

ANALYZING MECHANICAL PROPERTIES OF AL7075-BASED HYBRID METAL MATRIX COMPOSITE FOR AUTOMOBILE APPLICATION

Submitted in partial fulfilment of the requirements for the award of Bachelor of
Engineering degree in an Automobile Engineering

by

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**DEPARTMENT OF AUTOMOBILE ENGINEERING
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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

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APRIL – 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of Thai Naga Avinash(39860024), Akhtar(39860005) who carried out the project entitled “ Analyzing the Mechanical Properties of Al7075 Based Hybrid Metal Matrix Composite for Automobile Applications” Under my supervision from December 2022 to April 2023.

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We Thia Naga Avinash and Akhtar hereby declare that the Project Report entitled **“ANALYZING MECHANICAL PROPERTIES OF AL7075-BASED HYBRID METAL MATRIX COMPOSITE FOR AUTOMOBILE APPLICATION”** done by us under the guidance of **Dr. A.JAYAGANTHAN M.E., Ph.D.**, at SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Automobile.

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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 and Dr. V.K. Bupesh Raja M.E., Ph.D., Head of the Department, Dept. of Automobile 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 Dr. A. Jayaganthan M.E., PhD., for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

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

ABSTRACT

The application of composite materials in the automotive sector has grown in importance due to their desirable qualities such as high strength, low weight, and better corrosion resistance. For use in automobile applications, this study examined the mechanical characteristics of hybrid metal matrix composites (MMCs) based on Al7075 that had been reinforced with Boron carbide and polymer Halloysite nanotubes. Utilising the stir casting technique, the composites were created and put through a number of tests, including tensile, hardness, and With the inclusion of boron carbide and halloysite nanotube, the composites' hardness was significantly improved, according to the hardness test. According to the investigation, the hybrid MMC made of Al7075 reinforced with boron carbide and halloysite nanotubes has good mechanical characteristics, making it appropriate for usage in automotive applications. Manufacturing companies are widely used aluminium or aluminium alloy because the material has more strength, hardness, and many mechanical properties as compared to other material. In our project we used Metal Matrix Composite Aluminium 7075(Al7075) as a base material with that we will composite another two materials polymer Halloysite Nanotubes (HNTs) and Reinforcement material Baron Carbide(B_4C) with the weight ratio percentage for the first specimen- 97.5% Al7075, 0.5% HNT, 2% B_4C Second Specimen- 92% Al7075, 7% HNT, 1% B_4C , and Third Specimen- 99% Al7075, 1% HNT, 0% B_4C were prepared using the stir casting method[1]. The sample has high tensile strength of 587 Mpa and high hardness of 85.05 HN and contains Al7075 at a concentration of 97.5 weight percent, HNT at a concentration of 0.5 weight percent, and B_4C at a concentration of 2 weight percent.

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LIST OF ABBREVIATIONS

AMCs	Aluminium Matrix composites
HNTs	Halloysite Nanotubes
MMCs	Metal Matrix Composites
ASTM	American Society for Testing and Materials
UTM	Universal testing Machine
Psi	Per square inch
Mpa	Megapascal
HR	Rockwell Hardness

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CHAPTER – 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

A composite material is made up of at least two materials that work well together to improve the qualities of each component alone. There are numerous procedures that may be used to create composite materials, which are incredibly flexible and effective. Compared to traditional materials, the composite's final product is lighter, stronger, and more durable. One of the most significant developments in material history occurred with the creation of composite materials, which are used in design and manufacturing. The weight of composite materials for their respective stiffness and strength is the main factor in their selection for components. Composites are also more resistant to corrosion, oxidation, and wear at high temperatures.

In many aspects of our daily lives, including building, healthcare, transportation, aerospace, ships, and rockets, composites have become ubiquitous. Without them, many applications would not be possible. Due to their high scalar strength and inadequate resistance to mechanical and thermal stress, monolithic versions of these materials are inappropriate for use in applications where a whole family of solid materials can be used thanks to composite technology. Because to its complex structures, the composite is also well suited to numerous manufacturing processes, which lowers the cost of production. The composite materials closest to our personal hygiene come from the fiber glass shower cubicles and bathtubs we use. Many daily uses for AMCs have been identified. Using particle-reinforced AMCs has some benefits over using unreinforced materials, including increased 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 abilities. Particles, short fibers, continuous fibers, or mono filaments can all be used as reinforcing elements inside the matrix. These days, it is utilized in

the aerospace industry as well as in heat management applications, industrial goods, and automobile components like brake discs and engine pistons.

Metal matrix transmits loads to reinforcements when loads are applied externally to the composites, and dispersed reinforcements that are attached to the matrix then carry the loads. To achieve high strength of composites, a strong interface bond between reinforcements and matrix is necessary. During casting, an interface bond is created via reaction or mutual dissolution. Hence, when casting, proper wetting of the reinforcements is required[8][9].

1.2 INTRODUCTION ABOUT MATERIALS

We introducing a composite materials are Aluminium Alloy 7075(AA7075), Boron Carbide(B₄C), and Halloysite Nanotube (HNT). Aluminium alloy 7075 is a high-strength material that has found widespread use in the automotive industry due to its unique combination of strength, light weight, and durability. This alloy is composed primarily of zinc, with small amounts of magnesium, copper, and chromium. The resulting material has a high strength-to-weight ratio, making it an ideal choice for automotive applications where strength and weight are both important factors. One of the primary uses of aluminium alloy 7075 in the automotive industry is in the production of suspension components, such as control arms, knuckles, and shock absorber housings. These components need to be able to withstand the constant stresses and impacts of driving, and the high strength of aluminium alloy 7075 makes it an excellent choice for this application. Additionally, the lightweight nature of the alloy can help improve the handling and performance of the vehicle. Aluminium alloy 7075 is also used in the production of wheels for high-performance cars, where its strength and light weight can improve handling and reduce unsprung weight. The alloy is well-suited to high-stress applications such as racing, where durability and performance are critical. Another important use of aluminium alloy 7075 in the automotive industry is in the production of structural components such as body panels and chassis. The alloy's high strength and stiffness make it an excellent choice for these applications, and its light weight can contribute to improved fuel efficiency. Overall, aluminium alloy 7075 is a versatile and high-performance material that has found numerous uses in the

automotive industry. Its use in suspension components, wheels, and structural components has helped improve the performance, durability, and fuel efficiency of many types of vehicles, from high-performance sports cars to lightweight electric vehicles.

