Study of Mechanical Properties of Epoxy Composites Filled with Filler HBN

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***Abstract*— The progress and development in materials technology has resulted in several new materials. Epoxy based composites is one of them. This paper presents the density, hardness, Tensile strength and Flexural strength properties of composites made from Boron nitride filler particles and epoxy resin (EPOFINE – 556 + FINEHARD- 951). The density, hardness, Tensile strength and Flexural strength tests of composites based on HBN filler particles at different filler contents viz. bare, 0%,1%, 2%, 3%, 4%, and 5% and their testing were carried out according to standards i.e. density (ASTM D792) hardness (ASTM D2583), tensile strength (ASTM D638) and flexural strength (ASTM D790) respectively and their results were presented. Experimental results showed that flexural for 1% constituent composites is best having flexural strength 108 Mpa and average tensile strength 43.56Mpa with density 1.18 g/cc and hardness 35.6 Barcol no, which is very helpful where flexural strength required high with low weight in industrial application.**

***Index Terms*— Composites, Taguchi technique, tribology, epoxy, filler, flexural strength, tensile strength.**

I. INTRODUCTION

In the recent year there has been emerging a large use of fiber/filler reinforced epoxy composite material for various applications. Due to high stiffness–to-weight and strength-to-weight ratios, epoxy composite materials have its wide variety of structural applications such as in automotive, aerospace, chemical industries, constructions etc [1]. The use of fiber/filler in polymeric materials helps to improve mechanical strength, Thermal stability, Electrical properties, and Tribological properties [2]. Lot of research has been done on the epoxy composites material for mechanical and tribological properties. In graphite reinforced epoxy composite showed improved tensile modulus, flexural modulus and impact strength in bending properties with increase filler content as the functional group tends to decrease in composites with increasing filler content as gelation occurs vigorously in the composite.

Solid lubricant such as WS_2, MoS_2, graphite, silicon carbide etc. are used to improve the mechanical and tribological properties of epoxy composite material. Tungsten disulphide is used as a filler in epoxy which helps to improve the wear resistance of the composites[3]. Same as WS_2(tungsten disulphide) it is also seen that MoS2 (molybdenum disulphide) composites showed less wear in comparison to the MoS_2 free composite [4]. Hexagonal boron nitride reinforced composites have exceptional mechanical properties which are unequalled by other materials. This study investigates the effect of filler hexagonal boron nitride on mechanical behavior of epoxy composites.

II. EXPERIMENTAL

MATERIALS

Epofine 556 epoxy was used as the thermosetting matrix polymer whereas Finehard 951 was used as hardener, both epoxy and hardener was been supplied by Fine finish organics Pvt.ltd. Boron nitride filler was been used it found its application in industrial application because of following characteristics high load bearing properties, Excellent lubricating properties due to low coefficient of friction no wetting etc. The properties of epoxy resin and hardener are shown in table no 1 & 2.

Table 1 Properties of Epoxy resin Epofine-556

Sr. No.	Characteristic	Test Method	unit	Specification
1	Viscosity at 25^0C	ASTM-D 2196	mPas	9,000-12,000
2	Epoxy content	ASTM-D 1652	g/eq	180 - 190
3	Density at 25^0C	ASTM-D 4052	g/cc	1.15-1.20
4	Flash point	ASTM-D 93	°C	> 200
5	Storage life		Years	3

Table 2 Properties of hardener Finehard-951

Sr. No.	Characteristic	Test Method	Unit	Specification
1	Viscosity at 25^0C	ASTM-D 2196	mPas	~ 20
2	Density at 25^0C	ASTM-D 93	g/cc	1.15-1.20
3	Flash point	ASTM-D 4052	°C	> 200
4	Storage life		Years	3

The filler Boron nitride powder (hBN) is reinforced with epoxy resin EPOFINE - 556 chemically belonging to 'epoxide' family is used as polymer to be reinforced. Its common name is bisphenol A. Figure1 shows molecular structural of HBN. The filler material Boron nitride (hBN) having particle size in the range 4-10µm. Boron nitride find its application in heat radiation material, glass manufacturing process, dry lubricant, cosmetic, paint, dental cement etc.

