XX.
VYZTUŽENÉ PLASTY
REINFORCED PLASTICS
VERSTÄRKTE KUNSTSTOFFE

Karlovy Vary
25. - 27. 5. 1999
ČESKÁ REPUBLIKA

REICHHOLD

NESTE
Chemicals

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Conference office:

Dům techniky Plzeň, s.r.o.
(House of Technology Plzeň, Ltd.)
sady Pětatřicátníků 6
CZ 303 40 Plzeň
Czech Republic

Phone: +420-19-722 48 16
Fax: +420-19-723 71 15

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takes the honour to invite you to the

XX.
International Conference

REINFORCED PLASTICS '99

INVITATION AND PROGRAMME

May 25-27, 1999
Hotel THERMAL
Karlovy Vary (Carlsbad)
Czech Republic

15.00 - 17.30 **COMPANY PRESENTATIONS**

Glassfibre reinforcement for composites and bitumens
Skloplast, a.s., Trnava, Slovakia

Production line of ENYDYNE resins
Cray Valley, Paris, France

The unique "Low Emission Technology" from NESTE Polyester
Neste Chemicals OY, Bruxelles, Belgium

Gelcoats and barrier layers for protecting of RP
Scott Bader, Wollastonite, UK

Steel strip laminate (SSL) pipe
Ameron BV, Geldermalsen, the Netherlands

Renovation of chamber screws
(BOCO Pardubice machines s.r.o., Pardubice, Czech Republic

19.00 - 20.00 Concert

20.30 Evening party

Thursday May 27, 1999

8.30 - 12.30 Section **PROPERTIES AND TESTING**
Chairmen: Milan Jirouš
Josef Kabelka

Influence of different components on mechanical properties and modelling of SMC
Wacker M., Ehrenstein G.W., Erlangen, FRG
Kabelka J., Praha, Czech Republic

Acoustic emission and mechanoluminiscence as a diagnostic mean for composites
Sodomka L., Liberec, Czech Republic

Thermal conductivity of five thermoplastic polymers (Experimental investigation of the influence of the wall thickness, mold temperature and distance from the injection gate)
Loufek J., Lenfeld P., Liberec, Czech Republic

Problems concerning thermal treatment of large press-molded parts
Lenfeld P., Loufek J., Sůra R., Liberec, Czech Republic

The influence of glass fibre on the mechanical properties of the polyamide 66
Ünal H., Findik F., Adapazari, Turkey
Arda T., Istanbul, Turkey
Alkan M., Bursa, Turkey

A study on the mechanical and microstructural properties of polymer matrix composites
Ünal H., Findik F., Sevinc V., Adapazari, Turkey
Alkan M., Bursa, Turkey

Comparison of methods for investigation of elastic constants of wound composite pipes, application of the resonance frequency method
Černý M., Turčič B., Růžička M., Praha, Czech Republic
Uher O., Sušice, Czech Republic

Modeling the creep modulus of unsaturated polyester with calcium carbonate fillers
Theriault R.P., Ehrenstein G.W., Erlangen, FRG
Kabelka J., Praha, Czech Republic

Experimental verification of the corrosion resistance of G/VE-composites at desulphurisation of power stations
Černý M., Praha, Czech Republic

13.00 Closing of the conference

ORGANIZATION HINTS

Place and date

Karlovy Vary, (Carlsbad), Hotel Thermal - Congress Hall, **May 25 - 27, 1999**

Conference office

will start its activity on Monday, May 24, 1999 at 15.00 in the library of the Hotel Thermal. Within following days the office will be open during the conference hours.
We ask you to contact the conference office after your arrival. You will receive further information incl. accommodation.

Conference languages

Czech, Slovak, English and German.
Simultaneous translation secured.

