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EXPERIMENTAL STUDY OF FIBER REINFORCED POLYMER COMPOSITES GEAR

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Abstract: The wear reduction material analysis of noryl polymer matrix composites material mixed in the ratio of (70:30) is presented in this paper. In recent trends of advancement in gears, the automobile industries have been inclinations in developing composite materials for high durability, less replacement and low-cost. Several attempts have been made in varying composition of polymer matrix composite at the cost of durability and ruggedness. A few researchers have been landed up in nylon 6 polymer matrix composites material of ratio 80:20 to increase the strength of the material and wear resistance. However, the reduction in wear is still a challenging issue. The present study focuses on developing 70:30 noryl polymer matrix metal composites and analyzing the effect of various input process parameters namely process temperature and weight % of reinforcement (Abs) on the hardness, flexure and tensile strength and It has been observed on experimentation that mechanical properties of the noryl composites are significantly influenced by the weight percentage of glass fiber and 80% noryl + 20% composite shows the highest elastic modulus, yield strength and significantly improved tensile strength. These experimental results confirm the excellent wear reduction of the material that envisages for the better product life and less maintenance.

Keywords: Composite gears,Polymer matrix composite gears,Fibre-reinforced polymer (FRP) gears,Composite material gears,Reinforced plastic gears,Composite resin gears

1.INTRODUCTION

In now recent days, technology wants a high demand for the development of future generation. Hence, in order to manufacture a high-quality product which needs to satisfy the customers, it should be developed at an economical with the easiest way, excellent quality with minimum possible time challenging among the competitors. In order to satisfy the present scenario, a material for the new product plays a vital role in engineering industries. Hence, there is a need of quality, economy, and feedback to satisfy the current needs. In the past, the materials have high influential with that the name in the historical days. In modern days, there are enormous materials came into existence like polymers, metals, ceramics and composite materials. In present years, even high technology materials like Nanomaterial's, smart materials, and Meta-materials dominate the field. So many works are initiated in the area of material science which led to daily needs. Polymer composite materials are the latest trends among them showing major developments in recent years in material technology. They show very high importance and impact on industries and the method of manufacture improves as they proved combined properties of reinforcement and matrix for stronger materials when compared to the individual materials. The main aim of the hybrid structure is lightweight, stability, eco-friendly, noncorrosive in nature, etc.

2.LITERATURE REVIEW

Leonard LWH 2009 et al Polymeric composites were basically utilized in Aerospace, for instance, rudder, lift, fuselage, landing gear passages, that is a direct result of the lightweight, diminishing of higher shortcoming opposition in the clasp and number of segments.

Sathishkumar T P 2014. The different planning advancements were utilized for setting up the GRP composites with different natural conditions. Extreme rigidity and flexural quality of the fiberglass composite expanded. The damping properties of GRP were improved by expanding the GF content in composite and the common frequency was estimated for all conditions

Sudhir Kumar 2016 et al.Nylon 6 and Glass fiber Reinforced polymer composites examples were compensated for wear test and mechanical utilizing infusion embellishment machines. Wear tests were effectuated under non-wet state by a stick on- plate strategy. The impact of temperamental glass fiber substance (0, 10, 20 and 30wt.

%), connected distinction loads. The outcomes created the impression that as the glass fiber substance builds, wear rate diminishes and it is most minimal accomplished at 30wt. % of glass fiber.

Chand et al (2002) have experimentally led on woven glass fiber strengthened polyester composites on three distinct directions so as to decide the wear and rubbing coefficient. In this work, different loads and sliding rates are shifted to decide the qualities. Checking the electron magnifying instrument has been done to watch the progressions happened in the composite overlay. The outcomes show more improvement in friction coefficient just as well as wear loss.

Lin et al (2000) have looked into the effect of Kevlar fiber as a fortress with the bismaleimide and the impacts of the different substance medicines has been examined. In this work, the two classes of bismaleimide have been reviewed thermally by using differential analyzing calorimetry, thermogravimetry, and thermo mechanical examination. The result exhibits that there is an improvement in interfacial quality by cholosulphuric destructive treatment. The messed up surface has been examined by checking electron microscopy.

