20, 30, 40 N at sliding remove (400, 800, 1200, 1600) at different sliding speeds. The try is partitioned into L16 orthogonal cluster. The conclusion of the inquire about is SiC impact the wear and grinding properties sliding separate is following impact figure. At 3% of SiC the brake lining materials best suitable within the engine cylinders.
10. Ravi Kumar R (2020), the research is to study the mechanical properties of aluminum combination 6061 are strengthened with nano Zirconia. The strategy utilized within the inquire about is blend casting method. The composition was considered in all angles regard to is infinitesimal structure and mechanical properties. The composition of nano Zirconia (ZrO_2) rate changes 0, 0.5, 1, 1.5, 2% and magnesium is 3% for all compositions and rest is Al 6061. The nano-composite ZrO_2 powder included composite had

a solid abdicate of 82.851 MPa, a ductile quality of 128.148 MPa and wt% of nano-ZrO₂, and an stretching ratio of 6.18% over all composites.

CHAPTER 3

AIM AND SCOPE

3.1 AIM AND SCOPE

- To prepare the samples of difference compositions aluminium and zirconium oxide.
- To conducted the SEM and XRD of the difference composition both before and after sintering process.
- To conduct mechanical test on different composition of samples.
- To conduct test on pin on disc apparatus to collect information regarding specific wear rate
- Comparing the results among the samples at elevated temperature.

3.2 Scope of the project

Brake lining materials plays major role in the automobile field in braking process. Many materials are been used has brake lining materials in the automobile field. In this field there are many compositions of metals among with the same ingredients such as zircon, MgO, SiC, carbon dust, phenol, etc. In this study aluminium is mixed with the zirconium oxide (ZrO_2) at different compositions. At which percentage the samples give the best performance in all categories. This article seeks to provide an overview of commercial brake materials and additives and to identify their common characteristics and features, in particular in the case of heavy goods vehicles. The majority of the camion pads and shoe materials here mentioned are made to wear cast iron. Methods for testing of brake material are often mentioned briefly. The paper is not concerned with problems relating to the manufacture and production of brake products. Since there are practically thousands of additives in the brake material and their variations are almost infinite, listing them all here is not realistic. Rather, the main components and their roles have been attempted.

CHAPTER 4

MATERIALS AND METHODOLOGY

The work has been classified into three stages:

1. Preparation of samples at different compositions.
2. Tribological testing of samples at elevated temperatures.
3. Mechanical properties testing.
4. Microscopic structures.

4.1 Materials

For the preparation of samples for brake lining testing we need aluminium and zirconium oxide. This procedure includes mixing of aluminium and zirconium at various compositions to get the testing done. After mixing this compositions are taken to compact them at a pressure of 10 ton.

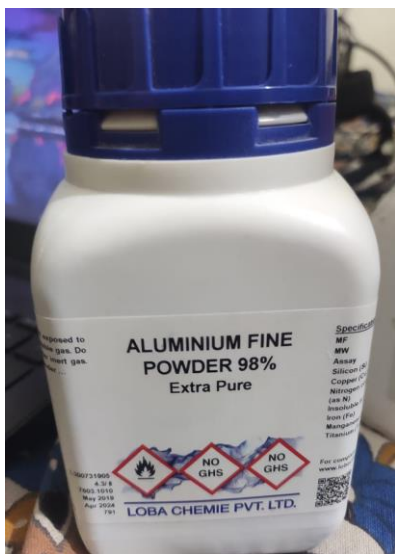


Fig 4.1 Aluminium powder (Al)



Fig 4.2 Zirconium oxide (ZrO₂)

4.2 Preparation of samples

The samples are prepared accordingly the composition of aluminium and zirconium oxide which were bought from stores. The sample preparation is involved in powder metallurgy which involves in ball milling, compacting, sintering and cooling. This all method are done in the VB Ceramics at Perungudi. Both SEM and XRD analysis of sample before and after sintering is also been carried out in that laboratory of VB ceramics.

S.No	Aluminium powder (Al) in %	Zirconium oxide (ZrO ₂) in %
1	100	0
2	99	1
3	98	2
4	96	4
5	92	8

Table 4.1 Samples compositions

In the samples preparation the powder metallurgy plays important role. First the powder of aluminium and zirconium oxide are mixed according to composition of samples. Each composition is mixed with the help of ball milling. The composition is mixed accordingly to proposition we mixed the aluminium and zirconium oxide by keeping fixed weight has 50 grams has stand weight for mixing of powder. A ball mill is a grinder type used for grinding or blending material for processes in mineral dressing, painting, pyrotechnics and ceramics. The theory of impact and attrition works: the decrease in size takes place by impact as the balls fall from the top of the shell. Ball mill is used to mix well the powders at 248 rpm for an hour in order to mix well. The advantages of using balls have several benefits relative to the rest of the systems: low installation and grinding costs; flexible capability and fineness by changing ball diameter; ideal for batch as well as continuous operation; suited for open and closed-circuit grinder; suitable for products of all harden types. Ball milling provides several advantages over other systems.

