Investigation of Epoxy Based Pmc for Wheel Rim Applications

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Abstract- *Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium metals (or sometimes a mixture of both). Alloy wheels differ from normal steel wheels because of their lighter weight, which improves the speed of the vehicle, however some alloy wheels are heavier than the equivalent size steel wheel. In the design of automobile, the industry is exploring polymeric composite material is suggested as the best material to replace the aluminium alloy to reduce the weight without significant decrease in vehicle quality and reliability. By using this material the mass optimization is achieved. The reduction of weight of a vehicle directly impacts its fuel consumption. After extensive literature survey, epoxy resin has been selected as the matrix and graphene powder as the reinforcement along with hemp as the binding agent. Hand Layup technique is being used for the fabrication of the composite material, as it is simple and economical. A lists of tests are to be performed over the composite which includes Tensile test (to determine the tensile strength), Compression test(to determine the compressive strength as the entire load of the automobile acts upon the rim) and Damping test(as it is subjected to vibrations).*

Keywords- composites; rim; fabrication; investigation; tensile; compression; damping

I. INTRODUCTION

The wheel (rim) is a critical component in its form and function with respect to vehicle motion in the automotive industry. The wheel is used in major forms of land transport (passenger vehicles, heavy industrial vehicles and motorcycles) and no one can dispute the importance of the wheel. The main function of the wheel is to transfer energy from the vehicle to the tyre. The wheel assists in vehicle support, the comfort of the vehicle ride and torque transfer during braking and acceleration.

In the last decade, wheel manufacturers have focused on lightweight wheel designs. This was done by introducing new materials and manufacturing technologies, which are in line with the changing requirements in the automotive industry. According to the above mentioned functions it is evident that the wheel is so important and ubiquitous, that designing an improved wheel from a new and more advanced material would have a major benefit on the transport industry. The major benefit for the transport industry will amount to fuel saving due to the high increase in fuel prices. The use of lighter materials with the required stiffness in vehicles will result in decreased fuel usage. The main focus point of this research is to investigate the feasibility of a composite material which includes epoxy resin as the matrix material and grapheme along with hemp as the reinforcement, for the wheel rim of a passenger vehicle.

II. BACKGROUND/ HISTORY

Earlier, man innovated the wheel and modern man updated the efficiency of the wheel by modifying the design with Rim, Hub, Spoke. Progressing through time, development of the automobile wheel rims is swiftly rotating from the past two decades. Research is being carried for improving the strength to weight ratio of the rim so that the unsprung mass reduces the fuel efficiency and performance of the vehicle is increased. Various experimental procedures are being carried on for this improvement. From the past centuries, utilization of the material has been changing from steel alloys to aluminum alloys, magnesium alloys because of their high strength to weight ratio and better fuel consumption with optimum stress resistance, design configuration, strength. Rim can be incorporated with nano materials such as Graphene, Carbon Nano Tubes in different forms such as metallic oxides. Graphene as a filling agent in composites enhanced the applications. Because of the physiochemical properties of graphene, it aids in strengthening of the material. Rate of publications being made on graphene in various disciplines is increased year by year since its invention. Various reports have stated about increasing the high levels of strength, stiffness and other mechanical properties by lowering loads of graphene.

III. COMPOSITES

A typical composite material is a system of materials consisting of two or more materials (mixed and bonded) on a macroscopic scale.

- Composites are a combination of two materials in which one of the material is called the reinforcing phase, is in the form of fibres, sheets, or particles, and is embedded in the other material called the matrix phase.
- Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material.

IV. FABRICATION

Once the composite specimens are prepared, then these specimens are cut according to the required dimension as per ASTM standards.

The mould is then prepared by Hand Layup Technique as follows.