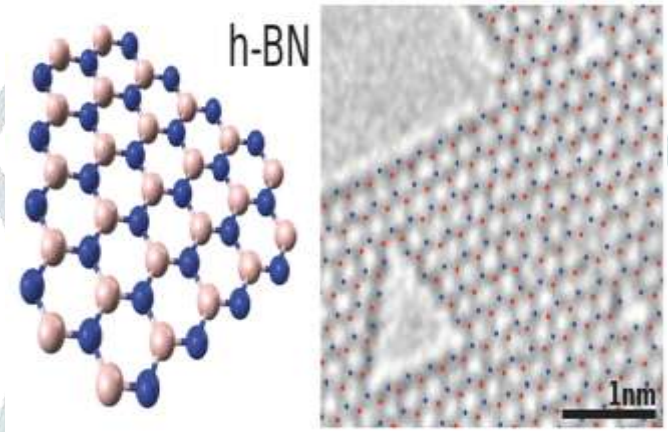

Fig. 1 Hexagonal Boron nitride structural model [5]

Table-3 Properties of hexagonal boron nitride (HBN)

Sr. No.	Characteristic	Unit	Specification
1	Density at 25^0C	g/cc	2.1 - 2.2
2	Color	-	White
3	Boiling point (^{0}C)	-	-
4	Odor	-	Odorless

Specimen preparation:

The epoxy resin Epofine - 556 is mixed with the hardener FINEHARD - 951 in the ratio 100:10 by weight in a different paper glass as recommended. The required quantities of the filler HBN were stirred gently into the liquid epoxy resin, taking care to avoid the formation of air bubbles. After that both the paper glass were kept in vacuum chamber so as to minimize the air bubbles. FINEHARD - 951 was kept for 7-8 minutes as recommended and mixture of EPOFINE-556 and filler HBN was kept until the air bubbles get minimized. The hardener FINEHARD-951 was added to the above mixture in the required ratio. The mixed composites is stirred gently to ensure complete homogenous mixing. The mixture is then poured into a metallic mould cavity coated with a release agent (wax) to yield specimens. Composites of five different compositions such as bare, 1%wt, 2%wt, 3%wt, 4%wt and 5%wt boron nitride filler was fabricated for mechanical testing. The mould was kept at room temperature for 24 hour, even though the reaction is exothermic heat is needed to be given. After that the mould was kept in an electric oven for 1 hour at 100^0C. Mechanical testing of specimen such as hardness, density, tensile strength, and flexural strength are tested at the FINE FINISH ORGANICS Pvt. Ltd, Taloja in their laboratory.

III. EXPERIMENTAL SETUP

In the following table it is shown that all the mechanical properties such as tensile strength, density, flexural strength and hardness where tested according to the ASTM only.

Table-3 Following tests were conducted in present work:

Sr.No.	Test specimens	ASTM
1	Density	D792
2	Flexural Strength	D790
3	Hardness	D2583
4	Tensile strength	D638

For measuring density electronic weigh machine was used. The tensile strength and flexural strength test were conducted using Universal testing machine (Tinius Olsen). The hardness is measured by using Barcol Hardness Tester. The specimen is placed under the intender of the Barcol Hardness Tester and a uniform pressure is applied to the specimen until the dial indication reaches a maximum. The depth of the penetration is converted into absolute Barcol numbers. Data is expressed as Barcol number given by the instrument.

IV. RESULT AND DISCUSSION

Following are the result and discussion of mechanical properties of epoxy composite filled with filler HBN.

a. Density

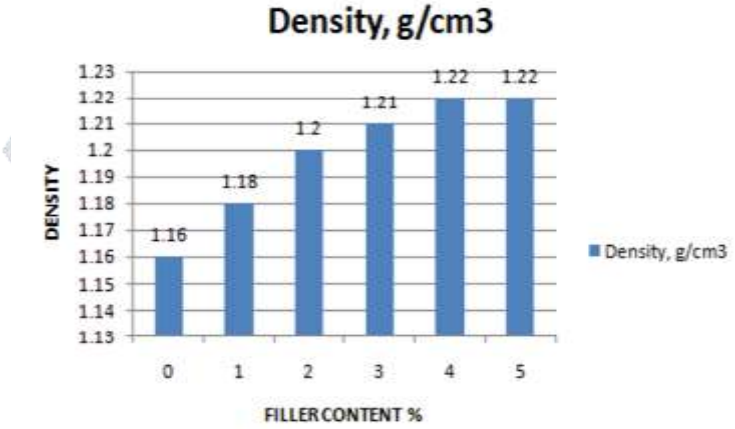

Fig.3 Graph for density vs filler content

The density of specimen is taken randomly throughout the length of the specimen. For calculation of electronic weight mettle balance is used. From the fig.3 it is observed that the density of composite increases as the filler %wt. goes on increasing. Density of specimen without filler is 1.16 g/cm3 and it goes on increasing as the filler content increases. It is seen that density of polymer after 4% does not increases much more.