A STUDY ON THE MECHANICAL AND MICROSTURUCTURAL PROPERTIES OF POLYMER MATRIX COMPOSITES

Hüseyin ÜNAL[1], Fehim FINDIK[1], Tekin ARDA[2], Murat ALKAN[3], İrfan AY[4]

[1]Sakarya University, Technical Education Faculty, Ozanlar, Adapazarı/TURKEY
[2] ** Ülker Topkapı Makine Co., Topkapı, İstanbul/TURKEY
[3]Emaş Plastic Inc., Bursa/TURKEY
[4] Balıkesir University, Engiineering Faculty, Balıkesir/TURKEY

INTRODUCTION

In the recent years, especially with the growth of the plastics industry and developments in fibres, a vast range of combinations of materials is available for composites. It's often possible to manufacture superior thermoplastic material by combining two or more substances with complementary properties. Resin impregnated glass fibre the best known form is GRP (Glass reinforced polymer) in which glass fibres provide strength while the polymer reduces brittleness. Thermoplastic materials, especially engineering polymers which have high performance which have different specific properties are obtained with the glass fibre addition to the different thermoplastics. So, reinforced plastics are used a vast range of application areas such as aircraft, space, automotive and electric/electronic industries due to mechanical strength, dimensional stability, good resistance to heat and relatively low cost.

The importance of fiber filled thermoplastics have experienced a major growth in recent years. This is understandable because of the superior mechanical and thermal properties of the composites [1]. Short fiber reinforced thermoplastics are used in automobiles for high mechanical performance, weight reduction, corrosion resistance, design freedom and ease of fabrication [2-4]. Two of thermoplastics are nylon 6 and nylon 66. Various properties of glass fiber reinforced thermoplastics are strongly depend on mechanical and microstructural parameters such as fiber-matrix adhesion, fiber orientation in the polymeric matrix, degree of crystallinity, disrribution of fiber length and diameter, volume fraction of fibers.

Fiber-matrix adhesion is an essential controlling factor for mechanical properties of composites. The ability of the interface to transfer a load from the matrix to fibers depend on physicochemical properties of both fibers and matrix. Poor bonding at the interface results in interfacial debonding and failure of the composites. Improved interfacial bonding is attainable through fiber treatments such as chemical and physical procedures [5,6]. The usefulness of the interface properties can be viewed within two aspects; first, it is responsible for good mechanical properties, and second it protects the composite properties from deterioration when submitted to environmental conditions such as humidity. A weak interface allows fiber-matrix discontinuity by allowing the introduction of water between fiber and matrix through the interface, giving rise to a loss of expected composite mechanical properties. Fiber orientation and lenght distribution vary with special position within the molding and are strongly related to the processing conditions [2,7]. The mechanical performance of parts manufactured from short-fiber reinforced thermoplastics is strongly influenced by the length distribution of the fibers and volume fraction of fibers.

Recently, it has also been reported that the glass fibers, as well as the amount added, can increase the crystallization rate and consequently, affect the microstructure of the base polymers [3].

In this study, the deformation and mechanical properties of a glass-fiber reinforced nylon 6 was examinated by varying the content of glass fibers. The effects of glass fibers on mechanical, microstructural and morphological aspects have been presented. In this paper, the mechanical and microstructural behaviours of nylon 6 matrix composites will be adressed.

EXPERIMENTAL PROCEDURES

The materials studied were nylon 6 reinforced by chopped E-glass fibers. Both unreinforced resin and material reinforced with 10 %, 20% and 30 wt. %. of short glass fibers were investigated. The list of raw materials used in this study is presented in Table 1. Nylon 6 was purchased from DSM Co. In Holland in the form of granules. E-glass fibers were supplied by Glass Fibre Ltd. in Gebze-Turkey.

Table 1. Raw materials

Materials	Commercial description	Suppliers	Comments
Nylon 6	GL 1001	DSM	Neat polymer
Glass fibers	PA 1	Glass Fiber Ltd.	Chopped strand 3-4,5 mm, diameter (13 μm)
	PA 2	Glass Fiber Ltd.	Chopped strand 3-4,5 mm, diameter (10,5 μm)

The composites were made by dry blending of chopped E-glass fibers and were injection moulded. Prior to processing, The nylon 6 was dried in a vacum oven for 4 h at 80 °C. Four loading levels of glass fiber reinforcement, 0 %, 10 %, 20 %, and 30 % by weight of the matrix , were made to examine systematically the role of glass fibers. Injection moulding of the composite pellets was performed using an ERAT injection moulding machine. The processing parameters are used in this study are reperted in Table 2.

Table 2. Injection moulding variables for Nylon 6 and Composites

Material temperature (°C)		
	Nylon 6	Composites
Rear	240	255
Center	250	265
Front	260	280
Nozzle	270	280

The samples were moulded according to ASTM D638 specifications using a universal testing machine (ZWICK, Z020 model). The test speed was set at 10 mm/min.