- The wax (releasing agent) is applied on mould surface then OHP sheets are cut according to the dimensions and are fixed in the mould to facilitate easy extracting of specimens and on top of OHP sheet another coat of wax releasing agent is applied the shown in below figure. The same process is continued for all moulds like tensile, compression, bending and damping
- In case-1, 5% of Hemp mat is used. And cut according to required dimensions and the amount of Hemp mat is varied for each case according to rule of mixture.
- The 93% of epoxy resin is used and mixture for each specimen was weighed using the digital weighing balance. 10% by weight of each Hardener (MEKP) was added to the weighed epoxy resin mixture. Then 2% of graphene is used and it is mixed up with epoxy resin.
- Similarly in case-2, 10% of Hemp mat is used along with 4% graphene and 86% of epoxy resin.
- Also in case-3, 15% of Hemp mat is used along with 6% graphene and 79% of epoxy resin.
- The mould is then cut as per the ASTM standard dimensions for tensile, compression and damping tests.

V. MATERIAL PROPERTIES

The main objective of this project is to determine the material properties of the PMC material material by conducting the following respective tests.

- Tensile test
- Compression test
- Damping test

A. TENSILE TEST

Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. Some materials use biaxial tensile testing.

B. COMPRESSION TEST

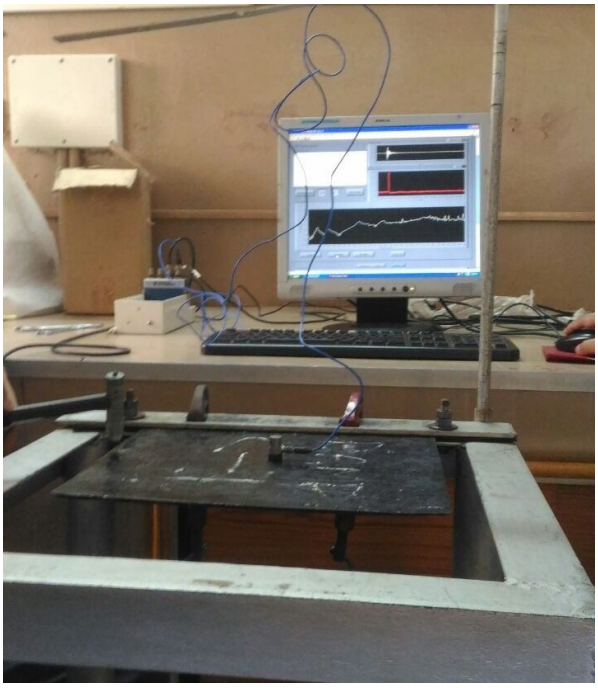
Compressive is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength

resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently.Similar to the tensile test, compression test is also performed using a Universal Testing Machine.

C. DAMPING TEST

Damping is the energy dissipation properties of a material or system under cyclic stress. Damping is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations.

The main function of transducer is to convert system response from one form to another form when system is vibrates. These signals are recorded in the form of voltage or current and amplify then these signals are passes to the analyzer where these signals are converted in to frequency and time domain by Fast Fourier transform (FFT). Then it is displayed on display unit.



VI. RESULTS AND DISCUSSION

A. TENSILE TEST

CASE 1(2% graphene, 5%hemp, 93% epoxy resin):
Maximum load for specimen1 =1205 N
Maximum load for specimen2 =995 N
Maximum load for specimen3 =730 N

CASE 2(4% graphene, 10%hemp, 86% epoxy resin):
Maximum load for specimen1 =1274 N
Maximum load for specimen2 =740 N
Maximum load for specimen3 =661 N

CASE 3(6% graphene, 15%hemp, 79% epoxy resin):
Maximum load for specimen1 =1379 N
Maximum load for specimen2 =985 N
Maximum load for specimen3 =867 N

B. COMPRESSION TEST

CASE 1(2% graphene, 5%hemp, 93% epoxy resin):
Maximum load for specimen1 =7147 N
Maximum load for specimen2 =7068 N
Maximum load for specimen3 =6427 N

CASE 2(4% graphene, 10%hemp, 86% epoxy resin):
Maximum load for specimen1 =5439 N
Maximum load for specimen2 =5239 N
Maximum load for specimen3 =3979 N