Mukherjee et al (2006) have studied the various properties of syndiotactic polystyrene composites with surface changed short Kevlar fiber. Network utilized is syndiotic polystyrene and the Reinforcement utilized as Kevlar fiber. The mix of the matrix and reinforcement raises the crystalline, warm, dynamic and mechanical properties. Kevlar fiber improves the crystallization of the grid through heterogeneous nucleation. Adjusted Kevlar fiber fortifications improve the warm of the composites.

Wu and Cheng (2006) have tentatively examined the impact of Kevlar mash strengthened with epoxy under dry and sliding conditions. The test has been performed against hardened steel on the grating and wear analyzer. The investigations were completed in encompassing temperatures of 10-200C, 50-60% relative humidity conditions. The connection between the particular wear rate and the rubbing coefficient against the Kevlar mash substance has been plotted for both dry and water greased up conditions. Friction coefficient has been diminished with an increment of filler content and got ideal arrangement when Kevlar mash content as 60%. Likewise, it is noticed that the particular wear rate diminished essentially when Kevlar mash substance has 40% volume of filler content as the ideal answer for the composites.

Bullet et al (2006) have experimentally investigated the degraded mode and load of fasteners in woven Kevlar PMC plates In this method, finite elements technique is developed for predicting damage initiation, progression and strength of joints. The experiments were performed to determine the effects of failure and appraise the effect of joint on analysis. The outcomes found that the examination has been made among numerical and trial strategies and acquired better outcomes.

Haocen et al (2006) examined the interfacial micromechanical conduct of fiber-matrix by methods for the mix of smaller-scale curve test and miniaturized scale Raman spectroscopy. The arrangement is to distinguish the conveyance of miniaturized scale mechanical properties including fiber residual stress, leftover pressure, interfacial shear stress, and stress move along with the interfaces between Kevlar fiber and epoxy resin. The outcome demonstrates that the axial stress move will quicken and shear pressure focus will be improved alongside increment in the interfacial edge. The geometrical qualities can impact fundamentally the pressure appropriations in the fiber framework small scale beads.

Wan et al (2006) have experimentally investigated the various mechanical properties of 3D braided carbon/Kevlar/epoxy composite and their effects of moisture absorption. The composite is immersed in hanks solution at 370C for upto 1700hrs. Graphical curves were plotted and the operational parameters were determined. The outcome demonstrates that kevlar fibers have both moisture absorption and mechanical decay upgraded with respect to carbon only Also, the mechanical debasement of the moisture saturated blended composites still kept at the high flexural quality.

Gang Li et al (2008) have experimentally researched the Kevlar fibers at various convergences of phosphoric acids. In this work, interfacial shear quality and interlaminar shear quality was analyzed. The composite mechanical properties are studied with differing blends of epoxy and hardener. The outcome demonstrates that the expansion of surface oxygen and hydroxyl gatherings of Kevlar fiber expanded essentially and examination has been finished with Kevlar fiber composite displays brilliant mechanical properties. The smaller scale basic examination has been improved interfacial grip brought about high mechanical properties.

Azmir et al (2008) experimentally researched the impact of abrasive water jet machining process parameters of glass fiber strengthens polymer composites. The procedure parameters, for example, standoff separation, weight, transverse speed, abrasive materials have differed and the comparing surface roughness has been estimated. The outcome demonstrates that there is unimportant power over cutting pace which influences surface completion and furthermore it needs improvement in acquiring ideal answer for fulfill the prerequisites for machining the glass fiber fortified polymer composites.

Fang guo et al (2009) have experimentally investigated the performance on tribological behavior of Kevlar fibers subjected to plasma treatment. Friction and wear test has been carried out to determine the performance of the resulting composites. The apparatus used to determine the friction and wear behavior is pin on disk apparatus. The test has been carried out number of times at ambient temperature, a load between 141N and 251N at a speed of 0.26 m/s over a period of 2 hours at day conditions. Average value has been taken as 10% of relative errors. The variation of friction coefficient and wear rate plotted against power in such a way that the air plasma bombardment increases up to 70W and then decreases. The Tribological properties of Kevlar have shown the best optimal solution when the power at 50W for 15 min. Tribological properties at first abatements and afterward increments with the plasma treatment time.

