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Analysis of Two-Stage Curing Reaction of Epoxy Resin Used for Electrical Insulators

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Epoxy has been used widely in electronic devices because of its excellent electrical properties for insulators. In epoxy resin curing reaction process, phenomena such as heat of reaction, reaction progress (degree of cure, physical properties, etc.), cure shrinkage and viscoelastic behavior, are related intricately.
It is known that there are serious problems of the delamination at the metal- epoxy resin interface and the crack failure in epoxy resin due to cure shrinkage when epoxy resin is used as encapsulating medium of insulators in electrical and electronic equipments. It is very difficult to make experimentally clear the mechanism of delamination and crack failure occurring in electrical and electronic equipments during curing reaction. Though several papers have been reported on the attempts to predict the stress-strain behavior during curing reaction, their simulation model are proposed under the conditions without cure shrinkage, heat of reaction, reaction progress, delamination or crack failure. Therefore, previous works cannot be always applied to the practical production process. In order to solve these problems, the authors have proposed a new simulation model which can applies to the curing process from potting (liquid state) to gelling (solid state) under a constant curing temperature. In this work, the authors have attempted the simulation with a finite element method for two-stage cure reaction as follows:
Epoxy resin was potted between the inner and outer iron cylinders. The potted epoxy resin was cured under a given temperature before gelling and under a higher temperature during gelling (two-stage cure reaction). In order to express the two-stage cure reaction, the equation of cure reaction was corrected and the temperature dependence of viscoelastic properties were obtained from dynamic viscoelastic analysis. The circumferential strain curves on the surface of outer iron cylinder predicted by the simulation is in good agreement with the experimental results.