Study of Mechanical properties & chemical testing of Glass/Epoxy composite - a Review

Abstract-- Composites meet diverse design requirements with significant weight savings and exhibit high strength-to-weight ratio compared to conventional materials. Composites have proved to be a worthy alternative to other traditional materials even in the high-pressure and aggressive environmental situations. Besides superior corrosion resistance, composite materials exhibit excellent fatigue performance, good resistance to temperature extremes and wear, especially in industrial sectors.

The strength of any composite depends upon volume/weight fraction of reinforcement, L/D ratio of fibers, orientation angles and other factors. In present work an attempt is made to relate the experimental and numerical results of tensile tests by considering the isotropic behavior of composites. Determination of fibre reinforcement influence on weight rate and wear mechanisms were examined. Moreover, effects of fibre orientation and specimen pressure on the counterpart were analyzed. The micromechanics of damage growth and failures underpin the understanding of the revealed fractography. The mechanical performances of the specimens at cryogenic conditions were compared with room temperature property by using SEM photographs. In this paper efforts have been made to study the effect of ageing environment on the degradation of Glass-Reinforced Epoxy by carrying out ageing tests and analyzing the moisture absorption and hence degradation of the internal polymer structure.

Key words—Glass fibre, Asbestos filler, Ageing, SEM, DOE, Minitab.

I. INTRODUCTION
Composites are fast taking over as superior alternative to other traditional materials even in high pressure and aggressive environmental situations. Applications of composite are increasing tremendously along with the concurrent need for knowledge generation in the area. With technology innovations and developments in processes and products, composites have become attractive candidates for applications in oil gas, piping system, topside applications, downhole tubing in sub-sea and others.

The unique and diverse characteristics of composite materials have increased in their utilization worldwide. From featherweight fly fishing rods to high performance airplane parts, the use of fiber reinforced composite materials is becoming more popular due to their high strength to weight ratio combined with easy manufacturing methods. With the growth in petroleum sector, the demand for composite products has increased manifold. The greatest problem faced by steel in oil and gas plants and installations is its poor corrosion resistance against seawater and other highly corrosive agents, such as chlorides, H₂S, CO₂, HCl, etc. that are encountered during exploration and production activities. Composites have proved to be worthy alternatives in high-pressure & aggressive environmental situations especially in the oil & gas industry. The performance advantages are typically combinations of lower weight, higher strength, higher fatigue resistance, higher durability and excellent corrosion resistance. Longer application span and lower lifecycle costs are driving the use of composites to withstand corrosive offshore conditions[1]. For over 50 years, fibre-reinforced plastic (FRP) materials have proven to be very successful in structural applications. They are widely used in the aerospace, automotive and marine industries. The term composite could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail. But in modern materials engineering, the term usually refers to a matrix material that is reinforced with fibres. For instance, the term FRP (for Fibres Reinforced Plastic) usually indicates a thermosetting polyester matrix containing glass fibres, and this particular composite has the lion's share of today's commercial market. Many composites used today are at the leading edge of materials technology, with performance and costs appropriate to ultra demanding applications such as spacecraft [2].

Fiber reinforced polymer matrix consists of reinforcing fibers and polymer resin. The fibres used in modern composites have strengths and stiffness far above those of traditional bulk materials. The high strengths of the glass fibres are due to
processing that avoids the internal or surface flaws which normally weaken glass, and the strength and stiffness of the polymeric fibres is a consequence of the nearly perfect alignment of the molecular chains with the fibres. The fibres may be oriented randomly within the material, but it is also possible to arrange for them to be oriented preferentially in the direction expected to have the highest stresses. Such a material is said to be anisotropic (different properties in different directions), and control of the anisotropy is an important means of optimizing the material for specific applications. The fibers are considered as principal load carrying constituent of the composite, while the role of polymer matrix is to transfer the load between fibers as well as provide corrosion resistance damage tolerance and thermal environmental stability [3].

Fillers are used along with various commodity as well as engineering polymers to improve the properties and reduce the cost. Incorporating inorganic mineral fillers into plastic resin improves various physical properties of the materials such as mechanical strength, modulus etc [4]. In general the mechanical properties of particulate filled polymer composites depend strongly on size, shape and distribution of filler particles in the polymer matrix and extend of interfacial adhesion between filler and matrix. The tailorableness of composites to suit specific applications has been one of its greater advanges such as imparting low thermal conductivity and low coefficient of thermal expansion, high axial strength and stiffness.

