Mechanical Characterization of Thermoplastic ABS /Glass Fibre Reinforced Polymer Matrix Composites

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Abstract: **Glass fibres (GF) are the reinforcement agent used in most of the thermoset and thermoplastic based composites, as they create a good balance between properties and cost. However the final properties of the composites are mainly determined by the strength and the stability of the polymer fibre interphase. The mechanical properties of the thermoplastic polymer changes gradually and drastically by addition of layers of glass fibre. This work provides an evidence for such variation in the mechanical characteristics, such as tensile, compression and bending for polymer matrix composites. Thermoplastic ABS material (Acrylonitrile Butadine Styrene) used as an matrix and glass fibre as an reinforcement agent. The laminates are prepared according to the ASTM standard, without glass fibre, ABS with single layer of glass fibre and ABS with double layer of glass fibre using injection moulding process. These laminates are tested for tensile, compression and bending according to the standard procedures, the obtained results are tabulated and compared.**

Keywords: Acrylonitrile Butadine Styrene, Glass fibre, Polymer matrix composites

I. INTRODUCTION

Composite material can be defined as two intrinsically different materials that when combined together produce a material with properties that go beyond the constituent materials. Composites are unique range of materials gaining its importance in today's materials due to its advantages such as low weight, corrosion resistance, and high fatigue strength. In composites material are pooled in such a way that it enables to make a better use of their properties and reduce the effect of their deficiencies. In contrast to the metal alloys, each of the materials retains its characteristics. The two constituent include the matrix and the reinforcement. The composites materials have benefit of their high strength and stiffness combined with low density when compared with the bulk materials. The reinforcement phase provides the strength and stiffness, in many cases the reinforcement is the harder stronger and stiffer than the matrix phase. An effective interphase will be obtained if there exist a adequate bonding between the interphase. In fibre length is much greater than its diameter. The ratio of length to diameter (L/D) is known as aspect ratio and can diverge greatly. The continuous fibres have long aspect ratio and short fibres have small aspect ratio.

Glass fibres are manufactured from the drawing process of molten glass into fine threads and immediately protecting it from them from contact with the atmosphere in order to conserve the defect free structure that is developed during the drawing process. The properties of glasses can be transformed to a limited extent by changing the chemical composition of the glass. The glass used by major volume in composite materials as reinforcement is ordinary borosilicate glass which is known as E-glass, another glass which has better properties including the higher thermal stability is S-glass but its higher cost has limited the extent of its use. The incorporation of glass fibres is known to improve the properties of thermoplastic materials by applying the traditional process such as injection moulding and extrusion. The mechanical performance of glass fibre reinforced composites depends not only on the properties of the individual component but also the contacts established between the reinforcing agent and the matrix. Polymer matrix composites are primarily reinforced to increase the properties of polymer.PMC are designed in such a way that that the mechanical loads which are structured is subjected to services are supported by reinforcement. The reinforcing of the polymers is the areas were developments have been made until now and there is still scope of improvements. The difficulty facing the manufacturer of composites is to develop suitable methods for combining the matrix and the reinforcement so as to obtain the required shape of component with properties appropriate to the design requirements.ABS provides industrial and scientific importance because of its dimensional stability, toughness, impact resistance and also its good surface finish. The flow ability of material allows material to be processed by injection moulding.

PMC play a crucial role in aerospace applications. Apart from the aerospace applications, composites are most utilized in automobile sector and industrial equipments.

Commercial aircrafts are utilizing the composites in their structural weight to reduce overall weight of aircraft and reduce fuel consumption. Additional markets for polymer matrix composites are storage of corrosive liquids, medical implants, reciprocating industrial machinery, sporting equipments, military vehicles and weapons. these opportunities makes rapid growth in developing a cheaper, reduced weight and durable materials.

This study incorporates the mechanical characteristics of the polymer matrix composites provides ABS as the matrix and glass fibres as the reinforcing agent and further the layer of glass fibre is increased to double layer its characteristics are studied. In this work it provides detailed comparison with the ABS material and ABS composite using glass fibre as its reinforcing agent. It also provides the variation in the characteristics by increasing the layer of glass fibre.

II. LITERATURE REVIEW

A. Fracture resistance of unfilled and calcite- article-filled ABS composites reinforced by short glass fibres (SGF) under impact load

Shao-Yun Fu* and Bernd Lauke Institute for Polymer Research Dresden eV, Hohe Strasse 6, D-01069 Dresden, Germany (Received 10 April 1997; revised 1 November 1997; accepted 1 November 1997)

Acrylonitrile-butadiene-styrene (ABS), unfilled and filled with calcium carbonate particles, used as a matrix for reinforcement with short glass fibres. The composites were studied with respect to the work of fracture, determined by the Charpy V-notch impact test. The results showed that the reduction in WOF caused by addition of SGF to pure ABS resin matrix is the result of a significant reduction in the matrix fracture work; on the other hand, the inclusion of SGF into calcite-filled ABS resulted to some extent in an increase in the WOF, this is due to the fairly large interface energy contribution to the WOF of the composite. This behaviour was explained in terms of the changes in fibre length distribution by using the total WOF theory and the fibre pull-out energy theory.