Working if the ball mill is continually worked, the material to be sold is feed by a 60° cone from the left and the output is discharged by a 30° cone to the right. If the coat rotates, the balls are raised on the elevated side from the top of the coat (or falls back into the feed). This limits the size of the solid particles between the balls and the dirt. A horizontal axis is rotated by ball mills, partly loaded with material to be ground plus grinding medium. Various materials such as ceramic balls, plaster pebbles and stainless steel balls are used as media. The material reduces to a fine powder an internal cascading effect. Ball mills will run constantly, fed on one end and unloaded on the other. Large to medium-sized ball mills are rotating by mechanical rotation, but smaller mills usually comprise a cylindrical capped box on two drive shafts.



Fig 4.2.1 Ball Mill (Planetary Mill)

Compacting the powder in order to give it shape. For compacting the equipment used is 10 tonne hydraulic press. Both the pores and the number of pores have a great effect on compaction pressures. The surface contact of the powder particles, which reduces porosity, increases by increasing compaction strength. Compacting the powder into the shape we required by placing the required dimensions present each composition in made into 6 samples out of which 5 samples are of dimensions are diameter 10 mm and height of 20 mm and the remaining one of dimensions of 20 mm diameter and 20 mm height. All compositions are prepared in 6 samples by using the apparatus 10 tonne hydraulic press. The compacting pressure is used in the research is 20 Newton. Compacting of powder into solid will increase its hardness of the samples by decreasing the porosity and density of sample. Compacting pressure varies for every material. Due to applying of compacting pressure properties of materials will increase. At perugudi this apparatus are there all samples prepared there itself. The compaction pressure is usually exerted by the dots on both ends of the instrument to reduce the density gradient in the compact. Ejection of the compact die by lower removal of die punch.



Fig 4.2.2 10 Tonne Hydraulic Press

Sintering is also chosen as the forming method for materials with exceptionally high melting points such as tungsten and molybdenum, so the sintering temperature does not have to exceed the melting point of the element. The study of sintering is known as powder metallurgy in metallurgical processes. The lightweight laser ceramics sintering temperature is normally about 200–300°C below the melting point of the respective composition. The selection of the sintering temperature depends on the growth of ceramic grains, since the rate of grain growth is steeply increasing. Sintering temperature is used in the research is 550°C and time of sintering is 3 hours. Sintering of samples is done using furnace. An expansion-temperature curve can easily be observed in optical dilatometer thermal analysis to ensure that all characteristic temperatures associated with phase change, glass transitions and melting spaces during the sintering period of a specific formulation of ceramics (i.e., tails and frits). In fact, sinterization requires a remarkable reduction of the material as glass phases flow as soon as their transition temperature is reached and the powder composition is consolidated and the material porosity is reduced considerably. Sintering is a heat treatment used to add resilience and integrity to a powder compact. The sintering temperature of the Powder Metallurgic substance is lower than the melting point.

Box Furnace processes the substance at temperatures above 1100°F (592°C) one by one, or in one community. The Box Furnaces are an ideal solution to process heat from welded and forged components and plates to a wide range of materials. Tempering, hardness, standardisation, clothing, pre-heating, stress relief, and other processes. Aerospace, gasoline, coal, car, defence, among many more are the sectors that are served. Aluminium, brass, cast iron, high-nickel alloys, titanium and more are all recycled materials.



Fig 4.2.3 Box Furnace

After sintering the samples are been cooled for 3 hours.

4.3 Mechanical Properties

Mechanical properties which are to be done in the research are hardness using Vickers hardness method, compressive strength using UTM.

4.3.1 Hardness

Hardness is a material's ability to survive deformation, as calculated by a specific test under which the surface resistance to indentation is measured. The hardness measures most often used are determined by the form or type of indent, the scale and the load.

Vickers hardness method is used in the research. Robert L. Smith and Georg E. Sandland at Vickers Ltd invented the Vickers hardness test in 1921 as a substitute for measuring substance hardness using the Brinell process. The Vickers test is usually easier to use than other hardness tests since the measures needed are irrespective of the size of the indenter and with any substance regardless of hardness the indenter may be used. As for all general hardness measure, the fundamental concept is that a substance should withstand the normal cause of plastic deformation. The Vickers test is ideal for all metals and has the largest scale of reliability measurement. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). The