Min su et al (2011) have experimentally explored the impact of oxygen plasma treatment for Kevlar filaments with bismaleimide as the matrix for better interfacial grip. In this work, Kevlarfiber were immersed in acetone for 24 hours and it is washed with refined water to expel outside pollutions. Filaments were dried at the oven for 3 hours at 120oC and afterward barraged with oxygen plasma. At last, the treated Kevlar fibers are examined with power and time subordinate factors. It is discovered that oxygen plasma-treated Kevlar fiber essentially influences the interfacial bond. In this manner, changing the parameters of the concoction structure and morphology of the surface, bury laminar shear quality, water obstruction and dielectric properties of the composite has been improved. It has been reasoned that, after oxygen plasma treatment, Kevlar fiber has the best state of 70W for 5 min as an ideal answer for conquering poor interfacial grip. And furthermore presumed that it has high potential in the creation of superior copper-clad overlays.

Song fang Zhao et al (2012) have examined the properties and crystallization conduct of PA6 and Kevlar fiber strengthened isotactic polypropylene. Kevlar fiber was adjusted with caprolactum utilizing toluene disocyanate. Warm and mechanical properties were improved with the changed KF. Interfacial connection of isotactic PP/KF/PA6 composite is expanded. The compatibilizer substance assumes a noteworthy work in the upgrade of warm and mechanical properties. The change of Kevlar fiber has improved the mechanical and warm properties of the composites.

Kabir et al (2012) have reviewed the too hardest fiber the Kevlar structure, goals, different evaluations of Kevlar, properties, uses and its applications. The utilizations of Kevlar in different fields like military body defensive layer coats, armor jacket, military protective caps, and vitality transmission applications were talked about in detail. Kevlar fiber likewise can go about as a composite material which has top of the line applications in all transportation vehicles lastly reasoned that lightweight composite will be executed in business purposes in future.

Abu Talib et al (2012) have considered the effective execution of a mixture composite made of woven fiber Kevlar-29 and Al2O3 powder/epoxy exposed to high velocity. The energy consumed because of the effect of little inflexible shots on composite material targets was considered both hypothetically and tentatively. A tube-shaped shot is utilized in this examination. A connection between as far as possible speed and the thickness of composite material was set up. It has been inferred that Kevlar and Al203 with Epoxy show the better ballistic point of confinement speed.

Guru raja et al (2013) have experimentally researched the impact of fiber direction on Kevlar/glass hybrid composites. The procedure has been finished by vacuum bagging method with three distinctive edge direction mixes along these lines brings about the progress of mechanical properties. In this investigation, Kevlar is utilized as the support and epoxy resin as them. The outcome demonstrates that the edge with the flat/vertical direction matrix got the critical consequence of peak stress, tensile strength, and tensile modulus. At long last, the failure investigation of the hybrid composites was additionally examined in detail.

Channabasavaraju et al (2013) have introduced and thought about the mechanical properties of glass, graphite and Kevlar fiber strengthened polymer matrix composites exclusively independent irrespective of the thickness of the laminate. The procedure included the hand layup strategy by vacuum bag molding method in order to improve the better bond between the fiber and the matrix. The tested specimens are considered and the outcome demonstrates that

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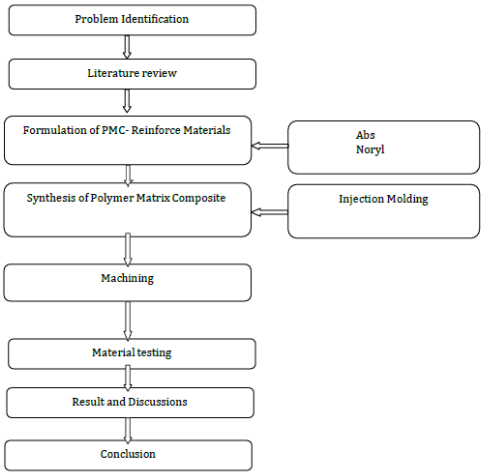
the expansion in the thickness of the example increments tensile and flexural properties of Kevlar fiber when compared with glass an **Ramadhan et al (2013)** have experimentally investigated the sandwich structure dependent on Kevlar 29 fiber with epoxy sap as a medium with the mix of various stacking grouping of 6061 aluminum plates put in the composite overlay. High-velocity effect test has been completed utilizing a nitrogen gas with a tube-shaped state of 7.62mm distance across steel projectile at different speeds. The parameters like ballistic limit speed, energy absorbed by the objective and contrasting the outcomes and the reproduction programming analys autodyne. The outcome demonstrates that the aluminum stacking arrangement at the rear gives the ideal structure to oppose the impact load. The most extreme mistake of 3.64% has been recorded while looking at hypothetical and exploratory outcomes. It is likewise noticed that sandwich structures display high energy absorbing power under high impact loading conditions which is reasonable for defensive layer applications.

