Numerical and Experimental Investigation on Tensile Properties of Natural-Sand Reinforced Polypropylene

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Abstract. Reinforced polymer composites are replacing metals in many engineering fields due to their high strength to weight ratio, low cost, and resistance to corrosion. In this study, the tensile properties of natural-sand particle reinforced polypropylene composites obtained by means of numerical method were compared with the experimental observations. Rectangular samples were prepared by heating the natural sand and polypropylene (PP) mixture at the melting temperature of PP and cooling in a rectangular mold. During cooling, pressure was applied on the upper part of the mold to avoid voids and shrinkages on the final sample. The concentration of the sand was varied as 5%, 10%, 15%, 20%, and 30% by weight. Then the samples were tested with 3-Point Bending and Universal Tensile Testing Machines to obtain the respective values of flexural and tensile properties of the composite samples. The numerical simulation was performed by using ANSYS software. For the simulation, structured mesh was constructed with 7500 elements and 36466 nodes. The experimental results indicated that the yield stress values dropped gradually from 21.62 MPa for 5% by weight to 8.01 MPa for 30% which leads to a conclusion that the higher the percentage of the sand particle reinforcement, the lower the tensile strength of the composite would be. Moreover, both the numerical and experimental results showed a linear increase in deflection with the increments of the applied load. These results are as expected and they confirm with the theoretical behavior of a bar subjected to axial loading. Hence, this study could assist in decisions regarding the design of reinforced composite products.

Introduction

There are many composites which can be applied in various fields of engineering. Some of the composites include polymer composites, ceramic composites, and metal composites. Currently, studies are concentrating on reinforce polymer composites because these composites have huge potential to replace metals in the automotive, aerospace, sport, and manufacturing fields. The reinforcements may be particles [1], natural fibers [2], or synthetic fibers [3]. Polymer (plastic) composites are advantageous than the other composites due to the fact that they have high ratios of strength to weight ratio, high fatigue properties, low cost compared to other types of composites, high toughness, and transparent properties [1,4].

Effect of sand addition on the tensile properties of compression molded sand reinforced polyethylene was studied by R.R. Zahran [5]. From his experiment, Zahran concluded that sand reinforced polyethylene composite is greatly affected by the sand particles. Moreover, he stated that the mechanical properties are affected by the weight percentage of the sand particles in the composite, as well as the size of the sand particles: the finer the sand size, the higher the strength will be. However, the strength of the composite varies by the weight percentage of sand. At lower weight percentage, the strength of composite is higher than pure polyethylene while in certain high percentage; the strength of the composite is lower than pure polyethylene. In another related research by P. Herrera-Franco, A. Valadez-Gonzalez and M. Cervantes-Uc [6], the development and characterization of a high density polyethylene (HDPE)-sand-natural fiber (henequen fiber) composite was performed and characterized. They manipulated the weight-to-weight ratio (w/w) filler contents to the thermoplastic resin and the