B. Characterization of tensile behaviour of hybrid short glass fibre/calcite particle/ABS composites

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Germany 7997)

The tensile properties of the hybrid, injection molded, short glass fibre/calcite particle/acrylonitrile- butadiene-styrene composites have been considered. Simple modification in rules of mixtures was used to approximate the fibre efficiency factors for the strength and modulus of the hybrid composites. It was observed that the fibre efficiency factor for the strength of hybrid composites, were reduced by the addition of calcite particles for the as-received case but not for the two sized cases. It appears that the glass fibre/ABS bond strength and the calcite particle/ABS adhesion strength have a combined effect on the strength of hybrid SGF/calcite/ABS composites. This study presents a qualitative explanation of the diminution in the fibre efficiency factor for the strength of the hybrid composites.

C. Improvement in Surface Properties of ABS Using Carbon and Glass Fibre Reinforcements

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Acrylonitrile Butadiene Styrene has quite a lot of mechanical applications. Here, ABS is reinforced with glass fibre and carbon fibre, in the ratio of 10% and 30%. Injection moulding process is used for reinforcement and the coefficient of friction was vague using pinon disk method. In reinforcement and carbon fibre reinforced ABS displayed greater improvement in surface properties compared to the glass fibre counterparts. ABS with 30% carbon fibre had the least coefficient of friction amongst all the samples.

D. Mechanical properties and electrical conductivity of carbon-nanotube filled polyamide-6 and its blends with acrylonitrile/butadiene/styrene

Olaf Meinckea, Dirk Kaempfera, Hans Weickmanna, Christian Friedricha,*, Marc Vathauerb, Holger Warthb

Composites of polyamide-6 and carbon nanotubes have been prepared on a corotating twin-screw extruder. The electrical conductivity of these composites was analyzed and compared to carbon black filled polyamide-6. It is evident that the NT-filled polyamide-6 shows an beginning of the electrical conductivity at low filler loadings. The tensile test of the NT-composites show a significant increase of 27% in the Young’s modulus, though the elongation at break of these materials dramatically decreases due to an embrittlement of the polyamide-6. As a result of the conductive filler to one blend component these materials show the electrical conductivity at very low filler loadings. The NT-filled blends show superior mechanical properties in the tensile tests and in IZOD notched impact tests.

E. Characterization of coconut fibre-filled polyvinyl chloride/acrylonitrile styrene acrylate blends

Sarawut Rimdusit, Siriporn Damrongsakkul, Patima Wongmanit, Duangporn Saramas and Sunan Tiptipakorn Characterization Journal of Reinforced Plastics and Composites

Coconut fibre-filled composites based on PVC/ASA blend were prepared. The result shows that the impact strengths of the PVC/ASA/coconut fibre composites are higher than those of PVC wood composites or polyolefin wood composites when comparison was made at the same fibre content. Dynamic mechanical analysis, thermograms shows two different glass transition temperatures of the blend matrix, indicating incomplete miscibility of the blends. The tensile strength of the blend is as high as 45MPa was obtained and found to only slightly decrease with the fibre content. The PVC/ASA blend shows a possible use as a matrix of high-impact wood composite products with good thermal stability due to the outstanding impact strength and thermal properties of the blend.

F. Tensile, flexural and impact properties of a thermoplastic matrix reinforced by glass fibre and glass bead hybrids

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The tensile and flexural properties, jointly with the unnotched and notched impact strengths of acrylonitrile butadiene styrene, glass bead and glass fibre composites have been studied. The tensile strengths of the hybrid composites were predicted, from a theory formulated, by using the strengths of the ABS/GB and ABS/GF composites alone. The addition of even a small quantity of glass fibre to ABS or ABS/GB composites changes deformation from one which shows growth and to brittle failure. Thus, the elongation at break, the area under the stress/strain curve and the impact energy decrease sharply with the introduction of glass fibre to ABS or ABS/GB composites.

G Dynamic Mechanical Properties of Copper-ABS Composites for FDM Feedstock

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This work provides study of dynamic mechanical properties of a copper-ABS composite material for possible fused deposition modelling feedstock. The material consists of copper powder filled in an acrylonitrile butadiene styrene. The detailed formulations of compounding ratio by volume percentage with various combinations of the polymer matrix composite are studied experimentally. It was found that, increment by vol percentage of copper filler ABS affected the storage modules and tan δ results. The tangent delta and storage modulus increased proportionally with addition of copper filled ABS.is is observed, the storage modulus and tangent delta are dependent on the copper filled ABS in the PMC material.