Impact properties were measured using both an izod impact tester (ZWICK, 5113.300 model) according to the ASTM D 256 and a high rate impact tester. The latter test was made at room temperature with a testing probe speed of 3,46 mm/sec. and at least five samples were tested to obtain the avarage.

Hardness of the composites samples were measured using Shore D hardness methods. The experiments were performed at 23 °C and 50% humidity.

The morphology was observed using a scanning electron microscope (SEM, Camscan S4 model). The fractured surface of the broken tensile specimens was sputtered with gold before viewing.

RESULTS AND DISCUSSION

Many commercially important physical properties of fiber reinforced composites appear to depend on processing conditions. Such observation are often discussed in terms of fiber length and distribution, fiber orientation and fiber content [8].

Figure 1 and 2 show the variation of the tensile strength and flexural modulus of the fiber reinforced nylon 6 composites as a function of fiber content. As expected tensile strength and flexural modulus increase with increment of fiber content. The reason is that, glass fibers bear load and the matrix transfers the load to the fibers. The results are consistent with polymer [3,9,10,11] and metal matrix [12] composites. As observed, composite materials that include PA 1 type (13 μm diameter) glass fiber have lower tensile strength and flexural modulus than composites that include PA 2 type (10,5 μm diameter) glass fiber. The reason is reducing of the amount of silan on the fiber in the matrix. Therefore, tensile strength and flexural modulus decrease with reducing silan content on the fibers.

As can be seen in Figure 3, the addition of small amounts of glass fibers caused the materials to fail at a relatively low strain, and the failure was in the brittle pre-yield manner. The reason is the rigidity of the composite increases with the increase of the glass fiber increment, in spite of that the elongation capability of that composite decreases with the glass fiber increment. This is consistent with the general composite rule [13] and previous work [9,10] Figure 4 shows the notched izod impact strength and the total energy measured by a high rate impact tester as a function of the fiber content. Impact properties increases with the increase of the content of the glass fiber reinforcement in the composites. The work to failure and impact toughness increase with the increase of the glass fiber content. The possible reason is that the fibers in the specimen are oriented perpendicular to the breaking direction. These results are generally consistent with the previous work [3,9,10,11].