CASE 3(6% graphene, 15%hemp, 79% epoxy resin):
Maximum load for specimen1 =3779 N
Maximum load for specimen2 =2679 N
Maximum load for specimen3 =1512 N

C. DAMPING TEST

CASE 1(2% graphene, 5%hemp, 93% epoxy resin):

Mode numbers	Frequency in Hz	Damping ratio %	Magnitude in m^2/N-s	Phase angle in degree
1	17.421	2.774	0.0153	151.1432
2	37.673	2.883	0.0157	32.2057
3	978.753	2.696	0.2564	97.4909
4	125.337	3.079	1.1710	130.2392

CASE 2(4% grapheme, 10%hemp, 86%epoxy resin):

Mode numbers	Frequency in Hz	Damping ratio %	Magnitude in m^2/N-s	Phase angle in degree
1	16.6492	1.665	0.0575	161.486
2	38.1724	1.368	0.1023	39.915
3	94.6663	1.632	0.7611	135.617
4	131.480	1.016	0.8108	107.304

CASE 3(6%graphene, 15%hemp, 79%epoxy resin):

Mode numbers	Frequency in Hz	Damping ratio %	Magnitude in m^2/N-s	Phase angle in degree
1	15.8275	1.271	0.0292	171.9849
2	38.3692	3.386	0.0015	73.7435
3	99.1357	1.777	1.5702	120.6944
4	117.126	0.975	3.3673	127.3545

VII. CONCLUSION

- were prepared according to rule of mixture.
- Compression strength is maximum for the case of 2% graphene + 5% hemp + 93% Epoxy resin i.e. 55.04 MPa & it is decreasing as the % of graphene increases.
- Damping ratio is maximum for case of 6% graphene + 10% hemp + 79% Epoxy resin i.e. 3.386. As the reinforcement increases damping constant is increasing.
- Maximum tensile strength achieved is 14.36 MPa for case of 6% graphene + 10% hemp + 79% Epoxy resin.

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REFERENCE

[1] Daniel Antony C, Prince Jerome Christopher J "Design and Analysis of Two Wheeler Alloy Wheel Rim Using Composite Materials". International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 5, May 2016.

[2] LT Matthew K. Chapman, Thesis on "Development of a Composite Wheel Rim for an FSAE Car",Undergraduate Thesis Report 2011, SEIT.

[3] Lehoelere Frederick Maserumule, research report on "Design Of A Carbon Fibre Passenger Car Rim",University of the Witwatersrand.

[4] K. Venkata Sai Karthik, N. Prakash "Design And Analysis Of Metal Composite Hybrid Wheel Rim". Int. J. Chem. Sci.: 14(2), 2016, 1077-1084,ISSN 0972-768X, Sadguru publications.

[5] M.Ravichandra, S. Ramesh Kumar Babu, A.Salmon, P.Nagaraju " Design And Structural Analysis Of Alloy Wheels For Light Weight Vehicles", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 6 Ver. V (Nov. - Dec. 2015).

[6] Hans Walther, Thesis On "Development Of A Lightweight Laminated Composite Wheel For Formula SAE Race Vehicles", University of Kansas.

[7] Dilini Galpaya, Mingchao Wang, Meinan Liu, Nunzio Motta, Eric Waclawik, Cheng Yan "Recent Advances in Fabrication and Characterization of Graphene-Polymer Nanocomposites".Published online October 2012, www.sciRP.org.

[8] S.Sunil Kumar Reddy, S.P.Akbar Hussain "Development And Testing Of Natural Fibre Reinforced Composites With Polyester Resin"October 2013, IJESRT, ISSN:2277-9655.

[9] Mohammed Mehdi Jalili, Seyyed Yahya Mousavi, Amir Soheil " Flexural Free Vibration As A Non-Destructive Test For Evaluation Of Viscoelastic Properties Of Polymeric Composites In Bending, March 2014.

[10] H Ku, H Wang, N Pattarachaiyakoop, M Trada " A Review On The Tensile Properties Of Natural Fibre Reinforced Polymer Composites", University Of Southern Queensland.