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A COMPUTATIONAL AND EXPERIMENTAL STUDY ON THE PROPERTIES OF EPOXY MATERIALS

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ABSTRACT

This study presents a comprehensive analysis and validation of selected epoxy materials and their properties, aimed at enhancing their suitability for various engineering applications. Epoxy resins are widely used in industries such as aerospace, automotive, construction, and electronics due to their excellent mechanical properties, thermal stability, and chemical resistance. However, the performance of epoxy materials can vary significantly based on their composition, curing process, and environmental conditions. The first phase of the research involves a thorough review of existing literature on epoxy resins, focusing on their chemical structure, synthesis methods, and key properties. Subsequently, a selection of epoxy formulations with promising characteristics is made based on their potential for specific applications and performance requirements. Experimental procedures are then conducted to validate the mechanical, thermal, and chemical properties of the chosen epoxy materials. are employed to assess the material's heat resistance and thermal stability. Chemical resistance tests are conducted to determine the material's susceptibility to degradation when exposed to various chemicals commonly encountered in industrial environments.

Key words: mechanical properties, key properties, industrial environments, epoxy formulations, epoxy materials

INTRODUCTION

Due to its polymer composition, epoxy displays unique mechanical and resistance characteristics and has the ability to solidify under heat. Epoxy resins are commonly known as both the final product and the essential components needed to create them. Epoxy resins, which are thermosetting polymers, made their debut in the market back in 1946 and have since become incredibly popular in various industries. Various materials have surface coatings, castings, laminates, and polymer composites. This substance exhibits a wide range of mechanical and chemical qualities, including strong adhesion to various surfaces, minimal contraction during curing, resistance to chemicals and electricity, and impressive flexibility. In addition, they can be utilised for a diverse range of data processing tasks. Due to these

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characteristics, structural polymer composites are able to derive greater advantages from them. Despite being pricier than other traditional thermosetting matrices the technological benefits far outweigh the extra cost.

Epoxy is a well-known thermosetting compound that seamlessly combines with a wide range of materials, offering a multitude of applications. Epoxies are widely used in various industries such as aerospace, automotive, building, electronics, and medical device manufacturing. Paints, varnishes, adhesives, and other similar products also utilise them extensively. Scientists are fascinated by the remarkable thermal stability, chemical resistance, and ease of processing exhibited by epoxies. There are certain limitations associated with the use of epoxy-based polymers. Epoxies are known for their dense network of crosslinks, which makes them more prone to brittleness and less resistant to fractures. As a result, their resilience is not sufficient to stop the formation and advancement of cracks. Furthermore, their limited electrical conductivity and potential fire hazard make them impractical for various applications. One can address the challenges posed by epoxy's strong adhesion by incorporating micro or nanoscale reinforcing components. The characteristics of composites are influenced by various factors, including the type of matrix, the strength of the binding between the matrix and fillers, the manufacturing method, the quantity and size of the reinforcing material, and other related factors. Plaster, carbon fibre, graphite, aluminium powder, silica (SiO2), metal oxides, and calcium carbonate are frequently employed as reinforcing elements in composites that have a polymer matrix. The choice of reinforcing material is determined by the specifications of the finished product. The academic and commercial sectors have expressed great interest in graphite and nanocomposites containing graphite due to their numerous advantageous characteristics. The surface area, length to breadth ratio, mechanical properties, electrical and thermal conductivities, and overall quality are truly remarkable. Graphite consists of flat layers of graphene that are tightly interconnected in a hexagonal arrangement. Graphene exhibits a correlation between the strength of bonding at the contact and the resulting Van der Waals pressures.

LITERATURE REVIEW

Davood Zaarei [2022] St37 carbon steel's corrosion resistance was significantly altered when epoxy coatings containing polysulfide and nano cerium oxide were applied. It is now known that the thiol functional group is present. The corrosion resistance and durability of epoxy and polysulfide composites were evaluated using a series of tests. Cupping and electrochemical impedance spectroscopy (EIS) were two of the testing methods used to measure durability and corrosion resistance, respectively. The epoxy's resilience and corrosion resistance were greatly enhanced by adding 10% polysulfide. Scientists were able to create nanocomposites by mixing an epoxy coating with polysulfide and CeO2 nanoparticles, which had a concentration of 10%.