Table 1.1 Composition of Aluminium 7075(Weight %)

Zn	Mg	Cu	Cr	Si	Mn	Ti	Fe	Al
5.6	2.5	1.6	0.23	0.11	<0.01	<0.01	0.08	Rem

Boron carbide is a remarkable material that defies expectations. It is an ultra-hard ceramic compound that is made up of boron and carbon atoms arranged in a complex crystal lattice. What makes boron carbide truly unique is its exceptional combination of properties: it is one of the hardest known materials, yet also has a low density, making it lighter than most metals. This means that boron carbide is both incredibly strong and lightweight, making it an ideal material for applications that require high strength and durability, such as armor plating and cutting tools. But despite its incredible hardness, boron carbide is also surprisingly flexible and has a high degree of elasticity, which allows it to deform without cracking or breaking under stress. This makes it an excellent material for use in applications where impact resistance is important. All in all, boron carbide is a fascinating material that pushes the limits of what we think is possible, and its unique properties make it a valuable asset in a wide range of industrial and technological applications.

Boron carbide has a number of properties that make it useful in the automotive industry. One of its primary applications is in the production of high-performance brake components. Boron carbide is an extremely hard and wear-resistant material, which means that it can withstand the high temperatures and friction that are generated during braking. This makes it an ideal material for use in brake pads and rotors, where it can help to increase the lifespan of the components and improve the overall performance of the braking system. Boron carbide is also used in the production of cutting tools for the automotive industry. Because of its exceptional hardness, boron carbide can be used to make tools that are capable of cutting and shaping even the toughest materials,

such as titanium and hardened steel. This makes it a valuable material for use in the manufacture of engine components, transmission parts, and other high-precision automotive parts. Additionally, boron carbide can be used as an armor material in vehicles. It is an extremely strong and lightweight material, which means that it can provide excellent protection against ballistic threats while also reducing the overall weight of the vehicle. This can help to improve the fuel efficiency and handling of the vehicle, while also enhancing the safety of the occupants. Overall, boron carbide is a versatile and valuable material that offers a range of benefits to the automotive industry, from improving the performance and lifespan of brake components to enabling the production of high-precision parts and enhancing the safety and efficiency of vehicles.

Halloysite nanotubes are a fascinating and relatively new class of nanomaterials that are capturing the attention of scientists and engineers around the world. These nanotubes are composed of a unique combination of metals and minerals, including copper, iron, silicon, and oxygen, arranged in a highly ordered lattice structure. What makes halloysite nanotubes truly unique is their exceptional combination of properties, including high electrical conductivity, mechanical strength, and chemical stability. One of the most exciting applications of halloysite nanotubes is in the field of nanoelectronics. Their high electrical conductivity and unique properties make them ideal for use in the development of advanced electronic devices and components, such as transistors, sensors, and batteries. Their high surface area and unique pore structure also make them excellent materials for use in catalysis, with potential applications in areas such as fuel cells, water treatment, and pollution control. Another promising application of halloysite nanotubes is in the field of biomedicine. Their biocompatibility and ability to interact with biological molecules make them promising candidates for use in drug delivery systems, tissue engineering, and biosensing. Additionally, their high surface area and unique pore structure make them useful materials for adsorbing and removing toxins and pollutants from biological fluids. Overall, halloysite nanotubes are a fascinating and versatile class of nanomaterials with tremendous potential for a wide range of applications. From advanced electronic devices to biomedical applications, their unique properties make them valuable assets in the development of new technologies and the improvement of existing ones.

CHAPTER – 2

LITERATURE SURVEY

G. Anil Kumar, J. Sateesh, Y. Kumar T, and T. Madhusudhan, “Properties of Al7075-B4C Composite prepared by Powder Metallurgy Route,” *Int. Res. J. Eng. Technol.*

The examination of the Al7075-B4C composite's characteristics, which was created by powder metallurgy, is presented in this work. The study's goal is to determine how the composite's mechanical and physical characteristics are affected by its various B4C content (0, 2, 4, 6, 8 and 10 wt%). The study, taken as a whole, sheds information on the characteristics of Al7075-B4C composites and emphasises the potential of the powder metallurgy method for creating them. The study's results can aid in the creation of novel materials for a variety of technical applications.

I. Topcu, H. O. Gulsoy, N. Kadioglu, and A. N. Gulluoglu, “Processing and mechanical properties of B4C reinforced Al matrix composites,” *J. Alloys Compd.*

According to the study, adding B4C particles greatly enhances the mechanical characteristics of composite materials, such as hardness, compressive strength, and wear resistance. For the best mechanical qualities, B4C particles should be between 3 and 5 μ m in size. The study shows how B4C reinforced aluminium matrix composites may be used in high-strength and wear-resistant applications. For the creation of novel materials with enhanced mechanical and wear qualities, the study's findings may be helpful.

S. Suresh, G. H. Gowd, and M. L. S. Deva Kumar, “Experimental investigation on mechanical properties of Al 7075/Al₂O₃/Mg NMMC's by stir casting method,” *Sadhana - Acad. Proc. Eng. Sci.*

The report includes an experimental study of the mechanical characteristics of stir-cast metal matrix composites augmented with Al₂O₃ and Mg particles and based on Al 7075. The scientists looked at how different Al₂O₃ and Mg weight percentages affected the mechanical characteristics of the composites. The results of the investigation

demonstrate a considerable improvement in the mechanical characteristics of the composites due to the inclusion of Al₂O₃ and Mg particles. At 2 weight percent Al₂O₃ and 1 weight percent Mg, the most improvement was seen. The weight percentages of Al₂O₃ and Mg particles had a substantial impact on the microstructure of the composites, the scientists discovered. The research puts the spotlight on the mechanical characteristics and microstructure of metal matrix composites made of Al 7075 reinforced with Al₂O₃ and Mg particles. The study's conclusions can aid in the creation of novel materials with enhanced mechanical characteristics for a variety of technical applications.

