STRUCTURAL CHANGES AND CRACKING RESISTANCE OF FOAMED THERMOPLASTICS SUBJECTED TO CHEMICALLY ACTIVE LIQUIDS

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New types of gas counter-pressure cast polymeric composite foamed thermoplastics designed for constructions have been investigated. Changes in their structures, mechanical behaviour and cracking resistance have been studied under the combined effects of mechnical strains, chemically active liquid media, composites, technological parameters and designed structural formation, in order to improve the service capabilities of the foamed thermoplastics products.

INTRODUCTION

Partially foamed thermoplastics [1-3] are particularly suitable for manufacturing machine parts and structures functioning in chemically active media. The structure of such modern and effective composite material with a foamed core and designed geometry is very complicated. From mechanical point of view certain limitations must be predicted during its investigation, using of a simplified model containing possibly more parameters of the realistic specimens.

EXPERIMENTS

Compositions have been studied based on: high density polyethylene (HDPE), polypropilene (PP), polyamide (PA)- pure and with glass filler (up to 30 mass %), HDPE with a dispersed filler in the granulate (kaolin-20 mass %).

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The following fillers have been used : dispersed graphite, acetylene black, vanadium or tungsten carbide, chalk, kaolin, glass fibre, and as a gas source - Ge - nitrogen AC-4 has been used. Test casting has been carried out by specialized TM 3200/250 and 10000/400 gas counter-pressure casting machines „Kuazy-800" automatic machine for thermoplastics. Specimens are shown in **Fig.1**. Test scheme, **Fig.2a** for disk specimens with simmetrical holes, allows uniform loading resulting in a biaxial uniform tension (bending) in their working sections. The homogeneity of the deformation zone is studied by means of a coordinate net, photolithographically applied on the specimens and strain gauges. Indications of these gauges, glued on the outer and inner sides of the surface, almost do not differ, which confirms the absence of strain gradient along the tested specimens section. Observations of the structure have been made by means of Reachert MEF optical microscope and JEM-7A electron microscope; the presence of residual stresses has been established by means of PMS-500 polariscope. Mechanical tests have been conducted on standard equipment in accordance with the valid national and international standards and techniques. The following chemically active media have been used: sulphuric and nitric acids of various concentrations, MD-10 type machine oil some solutions and for the purpose of comparison - distilled water.

ANALYSIS AND DISCUSSION

Fracture of polymeric products and structures and loss of serviceability may be caused both by accumulation of inadmissible high stresses in them and by initial „local" fracture of the thermoplastic matrix. The appearance of crack-like defects sharply accelerates the process of its fracture. It has been experimentally established that the concentration of submicro- and microcracks is higher in front of the propagating main crack and eventually polymeric molecular disruptions, cleavage in the phase formation interfacial zones may occur in the foamed structure composite specimens, tested in service. The opening of the crack tip or the length of the pre-fracturing zone may be assumed as an indirect proof of the material deformation in the pre-fracturing zone. Based on this, a number of mathematical models been made, taking into account the physical characteristics of the crack growth processes in polymeric specimens of conventional structure; **Fig. 2b** shows a structural model of a three-phase element