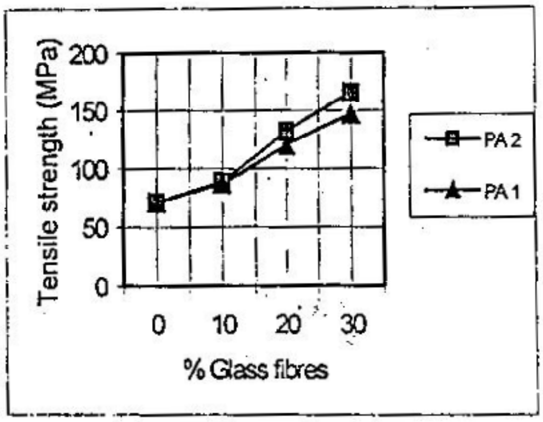

Figure 1. The relationship of tensile strength and glass fibre content

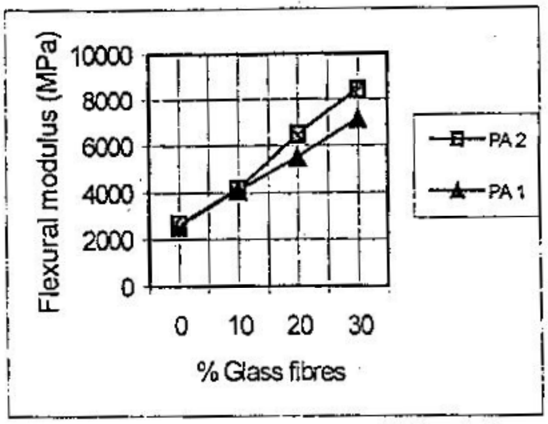

Figure 2. The relationship of Flexural modulus and glass fibre content

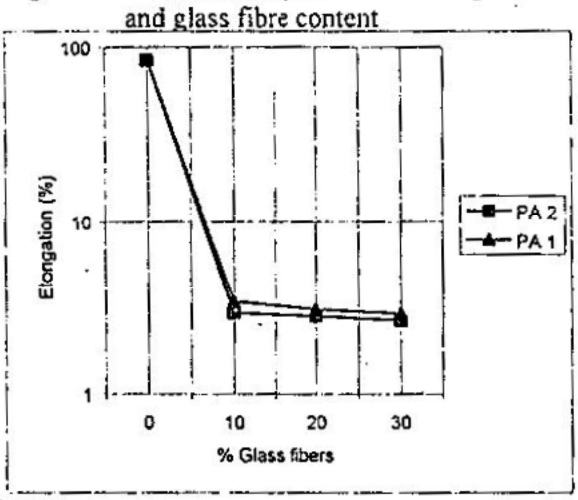

Figure 3. The relationship of elongation and glass fibre content

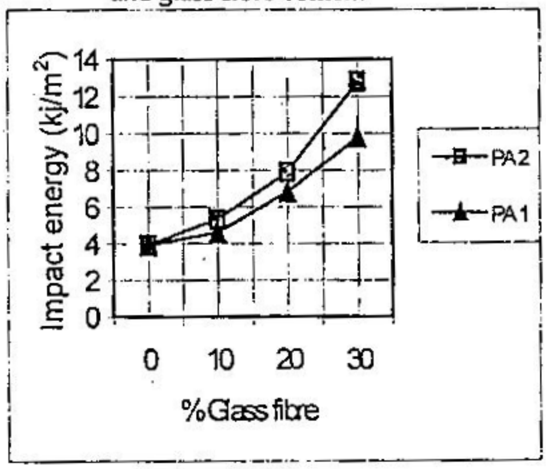

Figure 4. The relationship of Izod impact energy and glass fibre content

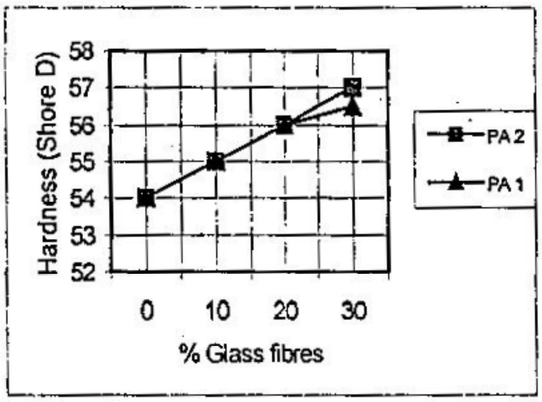

Figure 5. The relationship of hardness and glass fibre content

The obtained hardness measurements are shown on figure 5 as graph depending on glass fiber percent. It is shown in figure 5 that hardness gradually increases with the increase of the glass fiber percent. The results obtained from impact test are consistent with the previous work

The obtained hardness measurements are shown on figure 5 as graph depending on glass fiber percent. It is shown in figure 5 that hardness gradually increases with the increase of the glass fiber percent. The results obtained from impact test are consistent with the previous work [9,10] The hardness value of naylon 6 is within the range of 54-56,5 shore D. The reason of such indistinct hardness variation is that the matrix affects hardness more than the fiber does.

For the examination of the wetting between the fiber and matrix, SEM photographs were taken. Figure 6 (a) shows SEM fotographs taken for the cross section specimen. The distribution of fibers in the matrix is not uniform but the resin penetration into the fiber bundles is good. The fiber distribution as shown in Figure 6 (b). Figure 6 (c) and (d) show the SEM photographs of the specimen cross sections for the reinforced nylon 6 that includes PA 2 type glass fiber after the tensile test. The micrographs show many free fiber ends and even many holes, out of which the glass fibers have been pulled. Debonding of the interface and fiber pull-out seen to be a dissipation mechanism of the fracture energy in this composites. Fibers tend to be aligned parallel to the flow lines. During the flow in the narrow part of the die, most of the fibers changed their orientation to a direction close to parallel to the flow lines and kept their orientation through the divergent exit channel of the die, where the shear rate is expected to be very low compared with the entrance zone.

CONCLUSION

a) With the addition of glass fiber to polymer matrix, tensile, tield strenght and flexural modulus are continuously and quickly increased. As the more glass fiber, the more load is carried.
b) Tensile strength and flexural modulus of plastics that include PA 2 type glass fiber are higher than the plastic has PA 1 type glass fiber that bigger diameter.
c) With the addition of glass fiber (between 10 and 30%) to a polymer matrix, an increase in hardness is obtained.
d) The breaking work and izod impact strength are increased with addition of glass fiber to polymer matrix. Since the fibers in the specimens areoriented perpendicular to the impact direction.
e) Elongation is decreased with the increase of glass fibre due to rigit glass fibers.

