STRAIN ANALYSIS OF UNSATURATED POLYESTER RESIN USING DIGITAL IMAGE CORRELATION METHOD

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Abstract: Unsaturated polyester resin (UPe) was synthesized from maleic anhydride and product of glycolysis, obtained by polyethylene terephthalate depolymerization with 1,2-propylene glycol in the presence of etrabutyltitanate catalyst. The curing of UPe was performed using system of methyl ethyl ketone peroxide - MEKP (1 wt%) as the initiator and cobalt octoate - Co-oct (0.5 wt%) as the accelerator. The obtained glycolysis product and UPe were characterized by acid, hydroxyl, and iodine values and by FTIR and NMR analysis. During UPe polymerization, dimensional changes occur as effect of shortening of intermolecular distances of monomers in forming of crosslinked structure. 3D optical method for displacement and strain measurement using stereo cameras tracked the position of markers in 3D coordinate system. Changes in the position of markers were used to calculate the deformation of the measured object. The possibilities to experimentally measure polymerization shrinkage of UPesbased on the recycled PET using 3D optical method were presented in this paper.

*Keywords:*PET recycling, polyester resin, 3D optical system, strain displacement analysis

1. Introduction

Poly(ethylene terephthalate) (PET) is a semi-crystalline, thermoplastic polyester which possessesexcellent thermal and mechanical properties. By virtue of its performance, PET is one of the versatile engineering plastics applied to the bottles for packaging and films manufacture, [1]. The consequence of using PET based materials is formation of large amount of non-biodegradable waste. Recycling methods of polymers, classified as primary, secondary, tertiary and quaternary recycling are very important for reduction of pollution, [2]. The products of tertiary PET recycling, glycolytic PET depolymerization products, can be used as raw materials for production of new ones, such as oligomers, unsaturated polyester (UPe) and vinyl ester resins and alkyd resins [3].UPes are one of the most widely used thermosetting resins for the fabrication of glass-reinforced plastics and polymeric composites, [3]. Due to their wide application as reinforced plastic laminates, electrical components and pipes; the UPe market has huge economic potential.

2. 3D optical non-contact method for strain and displacement analysis

3D optical analysis for displacement and strain measurement has been widely used in the measurement of mechanical properties of materials and structures. The measuring system (GOM, Braunschweig, Germany) consists of two cameras, PC System, camera stand, trigger box and software for strain calculation - Aramis. Before the start of the measurement it is necessary to calibrate the measuring system. Calibration ensures dimensional consistency of the system, which is carried out using a calibration panel. Dimension of measurement object or region of interest defines dimension of measuring volume.On the surface of the calibration panel are 100 points in a predefined order. The calibration panel is photographed in 12 positions, so that for

the each position, left and right camera recognizes spatial position of the points. After completion of all 12-step system calculates calibration deviation and if the resulting value is less than 0.04 pixels, the calibration was successful and the system is ready to measure. Preparation of measuring surface consists of spraying a white backgroundfirst, and then finely dispersed black markers. During the loading, system recognizes change of thepositions of black markers and calculates deformation.

In this paper, UPe is inserted into a cylindrical mold, in order to measure the strain field after polymerization. Figure 1 shows the experimental setup for determining the dimensional changes of UPe resin.

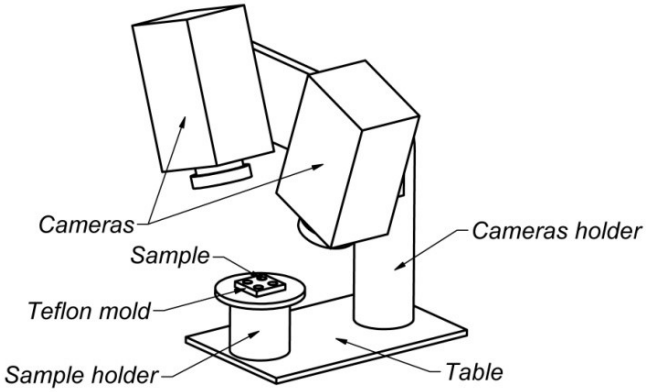

Figure 1 - Experimental setup

Determination of the polymerization shrinkage of polymer composites using 3D optical method was analyzed using sections in various local areas, [4].In the mentioned papers, it was not possible to measure more samples at the same time, as the polymerization was carried out by using LED lamps, and in this paper the experimental setup allowed measurement of several samples at the same time, as the chemical polymerization was performed without light initiation. As the planned time for polymerization shrinkage of UPe resin is 20 min per sample, for a large number of samples such an approach would greatly shorten the time required for measurement.

3. Conclusions

In this paper, the possibilities for application of non-contact 3D optical method to measure the deformation of UPe resin during polymerization. The mode of operation, from calibration to the sample preparation and measurement was also described. The experimental setup, with the system and materials,which can be used to simultaneously measure strain on multiple samples during polymerizationwas also presented.

References

[1] Karayannidis G. P., Achilias D. S. Chemical recycling of poly(ethylene terephthalate). Macromolecular Materials and Engineering 2007:292:128–146.

[2] Mendes L. C., Dias M. L., Rodrigues T. C. Chemical recycling of PET waste with multifunctional pentaerythrytol in the melt state. Journal of Polymers and the Environment 2011:19:254–262.

[3] Rusmirovic J. D., Radoman T., Dzunuzovic E. S., Dzunuzovic J. V., Markovski J., Spasojevic P., Marinkovic A. D. Effect of the modified silica nanofiller on the mechanical properties of unsaturated polyester resins based on recycled polyethylene terephthalate. Polymer Composites 2015:in press.

[4] Manojlovic D. Dramićanin D.M. Milosevic M. Zeković I. Cvijović-Alagić I. Mitrovic N. Miletic V. Effects of a low-shrinkage methacrylate monomer and monoacylphosphine oxide photoinitiator on curing efficiency and mechanical properties of experimental resin-based composites. Materials Science and Engineering: C. 2016; 58(1); 487-494.