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Influence of powdered chick eggshell (PECS) on mechanical and wear properties of kenaf fiber (KF) reinforced composites

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Abstract

The mechanical and wear characteristics of epoxy polymer reinforced composites using kenaf fibre (KF) and powdered chick eggshell (PCES) were examined experimentally. Calcined and uncalcined egg shell particles were created through the processing of egg shell. By using soil retting, kenaf fibres were extracted from the ground and then subjected to NaOH treatment. The composite was made by mixing the selected components in a specified ratio using the hand lay-up process. The produced composites' mechanical and wear characteristics were assessed. The results showed that calcium carbonate may be found in egg shell particles, and in most tests, the uncalcined ESP/SF reinforced epoxy composites outperformed the calcined ESP/SF composites. Additionally, it was found that most tests performed best at various weight fractions. The maximum results of this experimental investigation were 49.57 MPa, 3.64 GPa, 34.41 MPa, 3.49 GPa, 16.43 kJ/m^2, and 63.91 HS for tensile, flexural, impact strength, flexural, tensile modulus, and shore D hardness. The 2-wt% calcined PCES particles were responsible for establishing the better wear behaviour. However, the weight fraction with the best values was found to be 2 weights %.

Introduction

Numerous studies have been done over the last few decades to identify appropriate composite materials made of ceramics and polymers. Fiber-reinforced composites, which use a special mixture of polymers as the matrix and natural fibers obtained from plants as the reinforcement, are one of the most crucial techniques for gaining new features. Since the fiber is more rigid than the matrix, it serves as a solid support and the main bearing element for the scattered load. Natural fiber composites (NFCs) are created using either a thermoplastic matrix or a thermoset mixture. The study and development of corporate applications, as well as the aerospace, aviation, and automobile industries, have all boosted interest in NFCs [1]. Kenaf fibers are among the most sought-after natural fibers now on the market due to their minimal cultivation needs and quick, mass harvest. The stem, or bast, is used to harvest kenaf fiber, a type of plant fiber. With 0.97 million tons harvested annually, it ranks third among natural fibers used to make ropes, mobile cases, insulations, luggage, and packing materials. In comparison to other natural fibers, Kenaf fibers are significantly more inexpensive and robust [2]. The majority of recent research on NFCs has been on their mechanical characteristics, despite the fact that their performance is comparable to that of those synthetic fiber composites. Filler was chosen as a solution to enhance

the qualities as a consequence. Over the past several years, studies have been carried out using nanoparticles, which serve as filler materials and lessen the porosity in the composites [3]. Fillers were used to enhance some composite materials' mechanical performance. Due to inappropriate industry waste disposal, which has resulted in the usage of waste materials as filler in composites, researchers have been examining the consequences of waste materials on the human health and environment [4]. The tensile strength, mechanical qualities, and tribological characteristics of composites could be enhanced depending on the intended usage and the compatibility of the filler with other components [5]. Fillers come in both organic and inorganic forms, with the latter being more frequently utilized. Since agricultural waste may be used to obtain the organic fillers, which normally have low specific gravities, the acquisition cost is reduced. Due to financial and environmental considerations, waste materials are currently employed more frequently in polymer composites [6]. Chicken egg shell powder, a natural filler that can replace $CaCO_3$ in composite fillers, contains the majority of calcium carbonate (95 % by weight). It also enables hassle-free production because it has a lesser specific density than the mineral alternative [7]. The food processing industries produce several hundred thousand tons of egg shell waste each year, and both the expense of using this waste and its environmental impact are significant. By converting wastes into valuable products, wastes can be managed in creative ways that are both effective and sustainable [8]. The production of organic materials accounts for around 95% of the calcium carbonate in egg shell waste, with the remaining 5% coming from sulphated polysaccharide, collagen, as well as other proteins. $CaCO_3$ is added to polymers to boost their mechanical and thermal resilience [9]. Egg shell powder is combined with epoxy resin to enhance the mechanical characteristics of jute reinforced polymer composite [10]. The hybrid composite, which is composed of 5wt% glass fibers, 15wt% kenaf fiber, and 9wt% egg shell particles, demonstrated excellent tensile and flexural strengths in comparison. According to reports, adding natural fiber and egg shell powder greatly improves the hybrid composites' mechanical properties [11]. Experimental studies on the impact of egg shell powders on the mechanical properties of epoxy resin were undertaken in order to determine the effect of the filler content on the composite's structure [12]. He noticed an increase in the material's tensile strength, elongation (El) at break, and hardness. The SEM image showed excellent wettability between the microparticles and the polymer. Egg shell particle enhances hardness, % El at break, and flexural strength while decreasing tensile strength and elastic modulus, according to investigations on the mechanical properties and water absorption of egg shell polymer composite [13]. The mechanical behavior of kenaf fiber and epoxy-based polymer composites has been the subject of numerous studies. Utilizing the film stacking technique and a heat curing process, tensile and flexural characteristics of kenaf/polypropylene composites were created and experimentally tested. The tensile and flexural modulus were found to increase as the fiber content did [14]. Weaved kenaf/glass reinforced hybrid composites have been successfully researched and assessed. The glass and kenaf fibers utilized as reinforcement exhibited exceptional adhesion and compatibility, and it was asserted that one layer of kenaf could replace 20% of the fibers in the composite's total weight [15]. According to the current investigation, little has been written about the effects of egg shell powder, both calcined and uncalcined, employed as filler on the mechanical properties of kenaf fiber hybrid polymer composites. In order to characterize them for their mechanical and wear qualities, the hybrid effect of kenaf fiber with PCES was examined. Using various ratios of kenaf fiber and eggshell powder, we produced six distinctive hybrid composite panels (Fig. 1).

Section snippets

Materials and methods

The materials utilized in this experiment were eggshell, kenaf fiber, sodium hydroxide, filtered water, epoxy resin (LY556), and curing agent (HY951). While the epoxy resin and amine curative were purchased from Covai Seenu and company Ltd, Coimbatore, Tamil Nadu, India, the eggshell and kenaf fiber are collected and purchased from fields in the Erode district of Tamil Nadu, India. The soil retting process was used to remove kenaf fiber from the plant's leaves, which were then disinterred,…

Results and discussions

The calcined composites' highest flexural strength increased from 2 to 8wt%, as shown in Fig. 2, with 12wt% having one of the maximum flexural strengths at 44.74MPa. The uncalcined PCES Samples/KF at 6wt% have the highest flexural strength of the uncalcined composites, measuring 49.57MPa. This suggests that the egg shell and kenaf fiber added to the