hardness number can be converted into units of Pascal, but should not be confused with pressure, which uses the same units. The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force, and is therefore not pressure. The decision was taken that the indenter form should create geometrically identical impressions, regardless of size; the impression should have simple measuring points and the indenter should be highly resistant to itself. These conditions were fulfilled by a diamond, in the shape of a square pyramid. The optimum dimension of a Brinell impression had been determined to be $\frac{3}{8}$ the ball diameter. As two tangents at the end of a $\frac{3d}{8}$ chord at 136° , the decision was taken to use this as the inclusive angle between the plane faces of the tip of the indenter. This gives the usual angle of 22° from both sides to the horizontal plane. The angle was experimentally varied and, regardless of load, the durability value achieved in a homogeneous material was found to be constant. Based on the hardness of the material to be weighed, loads of varying magnitudes are then applied to a flat surface. The HV number is calculated according to the F/A ratio, where F is the force applied to the diamond by kg and A is the region of square millimetres of the resulting indentation. A by the formula can be defined.

$$A = d^2/1.8544$$

where d is the average diagonal length left in millimetres by the indenter,

$$HV = F/A = 1.8544F/d^2 \text{ kgf/mm}^2$$

4.3.2 Compressive Strength

Compressive strength: The ability of a material or structure to resist loads that tend to minimise size as opposed to loads that tend to elongate is the compressive strength. In other words, it is resistant to compression, however tensile force resists stress. Tensile strength, compressive strength and shear force can be separately measured in the study of material strength. The compression strength is produced by a compressive test experimentally. The device used for this test is the same as the one used for a tensile test. A uniaxial compressive load is applied instead of a uniaxial tensile load. As can be imagined, the specimen is shortened and extended laterally.

For the compression strength of samples using universal testing machine (UTM). UTM is used to test the mechanical characteristics of a given test specimen

(tension, compression, etc.) using a tensile, compressive or transverse stress. The machine has been named so that it can carry out various kinds of materials because of the wide range of tests. A UTM can be used for testing various types such as peel tests, flexural tests, tension tests, bend tests, friction tests, spring tests etc.

A UTM consists of two main units. They are loading and control units

The test specimens are arranged and the load exercises are kept in the loading unit. Variations are made from the control unit in load application and the corresponding test result.

The loading unit consists of three components. They are

1. Loading frame
2. Upper crosshead and lower crosshead
3. Elongation scale

Loading frame: A single or double supports the load-frame of a UTM. The loading frame is a bench, upper and lower crosshead.

Upper crosshead and lower crosshead: One end of the test specimen is clamped using the high cross head. A movable crosshead, which can be loosened for height adjustment and strapped, is the lower crosshead of the loading system. Both crossheads are centred with a tapered slot.

Elongation scale: A relatively large elongation scale is given with the loading element for the relative motion of the lower and upper table.

The control unit has three main components. They are

1. Hydraulic power unit
2. Load measuring unit
3. Control unit

Hydraulic power unit: This device consists of a petroleum pump providing non-pulsating oil flow through the main loading unit cylinder. This flux tends to apply the load on the specimen smoothly. An electric generator and a sump are used to operate the oil pump in a hydraulic power unit.

Load measuring unit: This device has a dynamometer of the pendulum with a small piston cylinder that travels with the undulating oil flow. A swivel heel connects the pendulum with the piston. Dependent on the load used in the

specimen, the pivot height deflects. This deflection is transferred to the load pointer and the load on the dial is shown.

Control unit: Electrical or hydraulic control systems may be used. Electrical controls use crosshead switches to turn the device on/off. There are two pipes, the right controlling valve, the left controlling valve or valve discharge, and a hydraulic control unit. The load on the specimen is loaded with a right control valve.

4.4 Microscopic Structures

Microscope structures of the samples are been collected by SEM and XRD both before and after sintering process of each composition of samples. SEM images are taken in three magnificent ranges such as 20 µm, 50 µm and 100 µm.

A scan electron microscope (SEM) scans the concentrated electron beam to create a picture on a surface. The beam electrons communicate with the sample, and produce different signals to provide knowledge about the topography and structure of the composition.

XRD is a study of the crystallograph composition of a substance used in the materials sciences. XRD acts by radiation of a sample by X-rays and then measures the intensity and dispersal angles of the ray material.

Crystals are normal atomic arrays, while X-rays can be used as electromagnetic radiation waves. Crystal atoms disperse the X-rays, largely through contact with the electrons of the atoms. The electron is referred to as the scatterer. This effect is called the elastic scatter. A range of spherical waves are generated on a regular basis. These waves, in the majority are annulled in disruptive interference; but in a few particular ways they contribute constructively, as laid down by the Bragg Law:

$$2d\sin\theta = n\lambda$$

Where d is the distance between diffracting planes, a comb is the corner of the occurrence, n is an integer, and μ is the longitude of the ray. The basic paths are called reflections in the diffraction pattern. The X-ray diffraction patterns are thus caused by electromagnetic waves that are impacted by a normal variety of dispersers.

