Rheological and mechanical properties of epoxy resins during cross-linking at various temperatures

D. Zupančič Valant[1], A. Oseli[1], Lidija Slemenik Perše[1]

[1] Faculty of Mechanical Engineering, University of Ljubljana, Aškerčeva 6, Slovenia
(lidija.slemenik.perse@fs.uni-lj.si)

Epoxy resins are commonly used as polymeric matrices in high-performance composites due to their low shrinkage, excellent mechanical properties, high adhesive strength, and adjustable functional structure. They are widely used for the production of composites that require high strength and excellent performance such as wind blades and composites for aerospace engineering. However, due to the nature of polymer crosslinking, the composite industry is time-consuming and therefore, often also uneconomical. In order to achieve the best performance, the material properties and the production process of these composites should be optimal. A crucial factor that contributes to composite efficacy is the process of curing, which depends on the selection of curing agents and processing conditions.

In the present work, the process of curing was studied with commercially available epoxy resin. Three, also commercially available, curing agents were used for crosslinking process, which was performed at three temperatures, i.e., below Tg, around Tg and above Tg. The influence of process temperature on the crosslinking time and material properties of epoxy resin during the process of curing was studied by differential dynamic calorimetry and rheological analysis. Comprehensive insight into the behavior of epoxy resin samples, crosslinked at different crosslinking temperatures, was obtained by dynamic mechanical analysis. The values of elastic and viscous contribution to viscoelastic behavior of solid samples were obtained by using three point bending tests. In this way, the effect of elevated temperature on crosslinking time was analyzed. Moreover, the results gave the insight into the crosslinking process resulting in understanding of how the accelerated crosslinking affects the material and mechanical properties of the crosslinked products.

The results showed that increased crosslinking temperature increases the glass transition temperatures, while the values of the viscoelastic moduli decrease. Rheological analysis enabled the determination of the shortest times at which the sample materials were cross-linked enough, to successfully remove them from the mold. Based on the findings, the production parameters can be optimized resulting in increasing processability and economy of the production of composite products.