b. Flexural strength

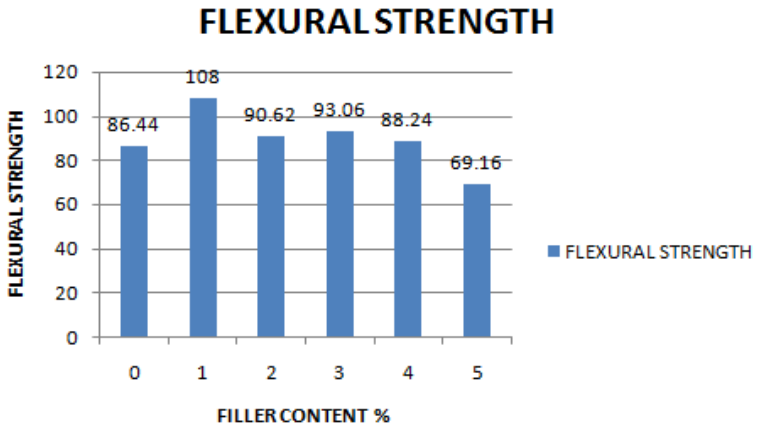

Fig.4 Graph for flexural strength vs filler content

From the above fig.4 it is concluded that after 3% filler content the flexural strength goes on decreasing. At 0% hBN flexural strength is only 86.44 mpa whereas at 1% filler content maximum flexural strength is observed i.e. 108mpa. It can be concluded that 1% hBN in epoxy composite will give good result where low weight and high flexural strength is required in industrial applications.

c. Hardness

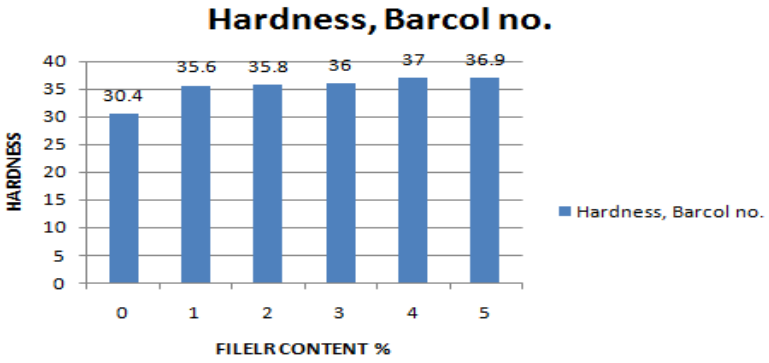

Fig.5 Graph for hardness vs filler content

The measured hardness values of all the 6 composites are presented in above fig.5. It can been seen that the hardness is increasing with the increases in filler content. It is seen that hardness of specimen without filler is 30.4 where as it goes on increasing with the filler content. In case of composites with filler content 4% gives higher value of hardness as compared to bare polymer.

d. Tensile strength

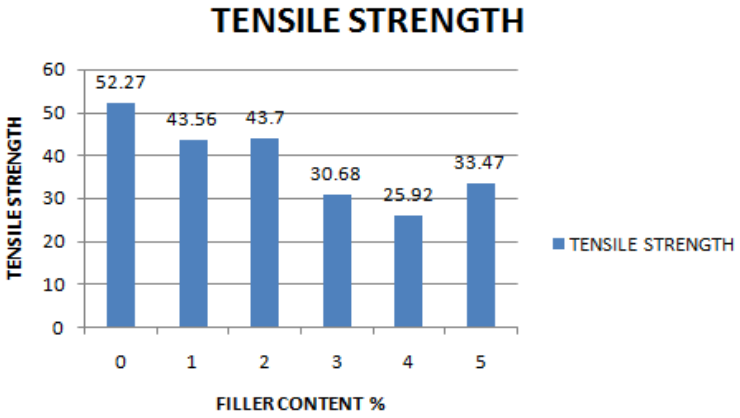

Fig.6 Graph for tensile strength vs filler content

It is seen from fig.6 that the tensile strength goes on decreasing as the filler content goes on increasing. At 4% filler content we get minimum tensile strength, thus increase in filler content effects the tensile strength i.e. decreases the tensile strength. Tensile strength of specimen without filler content i.e. 0% filler is maximum 52.27mpa as the filler content is added and vary it is seen that the material becomes harder and its tensile strength goes on decreasing. At 4% hBN minimum tensile strength is obtained but at 5% there is increase in tensile strength.