H. Strengthening acrylonitrile-butadine-styrene (ABS) with nano –sized and micron-sized calcium carbonate

l.JIANG, Y.C. LAM, K.C. TAM, T.H.CHAU, G.W.SIM, L.S.ANG

ABS was reinforced by both micron sized and naosized precipitated calcium carbonate particles. The MCC/ABS composites were found to have higher modulus but lower tensile and impact strength than pure ABS. In contrast, NPCC increased modulus of ABS or even increased its impact strength for a certain NPCC. SEM examinations revealed that NPCC particles were distributed in much smaller sizes in the composites than its MCC counterparts. The interfacial area between NPCC and ABS and cavitation induced shear yielding in the ligament are the main reason of the mechanical property improvement of the NPCC/ABS also shows completely different rheological behaviour from ABS. A NPCC network structure was thought to be formed in the composites and induced these pseudo-solid rheological behaviours.

III. METHADOLOGY

ABS is used as matrix material along with the glass fibre as reinforcement. the laminates are prepared using injection moulding process using injection mould tool having its rectangular component 250mm*250mm*4 mm in size. Glass fibres are used in the form of woven strand mat. Laminate with pure ABS, ABS with single layer glass fibre, ABS with double layer glass fibre are prepared.

IV. LAMINATES PREPARATION

A. Pure ABS

Tensile Specimen Compression Specimen Bending Specimen

Fig-1: Laminates of Pure ABS

B. ABS with Single Layer Of Glass Fibre

Tensile Specimen Compression Specimen Bending Specimen

Fig-2: Laminates of ABS with Single Layer Of Glass Fibre

C. ABS with Double Layer of Glass Fibre:

Tensile Specimen Compression Specimen Bending Specimen

Fig-3: Laminates of ABS with Double Layer Of Glass Fibre

V. RESULTS

A. Tensile Test:

Table-1: Tensile Test Results

	PEAK LOAD (KG)	ENGG UTS (KG/SQ-MM)
ABS WITH NO LAYER	216	2.462
ABS WITH SINGLE LAYER	253	3.360
ABS WITH DOUBLE LAYER	303	3.486

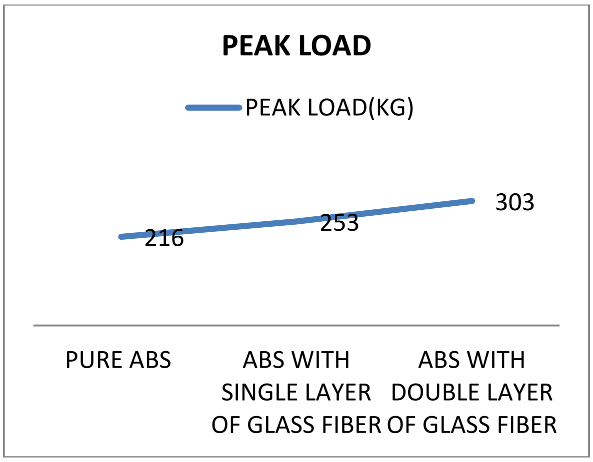

Chart-1: Comparison of Peak Load v/s Laminates

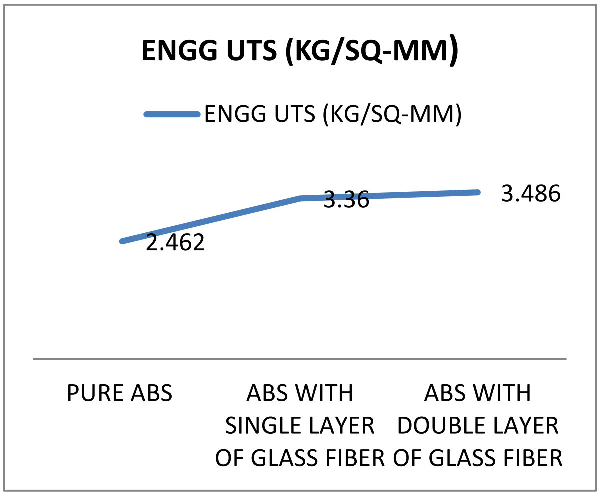

Chart-2: Comparison of Engg UTS v/s Laminates

B. Compression Test:

Table-2: Compression Test Results

	PEAK LOAD (N)	COMPRESSION STENGTH (N/MM2)
ABS WITH NO LAYER	71940	1676.45
ABS WITH SINGLE LAYER	94500	2309.61
ABS WITH DOUBLE LAYER	127020	3158.79