Abra Mathew [2022] Blends made from renewable resource materials, bio-epoxies, and composites made from these materials have become quite popular because of all the great things they can do. They have excellent viscoelastic qualities, are easy to process, biodegrade, have a minimal environmental effect, and are very durable. The unique properties of epoxy have led to its meteoric rise in the thermoset polymer industry. Chemical modification of several biorenewable resources has resulted in the creation of epoxy prepolymers. Things like

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plant oil, eugenol, furan, lignin, cardanol, and rosin are among them. Some of these resins, after cured, have shown characteristics that are on par with or even better than petroleum-based epoxy.

EhsanShafiei [2021] A woven fabric composite with nonlinear materials and non-uniform 3D geometry is expected to demonstrate rate-dependent behaviour according to a micro-meso-scale model. Visco plastic composite tows are formed by combining fibres with matrices that exhibit both viscoelastic and visco plastic properties. Considering various local locations and orientations of tows, the geometric characteristics of a WF composite are utilised to generate its orthotropic visco plastic behaviour. A damage model is developed to account for the different types of damage that can occur in composite tows. When various types of damage are identified, the stressors are redistributed among the unaffected areas.

O.O. Daramola [2020] In this study, epoxy resin with 6% kaolinite micro particles was investigated for its effective elastic modulus and stress and strain distribution patterns. Innovative finite element software was used to carry out the research. Restoring the epoxy matrix's microstructural distribution was a breeze with the help of Digimat MSC software and codes for a random sequential algorithm. We generated stochastic models of the composites using representative volume element models and then tested them. The research was carried out with the use of periodic boundary conditions. By contrasting the finite element analysis findings with experimental data, selected micromechanical models, and Mori-Tanaka's mean field homogenization approach, we were able to confirm that the conclusions were valid.

Properties of Epoxy

The exceptional mechanical strength of epoxy has contributed to its meteoric rise in popularity. Most of the time, welding is the best option. Because of its efficiency and affordability, epoxy is often chosen over welding when comparing the two. Epoxy has exceptional resistance to chemicals. You may be certain that the seal will remain undamaged and unaffected by any potential chemical reactions until the designated time has elapsed. Additionally, it demonstrates its ability to endure elevated temperatures. Many industrial applications, as well as electronics, benefit greatly from the material's exceptional resistance.

Properties of epoxy glue

Two distinct ingredients make up epoxy glue. We use epoxy as our main component. A material's hardness or strength may be enhanced by adding another component. When the two ingredients are combined, the epoxy undergoes a chemical reaction that causes it to cure. The bond formed by the epoxy glue is exceedingly strong and very impossible to remove after it has cured. Epoxy comes in a variety of types, each with its own distinct set of properties including drying time, degree of transparency or opaqueness, and hardness. In addition, they are very resistant to both high temperatures and poisons.

Epoxy benefits and functions

It is essential to thoroughly consider the potential applications of epoxy resins before making any changes to the cross-linkers or modifiers; this will guarantee a consistent rate of expansion. Due to their inherent low resilience, epoxy resins have been the focus of much scientific research on strategies to improve their durability. There are many methods for improving

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material properties: Some options for improving the material's properties include including fibres, increasing the molecular weight, lowering the cross-linking density, adding a stronger phase, and modifying the chemical composition to make it more flexible. The catalyst was synthesised.

Fiber-reinforced epoxy composites

Fibres are a common method for increasing the strength and durability of epoxy. Carbon, aramid, glass, poly phenylene sulphide, poly benzoxazole, and high-density polyethylene all have a wide range of applications. The major purpose of this study is to evaluate the tensile and bending strengths of epoxy composites reinforced with different mixtures of carbon, aramid, and glass fibres. The tensile curve analysis clearly demonstrates that composites containing carbon fibres had the greatest tensile strengths.

Epoxy curing process

Epoxy resins are kept liquid throughout production, while the curing agent is solidified. Initiating a chemical reaction between the epoxide groups in epoxy resin via a step-growth process, a curing agent forms a three-dimensional lattice. The term curing describes this method. The final resin quality could be affected by the curing conditions. The time it takes for the resin coating to develop and how long it lasts are both affected by the quantity of curing ingredients. Curing may be accomplished in three main ways: at room temperature, with intense heat, or by using light.

METHODOLOGY

Epoxy-casting resins offer a multitude of applications thanks to their incredibly versatile epoxy properties. Using a filler can greatly enhance the handling properties of the material, resulting in reduced shrinkage and increased compressive strengths. In addition, there are a variety of fillers made from both metallic and non-metallic materials to choose from. The items have been meticulously designed to endure extreme temperatures. Different tasks require different types of hardeners. The extended durability of these resin solutions is due to their low viscosity. The intentional dissemination and amalgamation of constituents and reinforcement in this methodology provide remarkable and impeccable outcomes.