K. Wang et al., "Synthesis of Aluminium Phosphate-Coated Halloysite Nanotubes: Effects on Morphological, Mechanical, and Rheological Properties of PEO/PBAT Blends.

The study's findings demonstrate that the mechanical and rheological behaviour of the PEO/PBAT blends are greatly enhanced by the inclusion of HNTs. The authors also discovered that the HNTs enhance PEO and PBAT compatibility, which enhances the blends' morphological features. The work sheds light on the utilisation of halloysite nanotubes with an aluminium phosphate coating as a viable reinforcing material for polymer blends. The study's conclusions may help in the creation of novel materials with enhanced mechanical and rheological characteristics for usage in a variety of engineering and materials science applications.

H. Singh, G. S. Brar, H. Kumar, and V. Aggarwal, "Characterization and sustainability of boron carbide reinforced 7075 aluminum metal matrix composites," J. Green Eng.

According to the study's findings, adding B₄C to composite materials greatly enhances their tensile strength, hardness, and impact resistance. The inclusion of B₄C greatly improved the composites' corrosion and wear resistance, according to the scientists. The study sheds light on the usage of B₄C as a reinforcing material for 7075 Al metal matrix composites and how it affects the durability and mechanical characteristics of the composites. The study's findings may be helpful in the creation of novel materials

with enhanced mechanical capabilities and sustainability for use in a variety of engineering and materials science applications.

E. Badea, C. Carşote, E. Hadîmbu, C. Şendrea, and M. C. Lupaş, "The effect of halloysite nanotubes dispersions on vegetable-tanned leather thermal stability," *Herit. Sci.*

The usage of leather in traditional assets and the significance of preserving their structural integrity. They provided an explanation of the prospective application of HNTs, a type of nanomaterial, in leather preservation. According to the study's findings, adding HNTs can make vegetable-tanned leather more thermally stable. The authors address possible uses for leather that has been HNT-treated in heritage conservation and present a thorough analysis of their findings. The work could have an impact on how heritage objects are preserved, and the authors make a significant contribution to the field of heritage science. To corroborate these results on a larger scale, however, it should be kept in mind that the study's sample size was very small and that additional research may be required.

A. Baradeswaran and A. Elaya Perumal, "Influence of B4C on the tribological and mechanical properties of Al 7075-B4C composites," *Compos. Part B Eng.*

the application of metal matrix composites and the value of enhancing their characteristics for various applications. They then go on to discuss their experimental procedures, which included making Al 7075-B4C composites and characterising their mechanical and tribological characteristics. According to the study's findings, B4C can be added to Al 7075 to increase the material's hardness, compressive strength, and wear resistance. The prospective uses of Al 7075-B4C composites in various industries are discussed by the authors along with a thorough review of their research findings. novel materials with enhanced properties, and the authors make a significant contribution to the field of materials science. It should be noted that the study primarily focuses on one particular composite system, and that additional research may be required to corroborate similar results for different metal matrix composites.

L. E. G. Cambronero, E. Sánchez, J. M. Ruiz-Roman, and J. M. Ruiz-Prieto, "Mechanical characterisation of AA7015 aluminium alloy reinforced with ceramics," J. Mater. Process. Technol.

According to the study's findings, AA7015 aluminium alloy can gain in hardness, compressive strength, and wear resistance by incorporating ceramics. The authors explain the potential uses of these composites in various industries and provide a thorough analysis of their findings. The authors make a significant contribution to the field of materials research, and the discovery may have consequences for the creation of novel materials with enhanced properties. To corroborate these findings on different metal matrix composites, it may be essential to do additional research, as the study solely focuses on one particular composite system

L. A. Dobrzański, B. Tomiczek, M. Pawłyta, and M. Król, "Aluminium AlMg1SiCu matrix composite materials reinforced with halloysite particles," Arch. Metall. Mater.

The study's findings imply that adding halloysite particles can increase the aluminium matrix's hardness, tensile strength, and elongation at break. The authors explain the potential uses of these composites in various industries and provide a thorough analysis of their findings. The halloysite-reinforced aluminium AlMg1SiCu matrix composite materials' mechanical characteristics. The authors make a significant contribution to the field of materials research, and the discovery may have consequences for the creation of novel materials with enhanced properties. To corroborate these findings on different metal matrix composites, it may be essential to do additional research, as the study solely focuses on one particular composite system.

M. Hanif, F. Jabbar, S. Sharif, G. Abbas, A. Farooq, and M. Aziz, "Halloysite nanotubes as a new drug-delivery system: a review," Clay Miner.

The study's findings point to a number of advantages that HNT-based drug delivery systems offer over conventional drug delivery systems, including better drug release kinetics, higher drug loading capacity, and lower toxicity. The authors describe the possible uses of HNT-based drug delivery systems in several scientific domains and provide a thorough analysis of their findings. the potential application of HNTs in

medication delivery. The authors make a significant addition to the fields of materials science and biomedical engineering with their study, which may have ramifications for the creation of new drug delivery systems with enhanced features. The work only examines one possible usage for HNTs, and more investigation may be required to confirm similar results for other possible uses.

M. Imran, A. R. A. Khan, S. Megeri, and S. Sadik, "Study of hardness and tensile strength of Aluminium-7075 percentage varying reinforced with graphite and bagasse-ash composites," *Resour Technol*.

The aluminum-7075 composites' tensile strength and hardness. The authors explain the potential uses of the composites in various industries and provide a thorough analysis of their findings. The creation of novel composite materials with enhanced characteristics, and the authors present a comprehensive review of their results. It should be noted that the study only looks at the particular materials utilised in combination, and that additional research may be required to corroborate these results for other possible material combinations.

T. H. Manjunatha, Y. Basavaraj, and V. Venkata Ramana, "Wear analysis of Al7075 alloyed with nano B₄C: A taguchi approach," *Mater. Today Proc*.