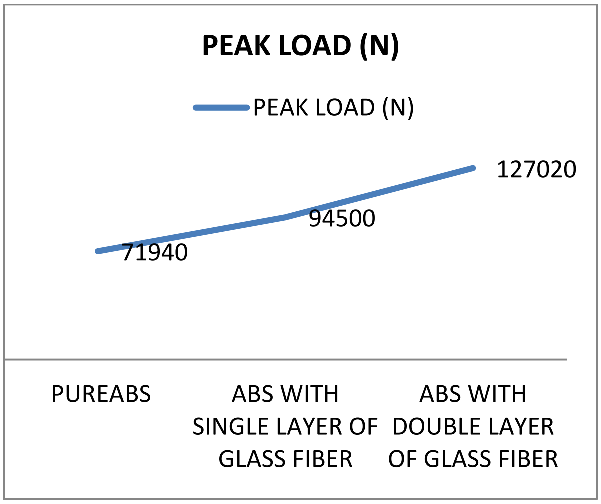

Chart-3: Comparison of Peak Load v/s Laminates

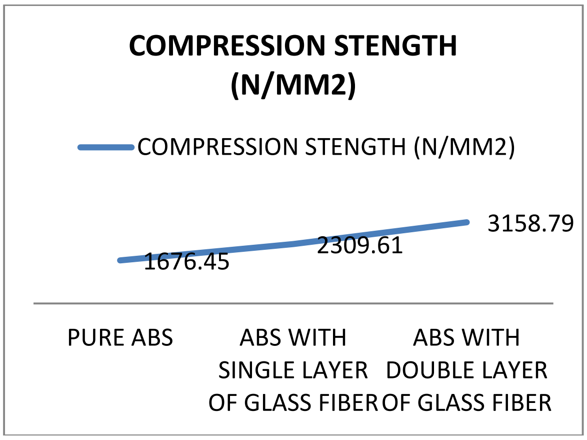

Chart-4: Comparison of Compression Strength v/s Laminates

C. Bending Test:

Table-2: Bending Test Results

	PEAK LOAD (KG)
ABS WITH NO LAYER	37
ABS WITH SINGLE LAYER	33
ABS WITH DOUBLE LAYER	32

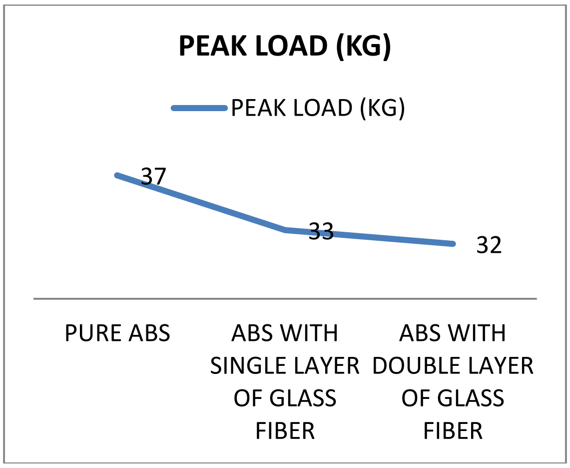

Chart-5: Comparison of Peak Load v/s Laminates

VI. DISCUSSION

A. Tensile Test:

- ABS without glass fibre produces least value of peak load and Engg UTS, whereas ABS with double layers glass fibre produces maximum value of peak load and Engg UTS.ABS with single layer glass fibre yields intermediate results.
- Inclusions of glass fibre have enhanced the properties of the ABS. ABS without glass fibre offers least results compared to ABS with glass fibres.
- With addition of the glass fibre properties are enhanced gradually, ABS with double layer glass fibre produces maximum strength.

B Compression Test:

- ABS without glass fibre produces least value of peak load and compression strength, whereas ABS with double layers glass fibre produces maximum value of peak load and compression strength.ABS with single layer glass fibre yields intermediate results.
- Inclusions of glass fibre have enhanced the properties of the ABS.ABS without glass fibre offers least results compared to ABS with glass fibres
- With addition of the glass fibre properties are enhanced gradually, ABS with double layer glass fibre produces maximum strength, when compared to ABS with single layer glass fibre.

C. Bending Test:

- In contrast to Tensile and Compression test, in bending test peak load of ABS without glass fibre offers maximum result when compared to ABS with single and double layer glass fibre.
- Inclusions of glass fibre have reduced the properties of the ABS. ABS without glass fibre offers maximum results compared to ABS with glass fibre.
- With addition of the glass fibres properties are reduced, ABS with double layer glass fibre produces less value, when compared to ABS with single layer glass fibre.
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