CERAMIC-ELASTOMER COMPOSITES WITH PERCOLATION OF PHASES

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Abstract

This paper concerns ceramic-elastomer composites with percolation of ceramics and elastomer phases, which were obtained via infiltration's method. Segmented urea-urethane elastomer (PU2,5) was infiltrated as a reactive mixture of the substrates in the liquid form into pores of Al_2O_3 ceramic preform. In addition ammonium polyphosphate as a fire retardant and coupling agent were used. Microstructure of the porous Al_2O_3 ceramics was characterized using X-ray tomography. SEM observations of ceramic-elastomer composites were carried out. Porosity of ceramic and Al_2O_3 -PU2,5 composites was measured using Archimedes method.

1 Introduction

Recently, an increase of interest in a new class of composite materials, which has been termed as interpenetrating phase composites (IPCs) has been observed. Percolation of two phases results in a material with a better mechanical characteristics, due to the combination of two phases with significantly different properties such as strength and strain.
Ceramic-elastomer composites with percolation of ceramics and elastomer phases are new advanced materials which combine the ceramic hardness and stiffness with the rubber elasticity of the elastomer. Such composites exhibit high compressive strength together with the ability to achieve large deformation This combination of properties suggest, that such composites can be used as shock absorbers [1-5].

2 Materials and testing methods

Ceramic-polymer composites were obtained from segmented urea-urethane elastomer, which was infiltrated as a reactive mixture of the substrates in the liquid form into pores of Al_2O_3 ceramic material. The infiltration was carried out using the vacuum under temperature of 120ºC. The molar ratio of 4,4'-diphenylmethane diisocyanate (MDI) and ethylene oligoadipate (OAE) was equal to 2.5. The chemical composition of aluminum oxide was Al_2O_3 (99,8wt.%), CaO (0,02wt.%), SiO_2 (0,04wt.%), MgO (0,04wt.%), Fe_2O_3 (0,03wt.%), Na_2O (0,07wt.%). Ceramic performs were obtained by sintering using hot isostatic pressure. The open porosity of preform was approximately 40% and closed porosity was negligibly

low. The synthesis of urea-urethane elastomer was carried out in one stage with the addition of ammonium polyphosphate (trade name Exolit) as a fire retardant to ensure the elastomer higher thermal stability and resistance to fire. It was found that the elastomer with addition of ammonium polyphosphate exhibits higher compressive and tensile strength, together with good thermal resistance. In order to improve adhesion between ceramic and polymer, N-2-(aminoethyl)-3-aminopropyltrimethoxysilane coupling agent (U-15) was used.
Microstructure of the porous Al_2O_3 ceramics was characterized using X-ray tomography. SEM observations of ceramic-elastomer composites were carried out on sections and fracture surfaces. Open porosity of ceramic and composites was measured using Archimedes method. Bending tests of composites were also performed to estimate the influence of coupling agents on composite bending strength.

3 Results

The image of the porous Al_2O_3 ceramics preform obtained using X-ray tomography is shown in fig.1. Moreover, distribution of size of the pores was specified (fig. 2). The volume fraction of the ceramics phase is approximately 40 vol.%, the remaining area (60 vol.%) can be filled up with elastomer.

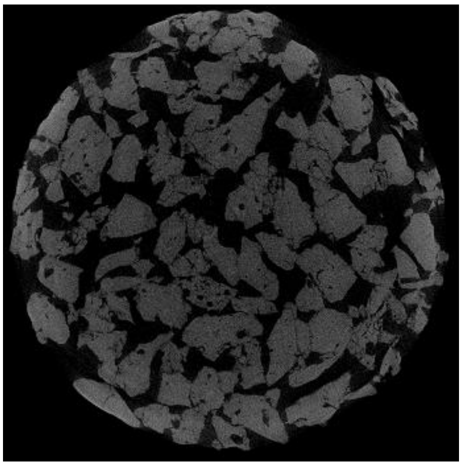

Figure 1. Tomography image of Al_2O_3 ceramic

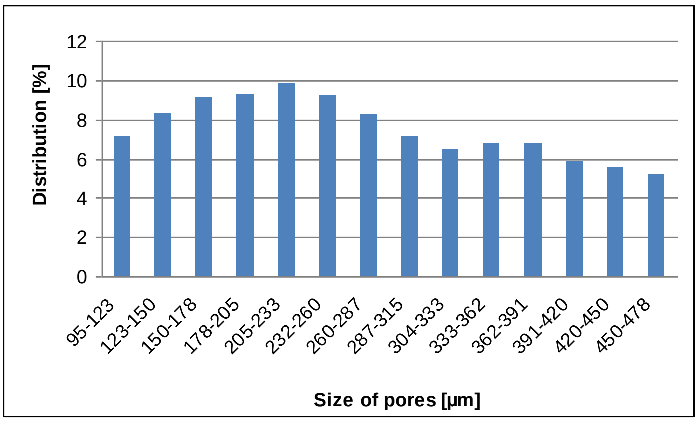

Figure 2. Distribution of size pores of Al_2O_3 ceramic

SEM investigations revealed that pores are fully filled by elastomer. The infiltration of ceramic porous preform by elastomer with ammonium polyphosphate, as well as application of silane coupling agent (U-15) ensure a good adhesion of phases (fig.3).