The wear resistance of the Al7075 alloy is enhanced by nano B₄C. The Taguchi approach—a statistical technique for engineering system quality assurance and optimization—is used by the authors to give a thorough examination of their findings. Additionally, they go over the many industries in which the nano B₄C-reinforced Al7075 composite could be used. The authors present a comprehensive analysis of their results, and the use of the Taguchi technique is a fresh and useful way to analyse the experimental data. However, it should be emphasised that the study only considers the specific combination of materials employed, and additional investigation may be required to corroborate similar results on other possible combinations of materials.

V. S. Kannan et al., "Analyzing the mechanical properties of aluminium (SiC, B₄C) hybrid Composite," *IOP Conf. Ser. Mater. Sci. Eng*.

Conclusions from the research demonstrate that the mechanical properties of the aluminium matrix composite are greatly enhanced by the inclusion of SiC and B₄C particles. Stress-strain curves and SEM micrographs of the broken surfaces are included in the authors' comprehensive analysis of their research findings. The mechanical characteristics of hybrid composites made of aluminium and reinforced with SiC and B₄C particles. The specimens were prepared and tested using a reliable approach, and the results were presented in an organised and understandable way. It might be essential to conduct more study to confirm these conclusions for additional possible material pairings.

M. Massaro, C. G. Colletti, G. Lazzara, S. Milioto, R. Noto, and S. Riela, "Halloysite nanotubes as support for metal-based catalysts," J. Mater. Chem. A

The upsides of adopting HNTs as support material, including their high surface area, thermal stability, and biocompatibility. The impact of the metal deposition method on the catalytic performance of the resulting metal-HNTs composites is also covered by the authors. These methods covered include impregnation, ion exchange, and electroless deposition. HNTs as support materials for metal-based catalysts and demonstrates their potential for use in a variety of catalytic processes, such as chemical synthesis, energy production, and environmental clean up.

B. P. R. Kamble, M. Ghag, S. Gaikwad, "Halloysite Nanotubes and Applications: A Review," Compos. Their Prop.

The hollow construction, significant aspect ratio, and high surface area of the naturally occurring mineral clay known as halloysite. After that, the authors go over the several ways to make halloysite nanotubes and the methods used to characterise them, including X-ray diffraction, scanning electron microscopy, and transmission electron microscopy. Halloysite can be employed as a cement composite reinforcement material, a medicine and other biomolecule carrier, a catalytic support, and a filler in polymer composites.

CHAPTER – 3

AIM AND SCOPE

The aim of our project is to get the best composite material for the automobile industry that will be used for manufacturing the part of the vehicle as well as other industries like aero-industry and such type of industries that are continually working for the manufacturing any type of mechanical components for that they need to keep in their mind when they select the material for the particular product manufacture in that way we can assume the quality of life of the particular product if we talking about like these manufacturing companies they need such type of material which can give more durability and strength. The investigation of our project is done the references suggested by the internal guide in the references mentioned the things were helpful for us , in the references we got the problems that will impact to the manufacturer to produce the product the problems are like corrosion, the strength of the material could be responses. Various analytical models used for the prediction of effective properties of composites are Hashin and Shtrikman model, Mura model, Budiansky model, Eshelby model, etc. The effective Young's modulus of composites with spherical reinforcements, with a large volume fraction can be predicted by Budiansky model. Eshelby model considers the reinforcement as ellipsoidal shape in an infinite matrix

CHAPTER – 4

MATERIALS AND METHODS

4.1 MATERIALS

In the Project, we have taken the materials like metal matrix material, reinforcement material, and polymer they are

1. Aluminium Alloy 7075(AA 7075)
2. Boron Carbide(B₄C)
3. Halloysite Nanotube(HNT)

4.1.1 Aluminium Alloy 7075 (AA 7075)

Aluminium 7075 Alloy (AA7075) is an aluminium alloy with zinc as the essential alloying element. It has gorgeous mechanical residences and reveals correct ductility, excessive strength, toughness, and desirable resistance to fatigue. It is greater inclined to embrittlement than many different aluminium alloys due to the fact of micro-segregation, however has appreciably higher corrosion resistance than the alloys from the 2000 series. It is one of the most normally used aluminium alloys for incredibly careworn structural functions and has been considerably used in plane structural parts. Aluminium 7075 Alloy (AA7075) is an aluminium alloy with zinc as the essential alloying element. It has gorgeous mechanical residences and reveals correct ductility, excessive strength, toughness, and desirable resistance to fatigue. It is greater inclined to embrittlement than many different aluminium alloys due to the fact of micro-segregation however has appreciably higher corrosion resistance than the alloys from the 2000 series. It is one of the most normally used aluminium alloys for incredibly careworn structural functions and has been considerably used in plane structural parts.

Table 4.1 Chemical composition of AA7075

Element Concentration(Weight %)								
Zn	Mg	Cu	Cr	Si	Mn	Zn	Fe	Al
5.6	2.5	1.6	0.23	0.11	<0.01	<0.01	0.08	Rem

Table 4.2. Mechanical Properties of AA7075

Density(g/cm ³)	Tensile Strength(σ_t)	H a r d n e s s , Rockwell A,B	H a r d n e s s , v i c k e r s
2.810	572 MPa	53.5, 87	175

4.1.2 Boron Carbide (B₄C)

Boron carbide has tremendous houses and is extensively used. Boron carbide is 2d solely to diamond and cubic boron nitride in hardness. It has many advantages, such as excessive melting point, low density, excessive strength, vast neutron absorption cross-section, super thermoelectric performance, and precise mechanical stability. And we can use it in aerospace, country wide defence, nuclear energy, and wear-resistant technology. The carbothermal discount is the main technique for the industrial manufacturing of boron carbide. Besides, the practices of boron carbide manufacturing encompass self-propagating thermal reduction, mechanochemical method, direct synthesis, sol-gel method, and so on.

