PROCESSING AND CHARACTERIZATION OF UHMWPE-CSP (COCONUT SHELL POWDER) COMPOSITE

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Abstract

The stringent environmental considerations like deforestation have led to a thinking to replace wood with various synthetic materials, such as polymer composites. In this paper, an attempt has been made to reinforce coconut shell.powders (CSP) in a ultrahigh molecular weight polyethylene (UHMWPE). Prepared by powder metallurgy route, these composites have been evaluated for its mechanical properties and compared with pure UHMWPE (0 vol% CSP). With increasing addition of reinforcement, the impact strength decreases marginally upto 20 vol% after which there is a sharp fall. But the compressive strength has not decreased much even after 30 vol% of CSP. An optimum loading of 20 vol% is found to be beneficial for better properties.

Introduction

In the age of materials, composites fulfil optimum requirement criteria for any designer's materials requirement. In the last fifty years polymeric materials have been in increasing demand, initially in the domestic sector then in technical fields such as automobile, aerospace, engineering, food processing, textile, medical implantation, and many more. Aerospace industry has revolutionized the concept of composite materials for light weight and high strength applications and polymer composites are the only viable materials to reckon with. Of course there is considerable development in other type of applications such as medical, food processing, textile and for day-to-day use of materials

Recently environmental considerations due to heavy industrialization or to preserve environment from direct exploitation, like, forestry, materials which can replace wood for making furniture etc., are being seriously considered. A novel concept has been introduced to make a polymer composite which can replace wood, utilize by-product of a primary Indian industry, upholding the problem of disposal, and also being cheap. It is a well known coconut shell powder (CSP). It can be mixed with polymeric materials composite to make products similar to wood, with competitive price and to obtain advantageous properties like resistance against degradation, chemical attack, water absorption etc.

Ultra High Molecular Weight Poly Ethylene (UHMWPE) and its Composite

UHMWPE is the best choice for this type of composite development. It has the best mechanical properties among all thermoplastic polymeric materials. It is inactive to most of the chemicals, compatible with materials like CSP or any other organic materials. There is no water absorption and is highly stable, unless temperature is too high for a polymer.

Inclination to make composite which can replace wood is not new, in fact, many of day to day furniture are already made of polymeric materials. But UHMWPE has not been exploited much, primarily because of its uneconomical price and also economically unviable processing methods. The process followed for making UHMWPE components are either hot extrusion and hot pressing. Hot extrusion is seldom preferred. Hot pressing is mostly followed, it is like sintering. Powder is compacted to the final shape by applying pressure, simultaneously temperature is regulated to have efficient compaction and formation.

UHMWPE-CSP Composite

The work done is primarily to study processing of UHMWPE and CSP mixture, its possibility of commercialization and enumeration of advantageous properties. In addition, study of interfaces, particle arrangement, texture, and crystallization is done.

Experimental setup

A set up for making UHMWPE-CSP composite is made in the department. It essentially consists of mechanical hand press, split furnace, and specially designed die-punch assembly. UHMWPE and CSP powders are supplied by FairDeal Corporation Bangalore, a propriety company. The company gets UHMWPE from Germany. The company makes components of pure UHMWPE as well as composites. Coconut shell powder is also supplied by the same company, procured locally.

UHMWPE and CSP powders are mixed and then blended in a ball mill, in a plastic container of 300cc, with no balls and is rotated for 10 hours. Using 100cc of the blend a cylindrical disc of 5cm diameter and 3cm height is made in five to six hours. Normal cooling rate i.e. leaving the sample to cool inside the die-punch arrangement with split furnace removed, is followed. Prepared sample looks like wood with dark grayish tinge. Three different composition composites are made, such as 20%, 30%, 40% CSP with UHMWPE. Properties of all these compositions are studied.

The schematic experimental arrangement and temperature- pressure cycle is shown in Fig.1.1 and 1.2.

Composite Characterization

After the samples are made, mechanical, SEM and X-ray studies are done. The different mechanical tests are compressive and notch impact tests. The primary objective of mechanical testing is to get a relative picture of strength, toughness with respect to pure UHMWPE, which has highest mechanical properties of all thermoplastic polymers.

Pure UHMWPE is very ductile, it needs a lot of energy to be broken. Even at cryogenic temperature it remains ductile, whereas by addition of a filler its ductility decreases. All the three different compositions of composites and pure UHMWPE were tested with non standard notch impact specimens. This test is done to get a relative idea about their ductility. The variation of impact strength with composition is shown in Fig. 1.3. The decrease in ductility in the 20 vol% CSP composite is nominal and with further increase in content of CSP ductility decrease rapidly, so for optimum notch impact strength 20 vol% CSP composite is ideal.