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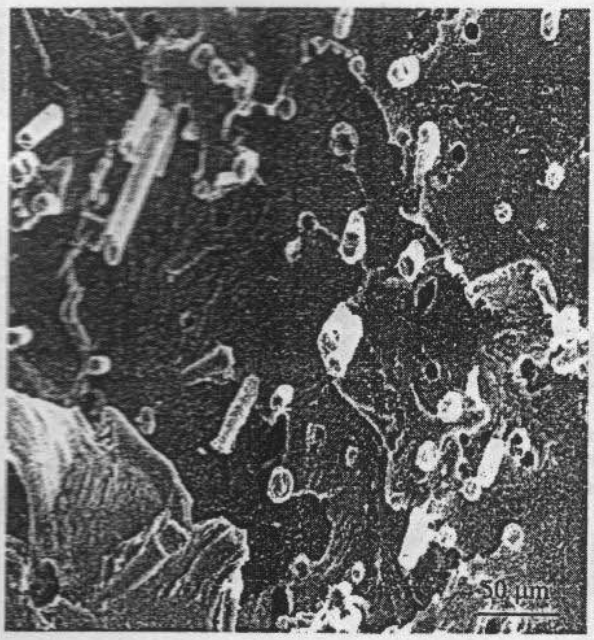
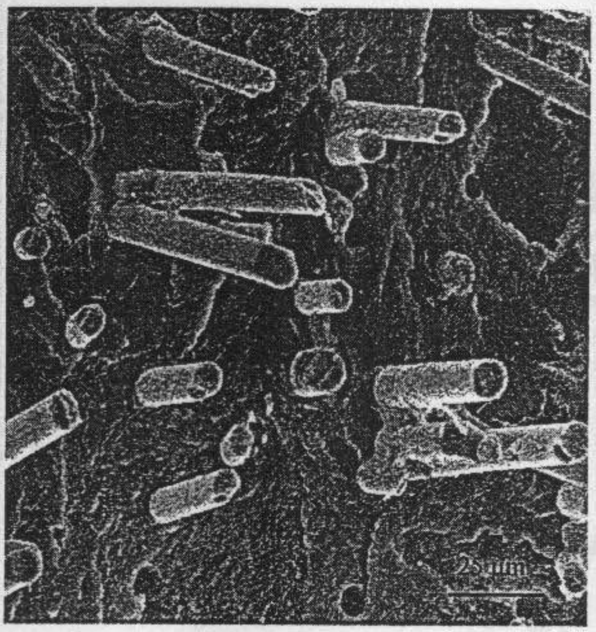
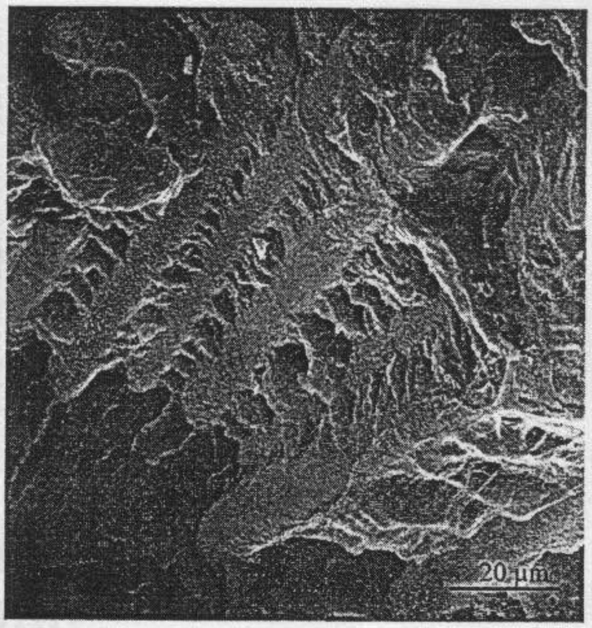


(a)

(b)



(c)



(d)

Figure 6. SEM photographs taken for the cross section glass fibre reinforced nylon 6 specimen (a) % 20 glass fibre (PA 2 type) reinforced nylon 6, (b)) % 20 glass fibre (PA 1 type) reinforced nylon 6, (c) % 20 glass fibre (PA 2 type) reinforced nylon 6, (d) % 30 glass fibre (PA 2 type) reinforced nylon 6.