Boron carbide (B₄C) has a complex crystal structure that is classified as rhombohedral or trigonal. Its unit cell contains 12 boron atoms and four carbon atoms, arranged in a three-dimensional network. The boron atoms in boron carbide form icosahedra (a polyhedron with 20 faces) that are linked together by carbon atoms in linear chains. These chains run parallel to the c-axis of the crystal and are separated by empty icosahedral sites. The crystal structure of boron carbide is unique in that it

contains a high degree of disorder, with both boron and carbon atoms occupying interstitial positions within the crystal lattice. This disorder contributes to the material's exceptional hardness, as it creates a high density of defects and imperfections that impede the movement of dislocations and prevent the material from deforming under stress. Overall, the complex crystal structure of boron carbide contributes to its exceptional properties, including high hardness, low density, and resistance to chemical and thermal damage.

4.1.3 HALLOYSITE NANOTUBE(HNT)

Halloysite nanotubes (HNT) are a naturally happening aluminosilicate with a predominantly hole tubular shape mined from herbal deposits in nations such as the United States, China, New Zealand, France, and Belgium.

Halloysite is an aluminosilicate clay mineral with the empirical components $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$. Its primary materials are oxygen (55.78%), silicon (21.76%), aluminium (20.90%), and hydrogen (1.56%). Halloysite commonly types by using hydrothermal alteration of alumina-silicate minerals. In the subject of pharmacy and fitness care, effectiveness of medicinal drug and remedy is very important, failure or disadvantage in the drug remedy may additionally lead to both ineffectiveness or aspect consequences which abate human health. Green nanotechnology pursuits at growing surroundings protected and much less hazardous nano products.

Halloysite clay nanotubes, nanocomposites, nano powders, and so forth are now rising as fashion setters in inexperienced nanotechnology. Halloysite nanotubes are eco-friendly nanotubes with low value than carbon nanotubes. In latest years there has been developing subject about the impact of carbon nanotubes on human fitness and on surroundings due to the fact of their conceivable poisonous nature Halloysite nanotubes discover several industrial purposes such as, components in polymers and plastic, digital components, drug transport vehicles, cosmetics and in domestic and non-public care products.

Table 4.3 Mechanical properties of HNT

HNT (wt %)	Density (g/cm ³)	Hardness (shore-D)	Tensile Stress (MPa)	Tensile Modulus (GPa)	Flexural Stress(MPa)	Impact Energy (j/m)
1	1.63	57	234.0	6.8	414.3	661.5
2	1.64	64	248.4	6.9	434.5	706.6
3	1.66	68	267.7	7.6	489.4	1563.2
4	1.71	62	257.8	7.1	446.3	857.1

4.2 METHODS

In this Project we have been executed the different methods to finding the Mechanical Properties for a Composite Materials and the methods are

1. Examining the Materials
2. Preparing a sample
 1. Stir casting
 2. Moulding
 3. Cutting
 4. Smoothing
3. Tensile Test
4. Hardness Test

4.2.1 Examining the Materials

Studying of a material is important before going to experiments. Here we will be finding the Mechanical Properties, Structure of a Material, Chemical Composition.

Mechanical properties are the characteristics of a material that determine how it will behave when subjected to external forces or loads. These properties are important to consider when selecting materials for engineering applications, as they can affect the durability, strength, and safety of a product.

Some common mechanical properties include:

Strength: This refers to a material's ability to withstand external forces without breaking or deforming. It is often measured in terms of tensile strength, compressive strength, and shear strength.

Hardness: This measures a material's resistance to surface indentation or penetration. It can be an important property for materials that need to withstand wear or abrasion.

Elasticity: This describes a material's ability to deform when subjected to a force and then return to its original shape once the force is removed.

Ductility: This measures a material's ability to stretch or deform without breaking.

Toughness: This refers to a material's ability to absorb energy without fracturing or breaking.

Fatigue resistance: This measures a material's ability to withstand repeated loading over time without failing.

Creep resistance: This measures a material's ability to withstand deformation or shape change over time under constant stress.

The specific mechanical properties of a material depend on a variety of factors, including its composition, structure, and processing.

4.2.2 Preparing a Sample

A sample piece is a small piece of material that is extracted from the three materials that cut into a required Form for a Tensile testing Hardness testing to find its properties. The sample piece is typically a small, representative portion of the bulk material that is used to study its mechanical, physical, or chemical properties. The size and shape of the sample piece will depend on the type of testing that will be conducted. For example, in tensile testing, a long and narrow sample is used to measure the material's resistance to being pulled apart. In hardness testing, a small and flat sample is used to measure the material's resistance to being scratched or indented. Sample pieces can be prepared in different ways depending on the material being tested and the desired testing method. For example, some materials can be easily cut or machined

into the desired shape, while others may require more specialized techniques such as casting, Furnace, Moulding, etc.

4.2.2.1 Stir Casting

Stir casting is a commonly used method for the fabrication of composite materials. It involves the incorporation of reinforcement particles and Polymers into a molten metal matrix using mechanical stirring. The process is also known as liquid-state processing, and it is widely used in the production of metal matrix composites (MMCs), which exhibit superior mechanical, thermal, and electrical properties compared to their monolithic counterparts. In the stir casting process, the reinforcing particles and Polymers are first preheated to a temperature above the melting point of the matrix metal. The preheated reinforcements are then added to the molten metal and the mixture is stirred using a mechanical stirrer. The stirring action ensures uniform dispersion of the reinforcing particles and Polymer in the matrix metal. Here the Metal matrix composite is Aluminium Alloy 7075, Reinforcement Material is Boron Carbide and Polymer is Halloysite Nanotube. And In This Experiment We need a Crucible (fig), Stir Rod(fig), Furnace with having 800⁰ C at maximum temperature. Taking a materials they are Aluminium Alloy 7075, Boron Carbide and Halloysite Nanotube. The Stir casting is done three types in different weightages they are mention in Table 4.4

Table.4.4 Composition Ratio (Weight %)

Specimens	Al 7075	HNT	B₄C
1	97.5%	0.5%	2%
2	92%	7%	1%
3	99%	1%	-



Fig:4.1 : Crucible



Fig:4.2 : Stir rod



Fig:4.3 : Stir Casting

4.2.2.2 Moulding

The composite mixture is then poured into a preheated mold and allowed to cool to room temperature. The cooling rate and solidification behaviour of the composite mixture are important factors that influence the final properties of the composite material. The Block of Moulding is made up of iron it's have a cuboidal empty space in between as shown in fig. The Moulding is done in different weightages according to the

above table 4.4 and then taking the three blocks to get into specimen having a length of 100 mm, breadth of 100 mm and height of 10 mm. And the specimen shown in fig



Fig:4.4 : Moulding blocks



Fig:4.5 : Specimen

4.2.2.3 Cutting

Composite materials we got in a specimen we can see in fig 4.6. This can be cut according to ASTM standards that will be useful in analyse the strength of the material the following fig 4.7 as shown and this is for mainly used tensile test and Rockwell hardness test.