Compression tests were done on ASTM standard specimen at room temperature, the strain rate was kept at moderate 0.01/s. To get a relative idea about the change of property, pure polymer sample and three different composition composite samples were tested. The specimens were of 12.5mm diameter and 25mm height cylinders. For each composition two specimens were made to get reproducible data. The variation of compressive strength with composition is shown in Fig. 1.4. There is not much decrease in the compressive strength with increase in CSP content, so for applications where compressive strength is the chief selection criteria higher percentage of CSP content composite can be used.

Polymers are not hard as compared to many materials like metals and ceramics. The thermoplastics are the softer amongst all polymers. As the molecular weight increases hardness increase, pure UHMWPE has hardness of Shore D 62-64. By addition of filler, hardness increases, this composite is slightly harder than pure UHMWPE, (Shore D 70-72).

Many other testing can also be done to generate data which are useful for engineering purpose. Nevertheless the experiments done have given enough information for a general characterization of these materials.

This composite can be improved or properties can be enhanced by blending, mixing a third element, or by putting whiskers, fibers etc. Colour of the composite can be varied.

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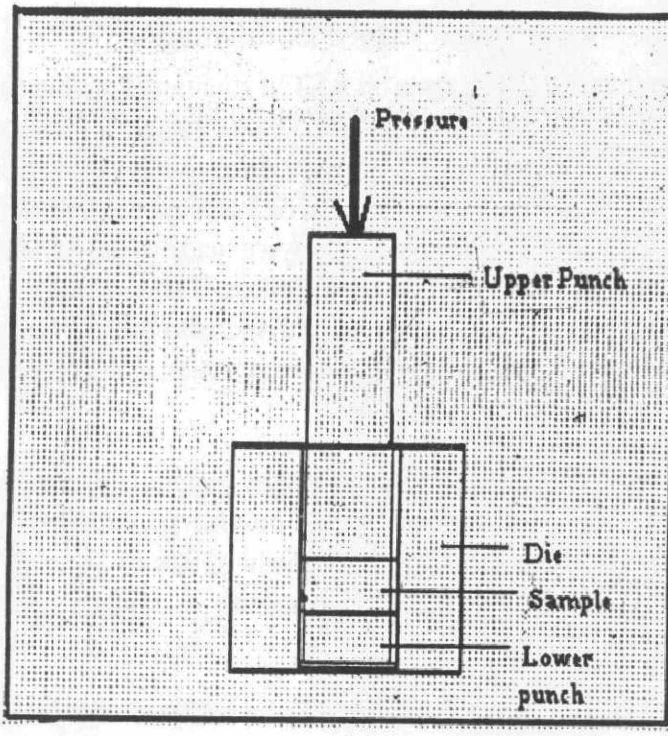

Fig. 1.1 - Schematic experimental arrangement.

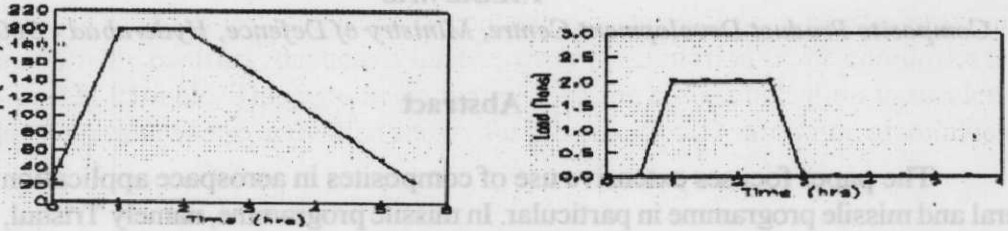

Fig. 1.2 - Temperature-Pressure Cycle.

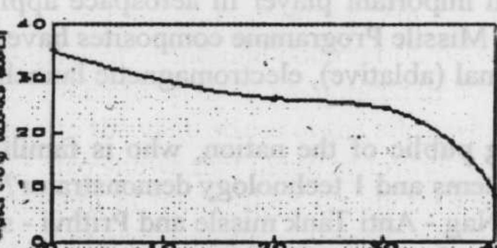

Fig. 1.3 - Variation of Notch Impact Strength with Composition.

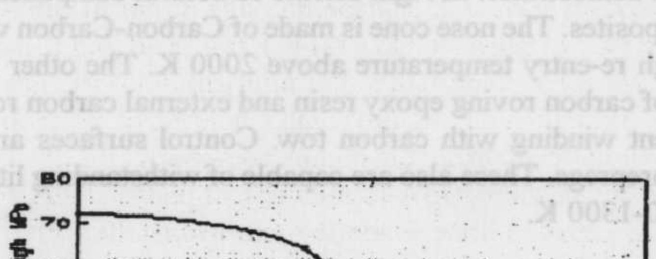

Fig. 1.4 - Variation of Compressive Strength with Composition.