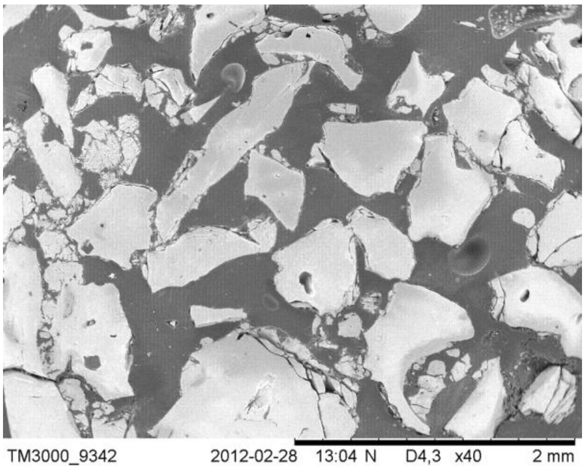

Figure 3. Microstructure of Al_2O_3/PU2.5 composites

In figure 4 open porosity of ceramics perform and ceramic- elastomer composites are shown. Application of U-15 coupling agent leads to decrease of open porosity and to increase of degree of infiltration the ceramic pores by elastomer.

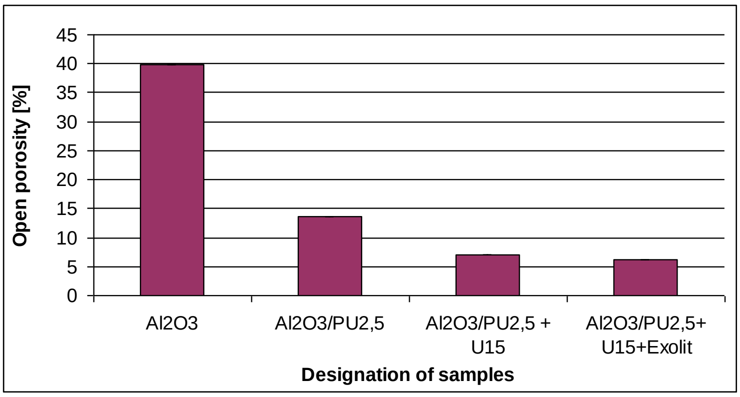

Figure 4. Open porosity of ceramic and Al_2O_3/PU2.5 composites

Bending tests of composites were also performed to estimate the influence of coupling agents on composite bending strength. The results of the studies proved that application of U-15 leads to the increase of bending strength of composites (fig. 5).

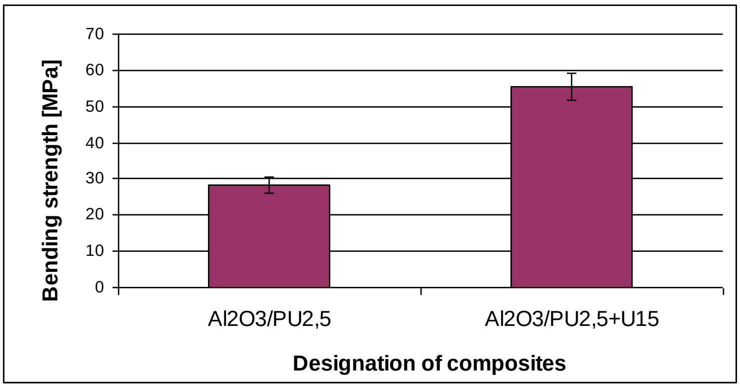

Figure 5. Bending strength of Al_2O_3/PU2.5 composites

4 Conclusion

SEM observations of the microstructure of the composite's materials indicated that the porous ceramic preform was successfully infiltrated by elastomer. Significant difference in the microstructure were found between the composites with and without the coupling agent. Open porosity decreased from 14% to 6% together with the addition of U-15 coupling agent. Moreover, the composites with coupling agents show a higher bending strength.
The obtained results show that the infiltration method is the useful method for fabrication of composites with percolation of the microstructure, which exhibits higher strength and sustain large deformation.

Acknowledgements

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