„thermoplastic matrix-filler-gas bubble" for the tested composite thermoplastics (foamed and filled). In accordance with the theory of macroscopic, homogeneous stress-strain state of a composite with a foamed structure and a disperse filler with in arrayed structure of versatile character, the particles, gas bubbles, have been here assumed to be spheres with a given radius, R, located at the sites of the presented lattice of the "triclinic syngony" type. The structure considered by means of this geometrical model is determined by six parameters: the three "a, b, c" spacings and three „α, β, γ„ angles. According to the model, crack growth begins when lattice array concentration in the pre-cracking zone reaches a certain value. A number of experiments have shown that chemically active media may lead to sharp worsening of the tested specimen service characteristics, other conditions being equal, where as their functional capabilities are preserved under normal „air" conditions.The ability of the polymetric specimens to intereact with chemically active liquids is most of all determined not by the length of their macromolecules but by the presence of active centers, leading to the breaking of chemical bonds (irreversible as compared to physically active media), both in the thermoplastic matrix and in the interphase regions as well as in the polymeric macromolecules themselves. It has also been established that composite structure significantly influences the destruction process kinetics. **Figure 3** shows two specimens : **a)** cast under gas counter-pressure, and **b)** cast without counter-pressure, all other technological casting parameters being equal. Higher degree of structural order, absence of internal stresses, high degree of smoothness of the inner wall surfaces, and the marked homogeneity of the composite inclusions of the counter-pressure cast specimens are to a great extent the reasons for the decrease of the destruction processes and of the nucleation intensity of microdefects during crack formation as compared to the convertionally cast specimens. Crack growth process is local and is almost completely determined by a set of phenomena occuring at the crack tip or immediately in front of it, **Fig.4a**. Test results show that under certain conditions a sharp intensifying occurs of the aggressive medium diffusion penetration into the regions in front of the crack tip. They also show material flow and a substantial looseness in front of the crack tip. This material looseness is by 30 to 40 % lower in the counter-pressure cast specimens (gas bubbles in the tested structure do not „communicate", they are isolated). The longer the looseness, the bigger the depth of developing destruction processes under the influence of aggressive media and the sooner the fracture will occur. This ensures the required life of polymeric structures and parts containing microcracks and functioning in contact with aggressive liquid media; it is necessary therefore, to assure the condition that the absolute size of the cleavage zone is minimum at the crack tip region **(Fig.4b)**. Besides, it is very rare case in practice when constant stresses continuosly act in the tested specimen or part. At the same time the rate of the relaxation processes in the specimen is considerably higher than the rate of the process zone fracturing due to aggressive media. It may be assumed that stress intensity factor at the longitudinal crack tip at the moment of final fracture of the process zone would have lower value than the allowable for the stress intensity factor.

CONCLUSIONS

1. The rising of surface "interphase" cracks in the foamed composites at the simoultaneous interaction of loading and chemicall aggresive media is due to inhomogenious destruction processes taking place in thermoplastics matrix structure.

2. The methods of linear fracture mechanics can be applied successfully in investigating the process of crack increase in thermoplastic foamed composties. For every type of thermoplastic matrix exists a certain critical value of the stress intensity factor, below which the rate of the cracks growth in the aggressive media is close to the rate of their growth in the solidified surface layer of the material (exceeding this critical value, the crack growth sharply accelerates).

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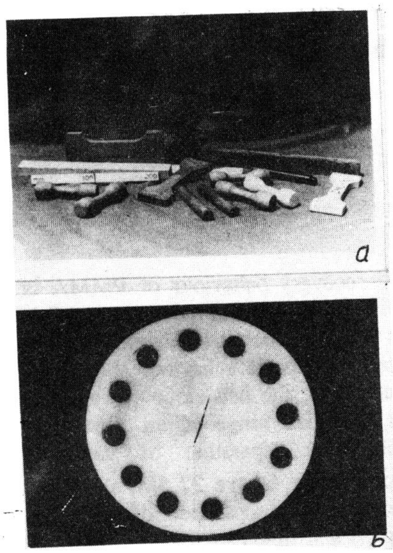

Fig. 1 a) Standard specimen
b) Disk-shaped specimen

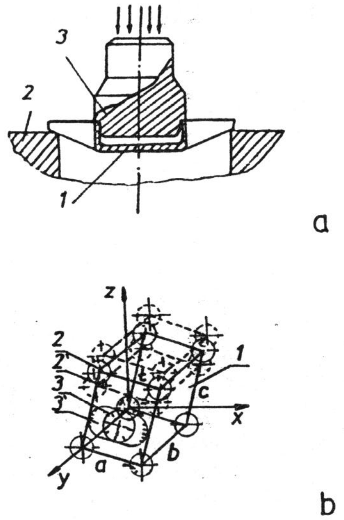

Fig. 2 a) Scheme of loading
b) Structure model

Fig.3 Specimen structure:
a)Counter-pressure cast (CPC)
b)without counter-pressure

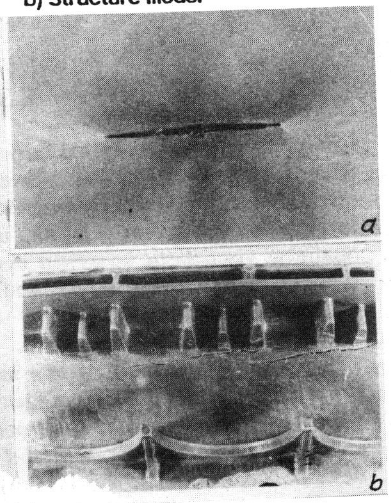

Fig.4 a)Crack tips with loosened zones
b) Absence of loosened zones
in CPC spesimen