ASTM has several standards for the preparation of composite material specimens. The specific standard to follow depends on the type of composite being tested and the type of test being conducted. However, in general, the following steps can be taken to cut a composite material specimen in accordance with ASTM standards:

- Determine the type of specimen needed: The ASTM standard for the test being conducted will specify the dimensions and shape of the specimen required.
- Choose the appropriate cutting tool: A saw or a water jet cutter may be used depending on the composite material being tested.
- Prepare the cutting area: Ensure the work area is clean, and the composite material is secured in place to prevent movement during the cutting process.
- Cut the specimen: Follow the dimensions and shape specified in the ASTM standard for the test being conducted.
- Check the specimen dimensions: After cutting, measure the dimensions of the specimen to ensure it meets the tolerances specified in the ASTM standard.
- Record specimen details: Record the specimen's identification number, dimensions, and other relevant information as specified in the ASTM standard.
- Finish the specimen: Finish the specimen's edges, if required, using sandpaper or a grinder as specified in the ASTM standard.

It is essential to follow the specific ASTM standard for the test being conducted to ensure the accuracy and repeatability of the test results.

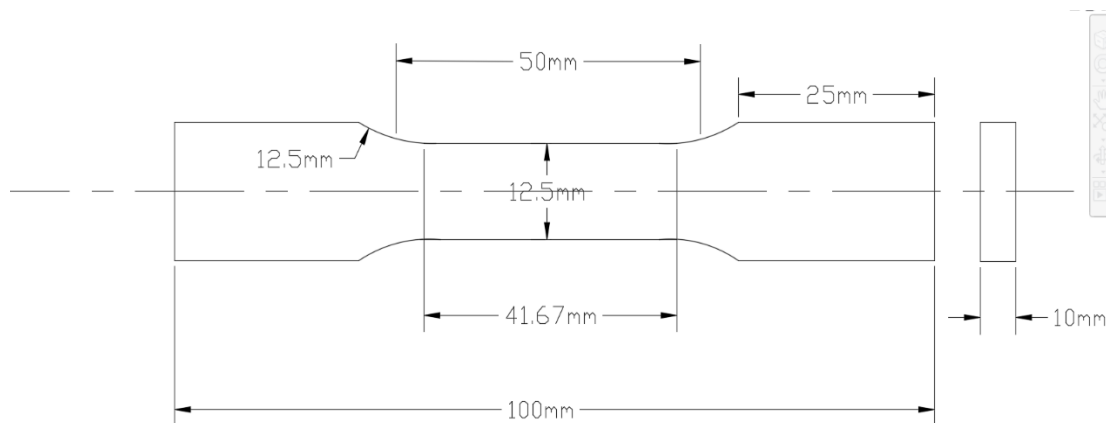


Fig: 4.6 : Tensile Specimen with measurements



Fig:4.7: After grinding in according to ASTM Standard tensile specimen

4.2.2.4 Polishing

Polishing of a composite material specimen for Rockwell hardness testing involves several steps to achieve a smooth and flat surface free from scratches or other surface defects that could affect the accuracy of the test results. Here are the general steps for polishing a composite material for Rockwell hardness testing:

- Prepare the specimen: Cut the composite material specimen to the appropriate size and shape, following the ASTM standard for the test being conducted.
- Coarse grinding: Use a coarse grinding wheel or sandpaper to remove any excess material or surface irregularities, such as burrs, bumps, or uneven edges. Apply water or a lubricant to the grinding surface to prevent overheating and to maintain a consistent finish.
- Fine grinding: Use a finer grit sandpaper or polishing wheel to further smooth the surface, removing any scratches or other defects left from the coarse grinding step. Continue to use a lubricant to prevent overheating.
- Polishing: Use a polishing wheel or cloth with a fine polishing compound to achieve a mirror-like finish on the surface of the specimen. Use a different wheel or cloth for each polishing compound to avoid contamination.

- Clean the specimen: Thoroughly clean the specimen with a mild detergent and water, and then rinse it with distilled or deionized water to remove any remaining polishing compound or debris.
- Dry the specimen: Use a clean, lint-free cloth or compressed air to dry the specimen completely.
- Verify surface quality: Use a microscope or similar tool to verify the surface quality and to ensure there are no visible defects, such as scratches or pits, that could affect the accuracy of the hardness test.

These steps will help ensure that the composite material specimen is properly prepared and polished for Rockwell hardness testing, and that the results obtained are accurate and repeatable.



Fig: 4.8 : Water Polishing

4.2.3 Tensile Strength

Tensile strength is the maximum amount of tensile stress that a material can withstand before it breaks or fails. It is a measure of a material's ability to resist deformation under tensile loading, such as stretching or pulling. Tensile strength is typically measured in units of force per unit of cross-sectional area, such as pounds-force per square inch (psi) or newtons per square meter (N/m² or Pa). The tensile strength of a material is determined through laboratory testing using a tensile testing machine here the machine is used as Universal Testing machine(UTM) shown in fig 4.10, which applies a controlled tensile force to a sample of the material until it fractures

or reaches its maximum stress point. Tensile strength is an important property for any composite material will be subjected to tensile loads, such as Strength of material

4.2.3.1 Universal Testing Machine(UTM)

A universal testing machine (UTM) is a common piece of equipment used to measure the mechanical properties of materials, including the strength of composite materials.