3.METHODOLOGY



4.MATERIAL SELECTION AND MANUFACTURING PROCESS

4.1.1 Material selection

The prime ingredient of the composite material is nylon 6 fibers which are tough, possessing high tensile strength, as well as elasticity and luster. noryl are wrinkle-proof and highly resistant to abrasion and chemicals such as acids and alkalis. In addition, the fiber can absorb up to 2.4% of water, although this lowers tensile strength. The glass transition temperature of nylon 6 is 47 °C. The next ingredient is the glass fibers that are thermal insulators because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack with a thermal conductivity of the order of 0.05 W/ mK. By trapping air within them, blocks of glass fiber make good thermal insulation. The most common types of glass fiber used in fiber glass is E-glass, which is alumino-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced plastics because high tensile strength. Addition of glass fibers improved the bending load carrying capacity of both symmetric and asymmetric gears. noryl polymer matrix composites material (70:30) 1 kg is prepared by taking 700 g of noryl in the shape granular form (70 %) and 300 g of glass fiber in the shape of crystal form (30 %).

4.1.2 Introduction of Mechanical Tests

This part manages the different mechanical tests and metallurgical test relating strategies received to decide the physical and mechanical behaviors of the composite example created by hand layup technique and Injection embellishment process. The morphological examination is completed to watch the interior structure of the composite overlay. It additionally manages the machining of composites to locate the ideal arrangement of the machining parameters, for example, standoff separation, weight and cross speed. The different mechanical test has been completed to decide the mechanical attributes which incorporate malleable test, pressure test, flexural test, sway test, exhaustion test, SEM test, TGA with DSC test and XRD test. According to ASTM benchmarks, different mechanical tests have been led for various examples of various classes.

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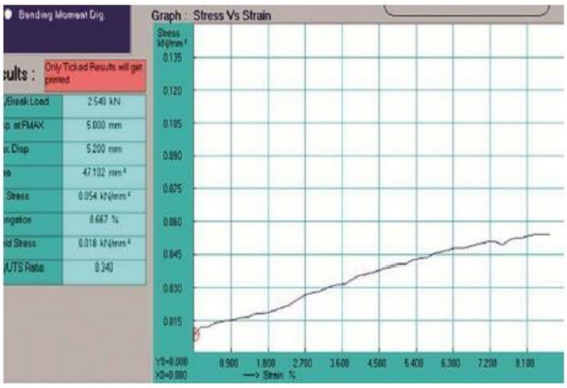
4.2 TENSILE TEST

The manufactured composites laminate is blanked according to the tensile test measurement. A standard dog bone formed samples (unadulterated Noryl and noryl composites of 30 wt % GF content) were considered for testing utilizing injection molded adhered to ASTM D638 details for elastic testing (Reinforced and unreinforced plastics).
The test specimen is loaded in the PC operated UT Machine. The machine load range is 0kN to 25kN. Tests are being carried out on composites with various blends with reinforcing materials to measure extreme tensile strength and rigidity. Synchronous load readings and extensions should be carried out at standard loading intervals.
A tensile test is completed at room temperature. The uniaxial tensile test is directed on the developed example to get data with respect to the conduct of a given material under slowly expanding pressure strain conditions.

Tensile Specimen before Testing

Tensile Specimen after Testing



Tensile test
Tensile Test Noryl -Abs Composites

4.2.1 FLEXURAL TESTS

The UT machines are utilized for the flexural test. The flexural strength can be calculated by using the tensile test. The key conditions for the bending test are to assess the inner laminar shear power, small beam shear tests are conducted, and 3-point bending tests are possible. In which the two ends of specimens are simply supported beam and the load is applied at the center of the specimens, the maximum load range is 0 kN to 0.45 kN As the load progress continuously, it tends to stretch to a point that it can withstand and then a breakdown of the composites begins. Five specimens were the tested. The ASTM D790 specifications for the Flexural Test performed in the composites sample.