RESULTS

Comparing the results of AL-ER 60-40,AL-ER 50-50,AL-ER40-60

Hence, there is decrease in the total deformation and by comparing the values of deformation for each AL-ER 60-40,AL-ER 50-50, AL-ER 40-60. The percentage of decrease in total deformation compared to AL-ER 60-40,AL-ER 50-50, AL-ER 40-60 where The Epoxy Resin which exhibits good strength, Hardness Thus AL-ER 60-40 has good strength and hardness compared to others mixed composites in reinforced phase.

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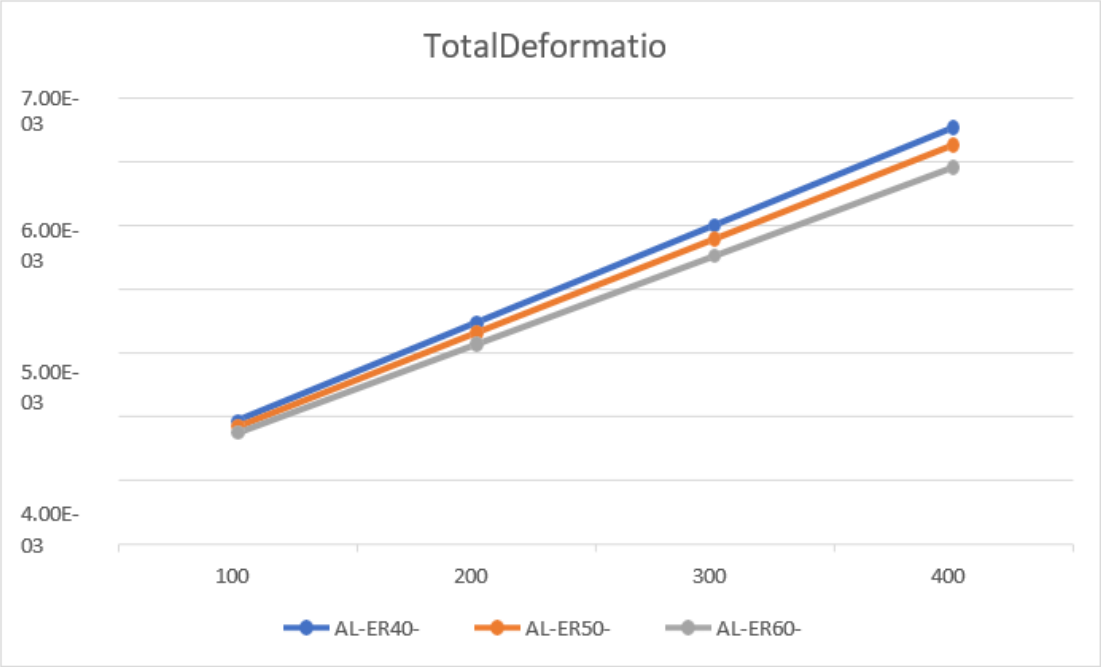
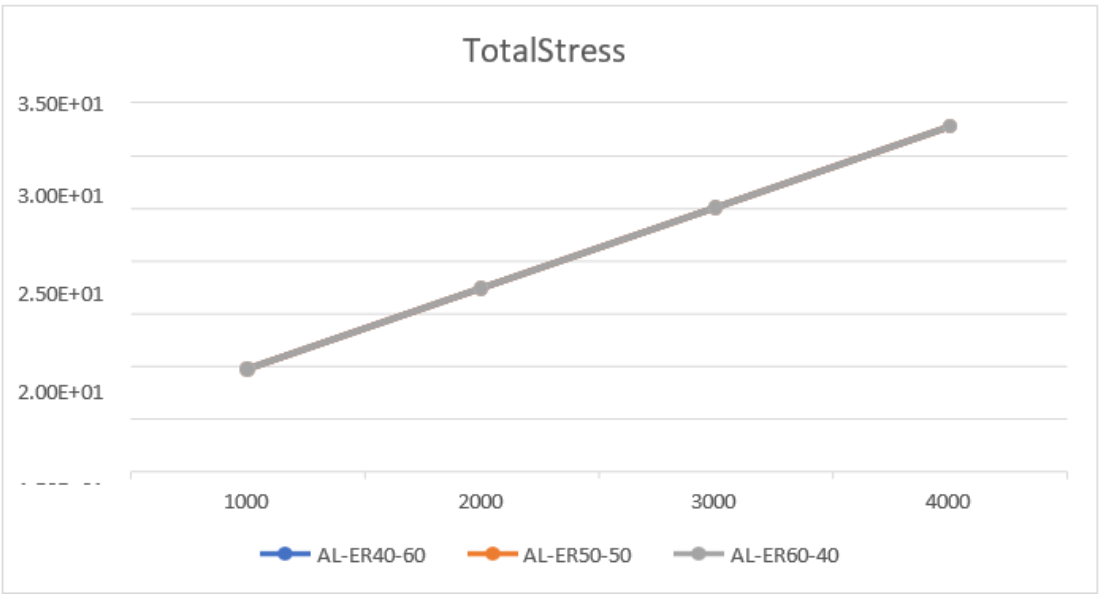