Procedure :-

To test the strength of a composite material using a UTM, a sample of the material is loaded into the machine and subjected to a tensile or compressive force. The machine is programmed to apply a steadily increasing load to the sample until it reaches its breaking point. During the test, the UTM measures the force applied to the sample and the corresponding amount of deformation, or strain, that the sample undergoes.

- a. The I-section of specimen of upper end and lower end tightened to the UTM machine which will be help full to enlarge the composite material
- b. Here we connect the UTM machine to the computer to the enlarge length when load applied to the specimen
- c. The load will be increased continuously the computer will measuring the length of specimen when load is going and increasing as usual.
- d. This will be done for up to breakdown of tensile specimen.
- e. Her the values we get in computerised form
- f. This was done for three specimens



Fig:4.9 : UTM

4.2.4 Hardness Test

Hardness testing is a test that will be applying constant load on a material then we will get the load observed material there can observe that pointed on material. This will measured as the hardness of the material. For hardness so many methods are used here one of then that is Rockwell hardness. This method mainly used hard materials so we have material as more weightage of aluminium in our composite material.

4.2.4.1 Rockwell Hardness Test

The Rockwell hardness test measures the hardness of metallic materials in a simple way that is here the process is

- a) The material is tightening to the Rockwell machine.
- b) The diamond structure is tightened to upside of the machine.
- c) We are working on Aluminium so we have to lock the load of 100 N. This information well be known on the machine.

- d) Then adding load to the material in different areas on specimen like 5 times which help full to take an average of whole specimen in once
- e) This same method done for three weighted Composite material.



Fig: 4.10: Rockwell Hardness Testing Machine

CHAPTER – 5

RESULT AND DISCUSSION

In this project we are mostly discussed about the topics like materials they are AA 7075, B4C and HNT and the methods we have done are stir casting, moulding, grinding, polishing, Tensile test and hardness test. The machines we are used for fabrication water polishing, machine grinding and Furnace. And the machine is used for testing the material they are Universal testing machine (UTM) and Rockwell hardness testing machine

According to the tensile test with help of Universal testing machine we have taken three specimens which there weightages are mentioned in table 4.4, This was discussed in Chapter 4. According to this we have created the three different weightages specimens and according to then with help of computerised UTM have created by graph of stress vs strain graph in fig 5.2

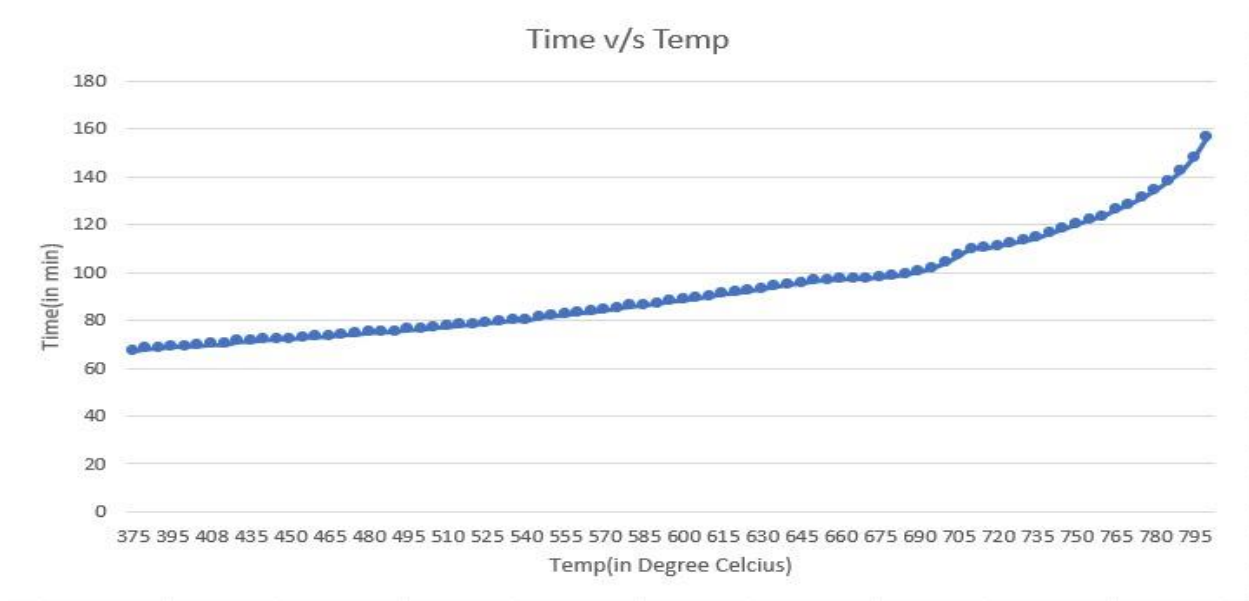


Fig.5.1 Time v/s Temperature

Table 5.1 Obtained Tensile Strength

S. No	Specimens\Test	Tensile Strength (MPa)
1	Al 7075 – 92 wt% HNT – 7 wt% B ₄ C – 1 wt%	120
2	Al 7075 – 99 wt% HNT – 1 wt%	534
3	Al 7075 – 97.5 wt% HNT – 0.5 wt% B ₄ C – 2 wt%	587