CHAPTER 5

RESULT AND DISCUSSIONS

5.1 MICROSCOPIC ANALYSIS

5.1.1 Sem Analysis

SEM images are been taken both before and after sintering process of every samples of different compositions. All samples has three pictures of SEM images at different magnificant.

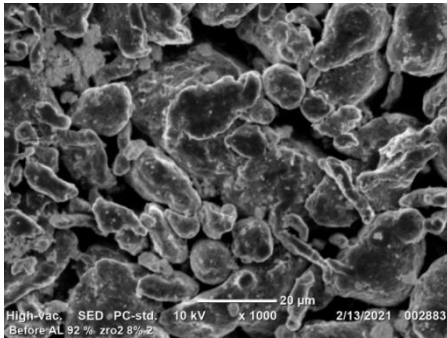


Fig 5.1.1.1 SEM images of ZrO2 8% before sintering

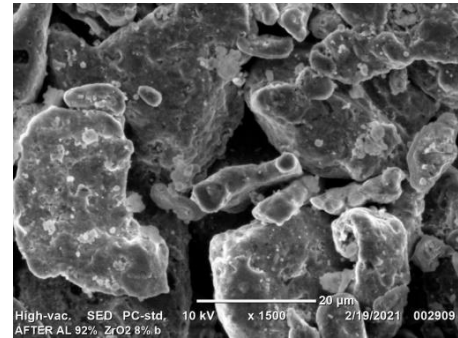


Fig 5.1.1.2 SEM images of ZrO2 8% after after sintering

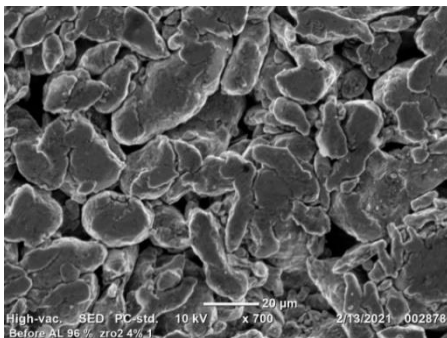


Fig 5.1.1.3 SEM images of ZrO2 4% before sintering

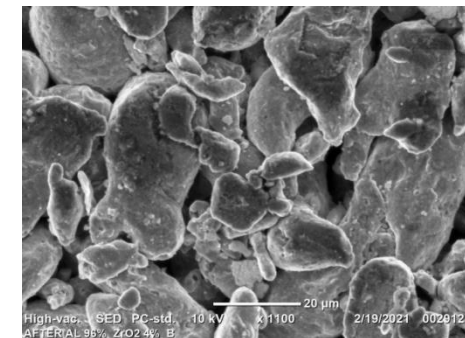


Fig 5.1.1.4 SEM images of ZrO2 4% after sintering

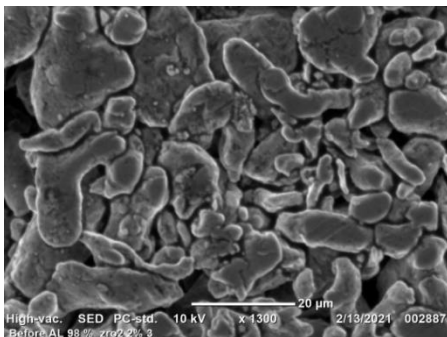


Fig 5.1.1.5 SEM images of ZrO2 2% before sintering

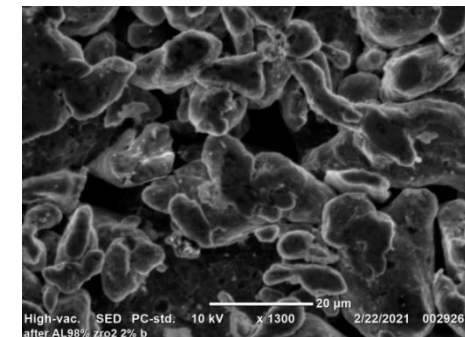


Fig 5.1.1.6 SEM IMAGES OF ZrO2 2% after sintering

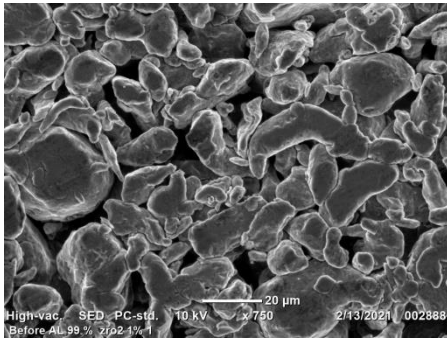