At present, epoxy resins are widely used in various engineering and structural applications such as electrical industries, commercial and military aircrafts industries and marine applications. In order to improve their processing and product performances, and to reduce cost, various fillers are introduced into the resins during processing. The effect of temperature on moisture diffusion and environmental ageing is a complex phenomenon. Moisture absorption at high temperatures may induce irreversible damage to polymers and their composites, such as chemical degradation, cracking and interfacial debonding [5]. The use of GFRP composites in petrochemical and critical marine components has usually been accompanied by conservative design safety factors because of limited durability data. Sea water ageing and corrosion problems are still remains an uncertain factor. However polymeric composites are susceptible to mechanical damage, when subjected to tension, wear and flexural loads resulting in interlayer delamination [6].

Influenced by the fiber content/ weight fraction of reinforcement in matrix.

‘The wear mechanisms of fibre reinforced composite materials’ by K. Naplocha & J.W. Kaczmar determines the wear mechanism & the microstructure of friction surfaces which were analysed and discussed together with results of wear rate. Determination of fibre reinforcement influence on wear rate and wear mechanisms were examined. Moreover, effect of fibre orientation and specimen pressure on the counterpart was analyzed.

‘Ageing Phenomena Influenced by Water Immersion in Mineral Filled Epoxies’ by F. Gerdinand, M. Budde, M. Kurrat aims at studying the forced and accelerated moisture induced interfacial ageing phenomena by immersing the test specimen in distilled water at 50°C. The mechanical material parameters and the glass transition temperature are measured during the ageing procedure at exactly defined time intervals. In order to check the sensitivity of the measured quantities to artificial ageing, a typical insulation system is aged under outdoor conditions in a first step.

‘Experimental studies on mechanical behavior and micro structural assessment of glass/epoxy composites at low temperatures’ by S. Sethi, P.K. Panda, R.Nayak and B.C.Ray studies a series of flexure tests with varying cross head speed that were conducted to study the mechanical behavior of glass/epoxy composites at low temperature. The micromechanics of damage growth and failures underpin the understanding of the revealed fractography. As increased cross head speed (strain rate), the matrix becomes brittle, and fracture strain decreases, but at very high strain rate, the fracture strain increases.

‘Effect of Aging Environment on Degradation of Glass-Reinforced Epoxy’ by Somjai Kajorncheappunngam; Rakesh K. Gupta2; and Hota V. S. GangaRao studies the effects of immersing coupons of glass-reinforced epoxy in four different liquid media at two separate temperatures were investigated in this study aimed at examining the durability of fiber-reinforced plastics.

‘An experimental and numerical investigation of mechanical properties of glass fiber reinforced epoxy composites’ by Satnam Singh, Pardeep Kumar, S.K. Jain focuses on determination of mechanical properties of pure epoxy and random oriented glass fiber (mat) reinforced epoxy at 10% and 20% weight fractions of glass fibers. An attempt is made to relate the experimental and numerical results of tensile tests by considering the isotropic behavior of composites.

‘Mechanical Behavior of Glass/Epoxy Composites at Liquid Nitrogen Temperature’ by Surendra Kumar M, Neeti Sharma and B. C. Ray deals with the mechanical behaviour of glass/epoxy composites at cryogenic temperature. 3-point bend tests were carried out to assess interlaminar fracture behaviour at cryogenic and at ambient conditions. The mechanical performances of the laminated specimens at cryogenic conditions were compared with room temperature property by using SEM photographs.

II. REVIEW

Review of literature on the various tests carried out such as Tensile test, 3-point Bending test and Abrasive wear test on the glass fibre reinforced epoxy composite with asbestos as the filler material revealed that the mechanical behavior is greatly
III. CONCLUSION

From the review of the papers it can be concluded that: A reinforced composite shows more tensile and wear strength than unreinforced epoxy. The value of young modulus of elasticity also increased with increase in weight fraction of material, which signifies increased strength and reduced strain. Fibres normal oriented to the friction surface transferring loads deep into matrix material caused higher deformation of the matrix.

The performance of these composites in longer durations is vital to employ them for critical areas such as marine structures, in which they are constantly exposed to moisture. The moisture diffusion through polymer composites and the resulting property degradation revealed that moisture diffusion and hence the degradation is accelerated by temperature and humidity levels.

Insulating systems based on epoxy resins, which are artificially aged by water immersion, show deterioration of the mechanical properties. The larger the moisture absorption, the more the danger of a mechanical, electrical and/or a thermal breakdown will increase due to degradation of internal polymer structure.

The main objective in this paper is to review the mechanical and chemical properties of glass/epoxy composite with asbestos as filler material with different percentages. The composite is manufactured by hand-layup process. Specimens were cut and tested according to ASTM standards. The mechanical properties were studied like tensile strength, bending strength and hardness of the material. The chemical properties were studied by keeping the material into sea water/salt solution (NaOH) and results were compared for different percentage of materials.

IV. REFERENCES