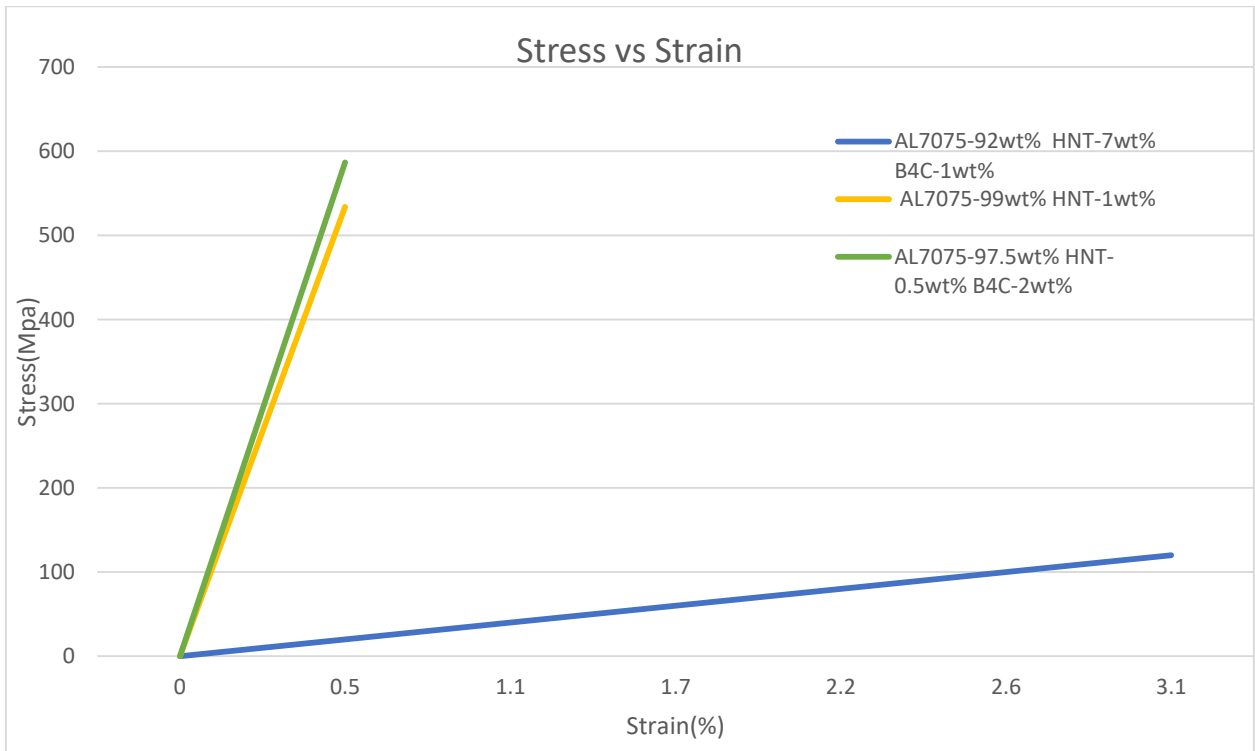


Fig 5.2 Stress vs Strain

Table 5.2. Rockwell Hardness Result

S. No.	Specimen / Test	Rockwell Hardness
1	Al 7075 – 92 wt% HNT – 7 wt% B ₄ C – 1 wt%	61.135
2	Al 7075 – 99 wt% HNT – 1 wt%	77.43
3	Al 7075 – 97 wt% HNT – 0.5 wt% B ₄ C – 2 wt%	85.05

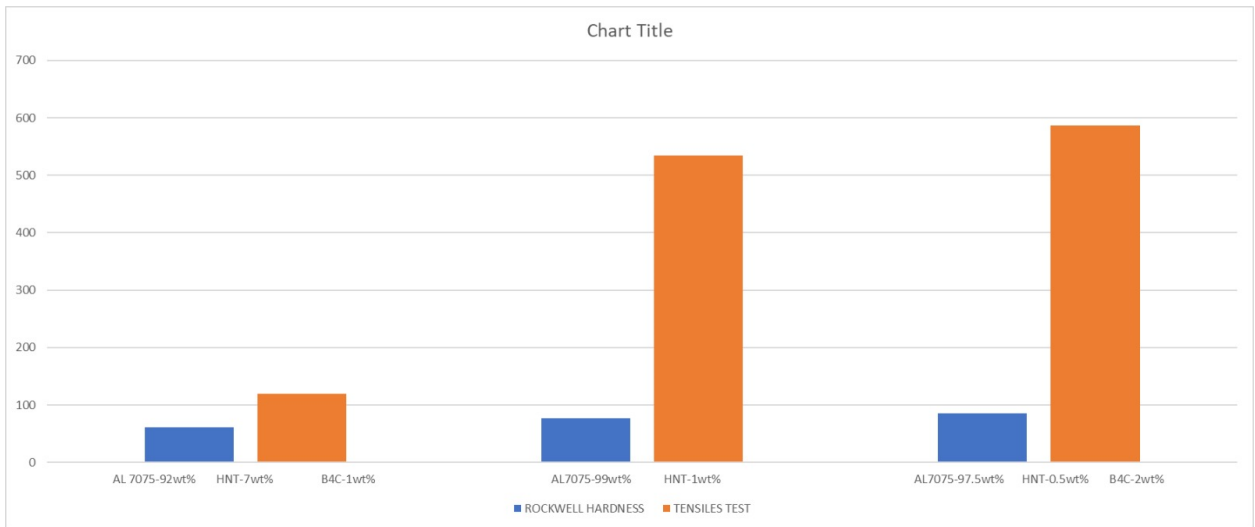


FIG.5.3 Hardness v/s Tensile strength

CHAPTER – 6

CONCLUSION

The mechanical characteristics of hybrid metal matrix composites based on Al7075 and reinforced with boron carbide and polymer halloysite nanotubes for automotive applications were examined in this work. The study's findings demonstrated that the hardness of the composites was greatly increased by the inclusion of boron carbide and halloysite nanotubes. The composites' high tensile strength was also noted, pointing to the possibility of using them in automotive applications. Given its desirable qualities, including high strength, low weight, and increased corrosion resistance, the study showed that the hybrid MMC made of Al7075 and reinforced with boron carbide and halloysite nanotubes is a viable material for the automobile sector. Additionally, The stir casting technology utilised to create the composites provides a practical way to produce these materials on a wide scale. The study's findings may stimulate additional investigation into the creation of lightweight, high-performance materials for automotive applications. By offering a more sustainable and effective solution, the findings of this study may ultimately have a substantial influence on the growth of the automotive industry. From the research on Al7075, B4C with HNT composite, the following crucial conclusions may be drawn:

- Stir casting is a useful method for creating hybrid metal matrix composites with high miscibility. Using the samples, tensile and hardness tests have been performed.
- Tensile test values rise with the addition of B4C whereas hardness test values fall.
- The sample has high tensile strength of 587 Mpa and high hardness of 85.05 HN and contains Al7075 at a concentration of 97.5 weight percent, HNT at a concentration of 0.5 weight percent, and B4C at a concentration of 2 weight percent

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