e. Overall mechanical properties

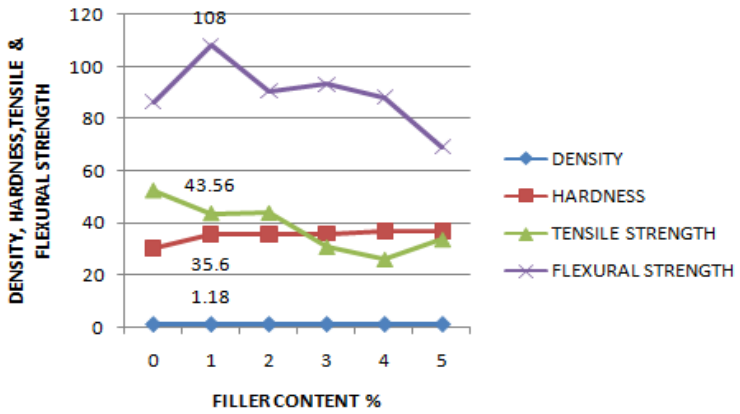

Fig.7 Graph for density, hardness, tensile strength & flexural strength vs filler content

From the analysis of all parameters of specimen, it is observed from that at 2% filler hBN is added to the resin the composites exhibits good result. The flexural and tensile strength for 2% constituent composites is best having flexural strength 108 Mpa and average tensile strength 43.56Mpa with density 1.18 g/cc and hardness 35.6 Barcol no which is very helpful where flexural strength required high with low weight in industrial application.

V. Conclusion

This experimental investigation into the mechanical characteristics of HBN filled epoxy composites leads to the following conclusions:

- This work shows that successful fabrication of Boron nitride reinforced epoxy composites is possible by simple hand lay-up technique.
- The hardness, density, tensile and flexural properties of the composites are greatly influenced by the content of filler.
- Filler content increases density also increases by after 4% filler content there is no much more change in density
- At 1% filler content maximum flexural strength is observed but as the filler content increases flexural strength goes on decreasing.
- Tensile strength goes on decreasing with increase in filler content.

VI. Acknowledgment

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References

1. C. Anand Chairman, S.P. Kumaresh Babu, Muthukannan Duraiselvam “Investigation on two-body abrasive wear behavior of titanium carbide filled glass fabric-epoxy composites- a Box- Behnken approach” International Journal of engineering, science and technology Vol.3, No.4,2011, pp.119-129.
2. M. H. Shaikh, G. J. Pawar, J. S. Sidhu “ Tribological characterization and Morphological study of epoxy composites filled with WS2 under dry sliding “International journal of science and research (IJSR), India Online ISSN:2319-7064 Volume 2 Issue 6, pg. 462-465.
3. J. S. Sidhu, G. S. Lathkar, and S. B. Sharma "Mechanical properties of micro tungsten disulphide particles filled epoxy composite and its resistance against sliding wear Polymer journal" (February 2014), pg. 24-32.
4. R.Ranjith Kumar, C.Velmurugan "Optimization of tribological properties in molybdenum disulphide and titanium carbide reinforced aluminium composites" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), pg. 47-54.
5. https://www.uniulm.de/einrichtungen/hrem/forschung/materialien/hexagonal-boron-nitride.html?print=1J.
6. J Sudeepan, K Kumar, T K Barman, P Sahoo " Study of tribological behavior of ABS/ CaCO3 composite using grey relational analysis" science direct Procedia Materials Science 6 (2014) 682 – 691.
7. Jianing Gao, Junting Li, Brian C. Benicewicz, Su Zhao, Henrik Hillborg and Linda S. Schadler "The Mechanical Properties of Epoxy Composites Filled with Rubbery Copolymer Grafted SiO2"Polymers 2012, 4, 187-210.
8. N.Mohana, C.R.Maheshaa, B.M.Rajaprakashb "Erosive wear behaviour of WC filled glass epoxy composites" science direct Procedia Engineering 68 (2013) 694 – 702.
9. Sunil Thakur & S R Chauhan "Study on mechanical and tribology behavior of cenosphere filled vinylester composites- A taguchi method" International journal of engineering and material science, (Dec 2013), pg 539-548.
10. Gaurav Agarwal, Amar Patnaik and Rajesh Kumar Sharma "Parametric optimization of three-body abrasive wear behaviour of bidirectional and short kevlar fiber reinforced epoxy composites" IJERA (December 2012), pg.1148-1167.