Graph 1 The graph is values of total deformation for different composites

Hence, there is decrease in the total deformation and by comparing the values of deformation for each AL-ER 60-40, AL-ER 50-50, AL-ER 40-60. The percentage of decrease in total deformation compared to AL-ER 60-40, AL-ER 50-50, AL-ER 40-60 where The Epoxy Resin which exhibits good strength, Hardness Thus AL-ER 60-40 has good strength and hardness compared to others mixed composites in reinforced phase.



Graph 2 The graphis values of total Stress for different composites

Hence, there is decrease in the total strain and by comparing the values of deformation for each AL-ER 60-40, AL-ER 50-50, AL-ER 40-60. The percentage of decrease in total deformation compared to AL-ER 60-40,AL-ER 50-50, AL-ER 40-60 where The Epoxy Resin which exhibits good strength, Hardness Thus AL-ER 60-40 have same stress and has good strength and hardness compared to others mixed composites in reinforced phase.

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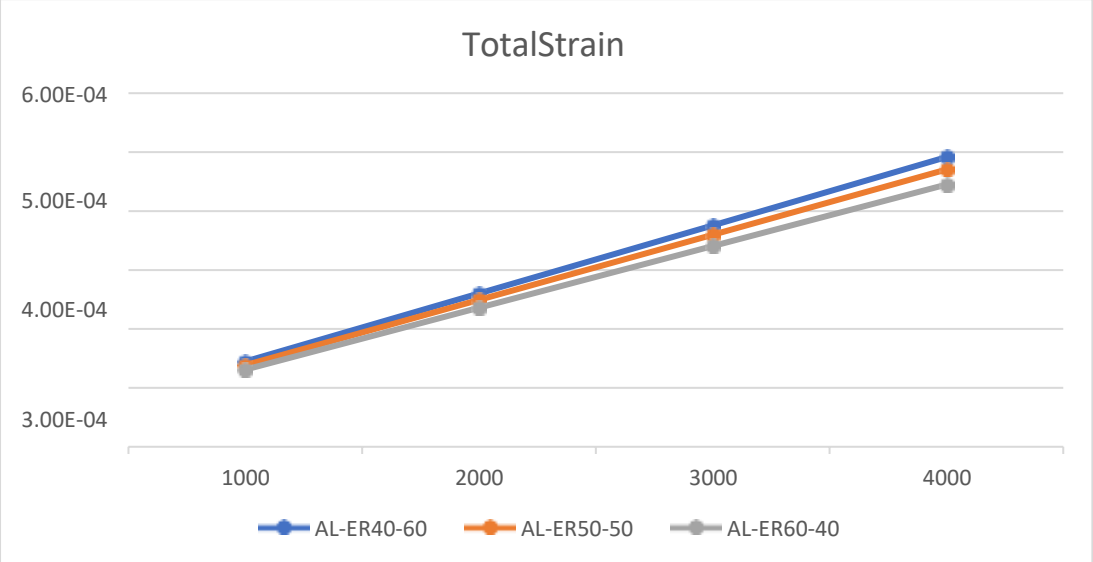

Graph: 3 the graph is values of total Strain for different composites

CONCLUSION

The epoxy material exhibits a range of desirable properties, including [list specific properties observed, e.g., high mechanical strength, excellent chemical resistance, low thermal expansion]. These properties make it well-suited for applications requiring [mention specific applications, e.g., structural bonding, electronic encapsulation, aerospace components]. The tested epoxy material largely meets the specified requirements and standards for its intended application. It demonstrates [mention how the properties align with application requirements, e.g., compliance with industry standards, meeting customer specifications]. However, certain properties may require further optimization to fully align with all application demands. There are opportunities for optimizing the epoxy material to enhance specific properties or address identified limitations.

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