Fig 5.1.1.7 SEM images of ZrO2 1% before sintering

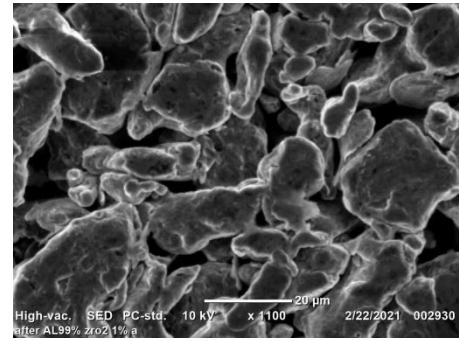


Fig 5.1.1.8 SEM images of ZrO2 1% after sintering

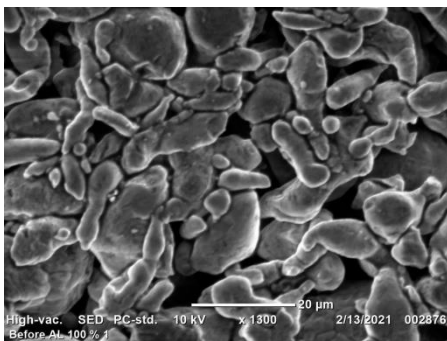


Fig 5.1.1.9 SEM images of ZrO2 0% before sintering

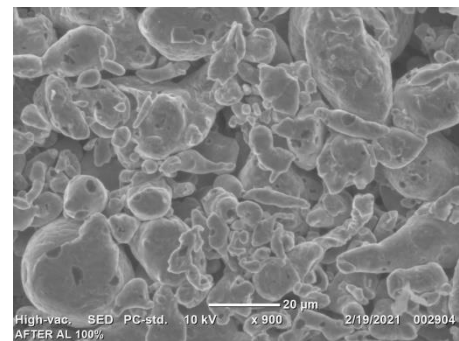


Fig 5.1.1.10 SEM images of ZrO2 0% after sintering

5.1.2 XRD ANALYSIS

XRD analysis of the samples are also been collected both before and after sintering. This work also been carried out VG ceramics at perungudi.

Measuring conditions are same for all samples where XRD is been collected both before and after sintering of all compositions.

X-Ray	30 kV , 12 mA	Scan speed / Duration time	8.0000 deg./min.
Goniometer		Step width	0.0200 deg.
Attachment	-	Scan axis	2Theta/Theta
Filter	None	Scan range	10.0000 -
Diffracted beam	None	Length limiting slit	-
Detector	SC-70	Receiving slit #1	-
Scan mode	CONTINUOUS	Receiving slit #2	-