Flexural Specimens before Testing

Test Specimens before compression

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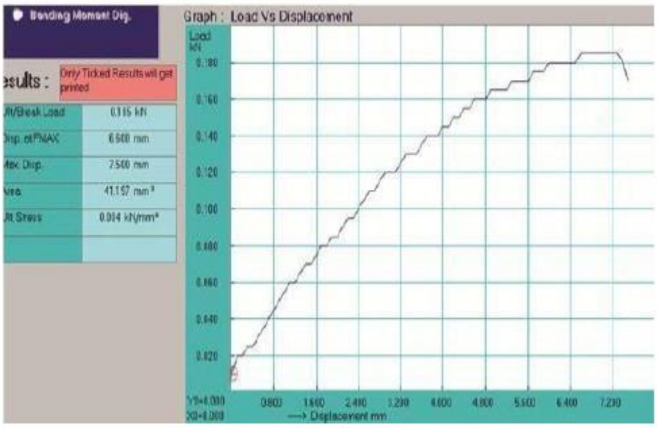

Flexural test

4.2.2 Compression Test

Material quality can be found by testing the material in compression or tension. Test specimens are prepared by ASTM D315 standard, every testing specimen has 30 mm width and 280 mm measure range. The example is the arrangement in PC controlled UT The machine load range is 0kN to 25kN. Tests are led on composites of various mixes of fortifying materials and extreme elasticity and flexibility are estimated. Synchronous readings of load and stretching are taken at uniform interims of the load. The tensile test is completed at room temperature. The uni- axial tensile test is directed on the test specimens to acquire data corresponding to the conduct of a given material under bit by bit expanding stress-strain conditions. Essentially, it depends on the material property under which the proposed section must usually maintain a sudden shock, which results in the hardness of the material being tested. The ASTM standard used for the hardness measurement is ASTM D258.

Compression Specimens before Testing

Compression Specimen after Testing

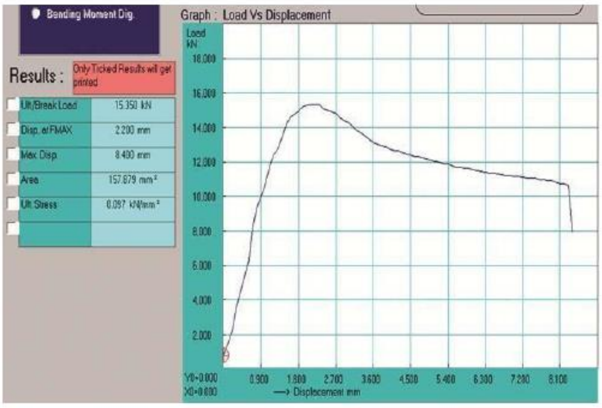

Figure 4.9 Compression Test

4.2.3 Compression Test Noryl + ABS Composites

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Compression Test specimens	Ult. Breaking load in kN	Maximum Displacement in mm	Ult. Stress in kN/mm^2
1	18.37	8.06	0.116
2	19.31	6.36	0.122
3	17.69	8	0.112
4	19.25	6.36	0.121
5	15.42	8.09	0.098

5.CONCLUSION

5.1.1 INTRODUCTION

This chapter describes the main research results drawn from studies related to experimental investigations and analysis of the results of various polymer composites and performance testing on composites polymer gears. This section presents important characteristics and contributions of the research work in this thesis. The scope has also been identified for further research and is listed in the section.

5.1.2 TESTING Results of COMPOSITES

In tensile test, it is observed the higher load values gradually withstand the percentage of the elongation and also it gives capacity for withstanding the higher load. The increase between 6.66 % and 18.5 by % elongation of 70 wt % noryl blend with 30 wt % glass fiber polymer composites showed the range of increase in material toughness and reflected the variation in yield stress.

In flexural test, 70 wt % noryl blend with 30 wt % glass fiber polymer matrix composites specimens showed better flexural strength results. The flexural strength in the sample was observed to be higher in the range of 0.185 kN that showed that 70 wt % noryl blend with 30 wt % glass fiber is the ideal material for polymer matrix composites.
Compressive stresses between 97-116 MPa verified that polymer matrix composites are more than 80 MPa ideal validating 70 wt % Noryl blend with 30 wt % glass fiber. Composites are subject to compression stress in high toughness material conditions.

Based on the results of the above studies, 70wt % noryl with a 30 wt % glass fiber polymer composites and 80wt % noryl with a 20 wt % glass fiber polymer composites were taken for testing gear.

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