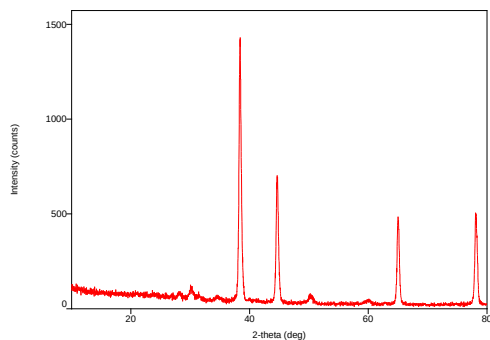


Fig a

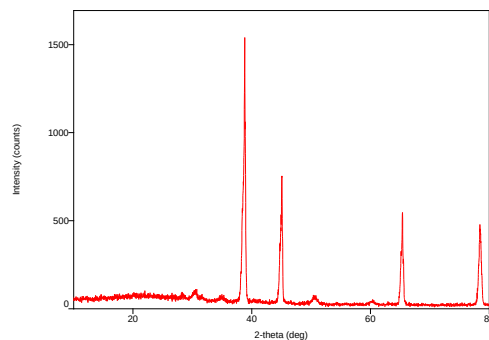


Fig b

FIG 5.1.2.1 XRD analysis of ZrO₂ 8% a is before and b is after sintering

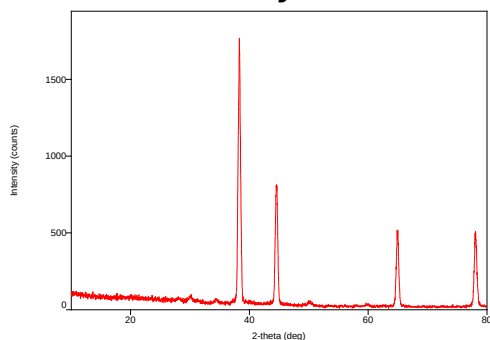


Fig a

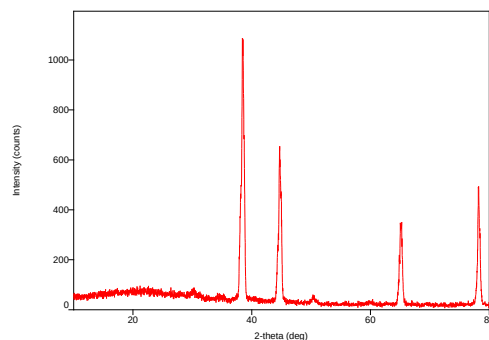


Fig b

Fig 5.1.2.2 XRD analysis of ZrO₂ 4% a is before and b is after sintering

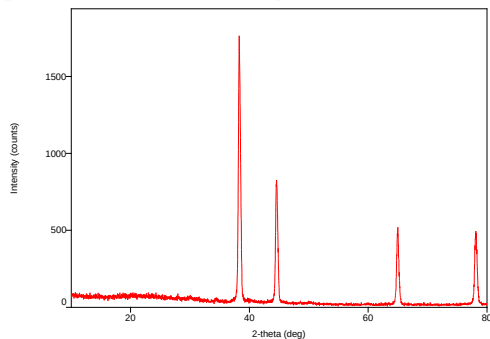


Fig a

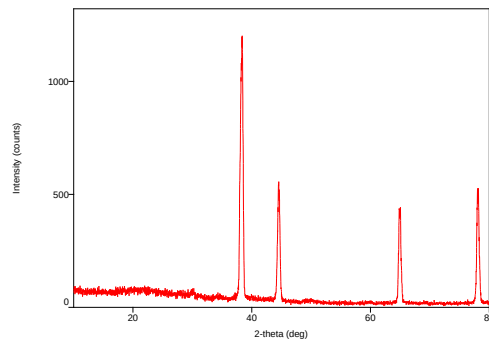


Fig b

Fig 5.1.2.3 XRD analysis of ZrO₂ 2% a is before and b is after sintering

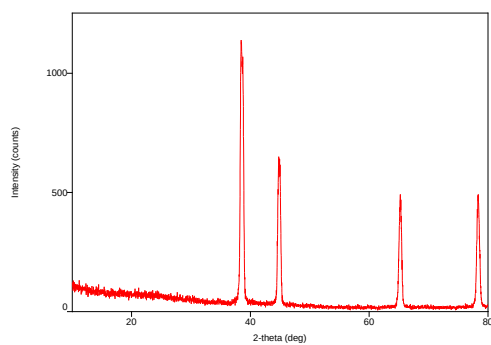


Fig a

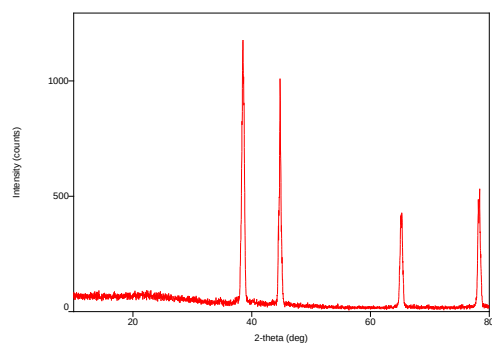


Fig b

Fig 5.1.2.4 XRD analysis of ZrO₂ 1% a is before and b is after sintering

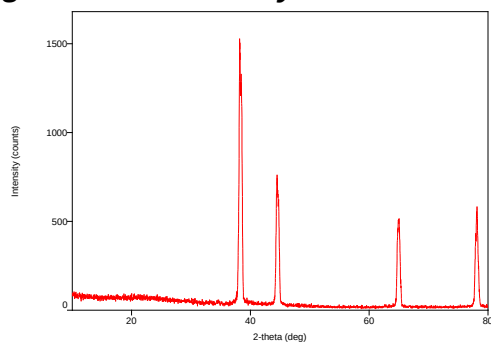


Fig a

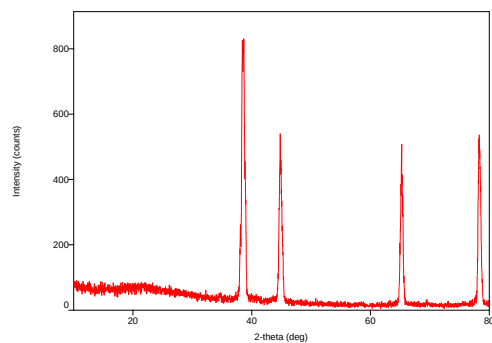


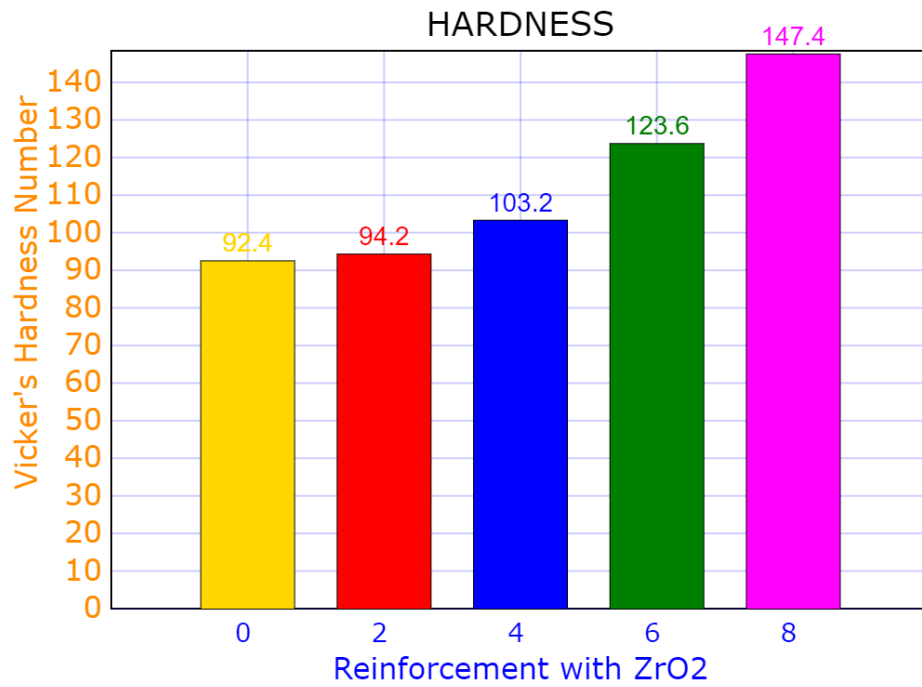
Fig b

Fig 5.1.2.5 XRD analysis of ZrO₂ 0% a is before and b is after sintering

5.2 MECHANICAL PROPERTIES

5.2.1 VICKERS HARDNESS

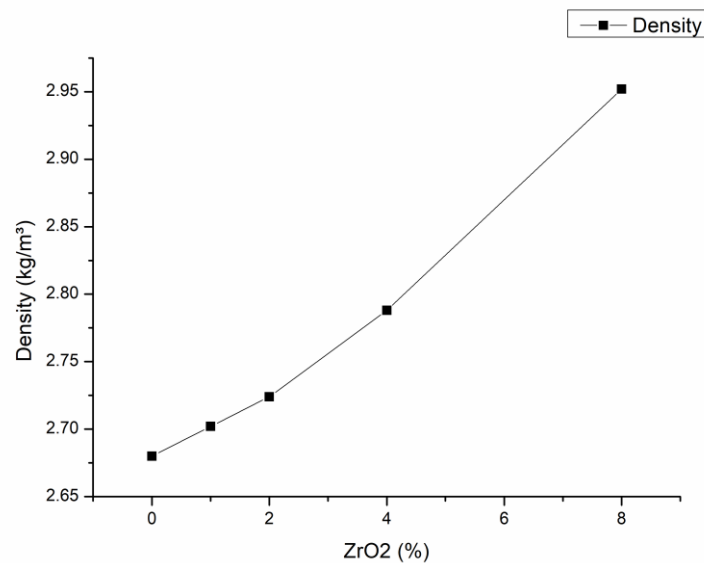
One of the methods to find the strength of the material is by conducting a hardness test. Hardness is the property of a material that enables it to resist penetration, plastic deformation, indentation and scratching. Vickers hardness method is suitable for low level loads for any type of surface treatment process. The Vickers hardness tester has a diamond shaped indenter and fisheye lens placed above the indenter to measure the micro hardness of the specimen. The load is applied on the indenter using a knob handler. Indentations were made on the specimen at five different places along the longitudinal and transverse direction to get the micro hardness value of the coating. The indentations were made on the surface of the materials. The test was carried on all the different composition samples with different parametric combination. The values and graph obtained from the micro hardness test shows that the hardness value of the sample. The hardness of the samples is been collected by using Vickers hardness. The graph is plotted according to the values. The density of samples increases with increases in the percentage of ZrO₂ content in the composition. The slight increases of ZrO₂ 1% show more increases in hardness of the sample. The graph 5.1 shows that with increasing the ZrO₂ content results in increasing the hardness of samples. At 8% of ZrO₂ and rest was Aluminium shows the highest hardness among the selected compositions. The gradual increase in the percentage of ZrO₂ results in increase in the hardness of brake lining materials.



Graph 5.1: Variation in the hardness of brake lining material with influence of ZrO₂

5.2.2 DENSITY

Density of the substances is the measurement of the mass to the volume of the substances. Density of the samples increases with increasing in the percentage of ZrO₂ in composition.



Graph 5.2 Density of the samples

SUMMARY

When it comes to brakes and friction products, there's no room for compromise. Brake dimensions are getting smaller, standards are rising, reliable performance is everything. Choosing the right materials for brake pads, brake linings and clutches has never been more important. Novel innovations and surging needs in automobile industry ask for modified metal matrix composites. Metal Matrix Composites (MMCs) have emerged as an important class of materials for structural, wear, thermal, transportation and electrical applications because it offers high strength to weight ratio, high stiffness and good wear resistance. The aluminum-based metal matrix composites are excellent novel materials for applications in aerospace, automotive and transportation industries. The fabrication methods of the aluminum-based composites can be categorized into three processes: solid-state methods, semisolid state methods and liquid state method. Brake lining is a friction causing material which is used in most of the mechanical braking systems. For reduce speed of the vehicles. Friction materials are heterogeneous and made up of a few different components that are used to demonstrate friction properties at low and high temperatures, improve life span, mechanical properties, and reduce porosity and noise. The study of tribological behaviour focuses on wear resistance, friction, and lubrication between interrelated surfaces. A brake is a mechanism that is used to slow or stop a moving object. When the speed of descent is regulated, reliable brakes are needed to absorb the kinetic energy of the moving parts or the P.E. of the thing being lowered by the host. Brakes absorb steam, which is then dissipated in the form of heat. To bring the engine to a halt, the heat is dissipated in the ambient atmosphere.

CONCLUSION

In the present study investigations were made on the mechanical properties of aluminium/Zirconium oxide/coconut shell ash composites and the conclusions are summarised below:

- The composites were fabricated with minimum porosity by compaction method and presence of ZrO₂ in aluminium alloy was evidenced by XRD study.
- Density of the composites initially decreased and then increased. Density of the composites increased to a maximum of 11.1% compared to the base aluminium alloy.
 - Addition of ZrO₂ in aluminium alloy increased the hardness of composites. Hardness of the composites increased to a maximum of 31.5% compared to that of the aluminium alloy.
 - Increase in addition of ZrO₂ particles increased the strength of the composites initially, while addition of 10% of ZrO₂ decreased the strength of the composites.
- From result we can conclude that beside ZrO₂.which is economically less cost and less weight ratio gives nearly less stress and deformation value in static analysis and giving good thermal distribution value so it can also use as the material for brake lining beside general materials.
- Thus, the modelling and analysis of brake lining is done with different materials at different boundary conditions.

REFERENCES

1. K. Ravikumar, K. Kiran, V.S. Sreebalaji, Characterization of mechanical properties of aluminium/tungsten carbide composites, *Measurement*, 102 (2017) 142–149. doi: 10.1016/j.measurement.2017.01.045
2. Prashanth Kumar H.G, Anthony Xavier, Assessment of mechanical and tribological properties of Al 2024- SiC - graphene hybrid composites, *Procedia Eng.* 174 (2017) 992 – 999.doi: 10.1016/j.proeng.2017.01.251
3. Jaswinder Singh, Amit Chauhan, Characterization of hybrid aluminum matrix composites for advanced applications – A review, *J. Mater. Res. Technol.* 5(2) (2016) 159–169.doi: 10.1016/j.jmrt.2015.05.004
4. T. Rajmohan, K. Palanikumar, S. Ranganathan, Evaluation of mechanical and wear properties of hybrid aluminium matrix composites, *Trans. Nonferr. Met. Soc. China.* 23 (2013) 2509–2517.doi: 10.1016/S1003-6326(13)62762-4
5. B.Rajeswari, K.S.Amirthagadeswaran, K.G.Anbarasu, Investigation on mechanical properties of aluminium 7075-silicon carbide-alumina hybrid composite using Taguchi method, *Aust. J.Mech. Eng.*13(2) (2015) 127-135. doi:10.7158/M13-051.2015.13.2
6. Dora Siva Prasad, Chintada Shoba, Nallu Ramanaiah, Investigations on mechanical properties of aluminium hybrid composites, *J. Mater. Res. Technol.* 3(1) (2014) 79-85.doi: 10.1016/j.jmrt.2013.11.002
7. G.Narasaraju, D. Linga Raju, Characterization of Hybrid Rice Husk and Fly ash Reinforced Aluminium alloy (AlSi10Mg) Composites, *Mater. Today: Proc.* 2 (2015) 3056 – 3064.doi: 10.1016/j.matpr.2015.07.245
8. Aoshuang Tan, Jie Teng, Xiang Zeng, Dingfa Fu, Hui Zhang, Fabrication of aluminium matrix hybrid composites reinforced with SiC microparticles and TiB₂ nanoparticles by powder metallurgy, *Powder Metall.*60 (1) (2017) 66-72. doi:10.1080/00325899.2016.1274816
9. Gaurav Gautam, Anita Mohan, Effect of ZrB₂ particles on the microstructure and mechanical properties of hybrid (ZrB₂ + Al₃Zr)/AA5052 insitu composites, *J. Alloys Compd.* 649 (2015) 174-183.doi: 10.1016/j.jallcom.2015.07.096