TA Instruments

Thermal Analysis & Rheology

RHEOLOGY SOLUTIONS

CHARACTERIZATION OF SHEET MOLDING COMPOUND (SMC)

PROBLEM

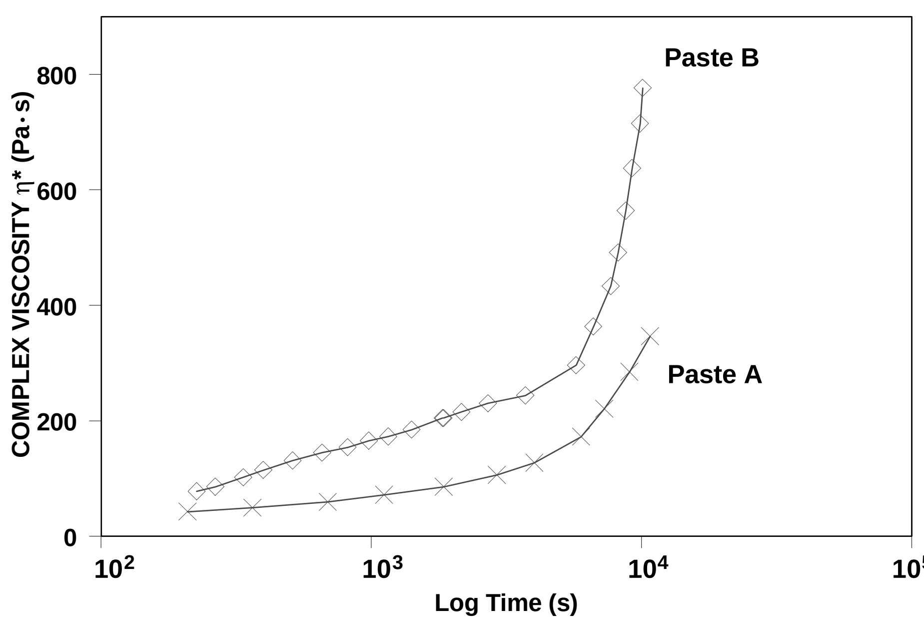
Sheet Molding Compound (SMC) is a complex composite material which is used in the automotive, aerospace, electronics, defense, energy, recreational, and home-related industries. SMC paste usually contains unsaturated polyester resin, thermoplastic resin, styrene monomer, initiator, catalyst, thickener (earth oxide or earth hydroxide), filler and a mold release agent. This resin paste is combined with fiber reinforcement via a continuous line process to form a “prepreg” which is stored between thin plastic sheets at low temperature for later use in molding finished parts. During molding, the cure of the paste is advanced to produce the final rigid product.

Manufacturers of SMC materials are interested in tests which can determine the materials’ handling properties throughout this process.

SOLUTION

Controlled stress rheology which measures the flow properties of materials can be used to characterize the resin pastes used in SMC materials. Specifically, oscillatory tests which enable material structure to be evaluated, non-destructively, are ideal for SMC evaluation. Figure 1, for example, shows the increase in viscosity with time at 32°C (storage temperature) for two different SMC pastes after initial mixing. Thickeners are added to the resin paste to increase its viscosity during preparation and storage prior to molding. Hence, the viscosity of the paste increases over time as the “thickening” reaction occurs. Lower viscosity is preferred initially so that the paste can properly “wet out” the reinforcement fibers. Subsequent handling is improved, on the other hand, by gradually increasing viscosity. Too much viscosity increase is not desired. The

Figure 1. THICKENING OF SHEET MOLDING COMPOUNDS



results in Figure 1 show that the viscosity for Paste B increases more dramatically than Paste A. In subsequent production, Paste A performed better (i.e., handled more easily).

During molding, there are several specific characteristics of interest including the minimum viscosity, gel temperature and gel time. Figures 2 and 3 illustrate the viscosity versus time and temperature results respectively for a paste heated at 4°C/minute and 40°C/minute. From these curves it is possible to compare the minimum viscosity, gel temperature and time achieved under these two different processing situations. The results are summarized below:

Heating Rate	Gel Time	Gel Temperature	Minimum Viscosity
4°C/minute	1800 sec	145°C	200 Pa·s
40°C/minute	250 sec	190°C	50 Pa·s

Results such as these enable the manufacturer to optimize processing conditions for a specific paste.

Although the handling and processing properties of SMC materials are largely based on the characteristics of the resin paste (since by weight most SMC compounds are 75% paste and 25% glass fiber), there are situations where evaluation of the complete "prepreg" (paste and reinforcement) is desirable. This cannot be accomplished with a rheometer, but can be done with a related thermal analysis technique - dynamic mechanical analysis (DMA). See TA Instruments publication H-09192.

Figure 2. CURING OF SHEET MOLDING COMPOUNDS

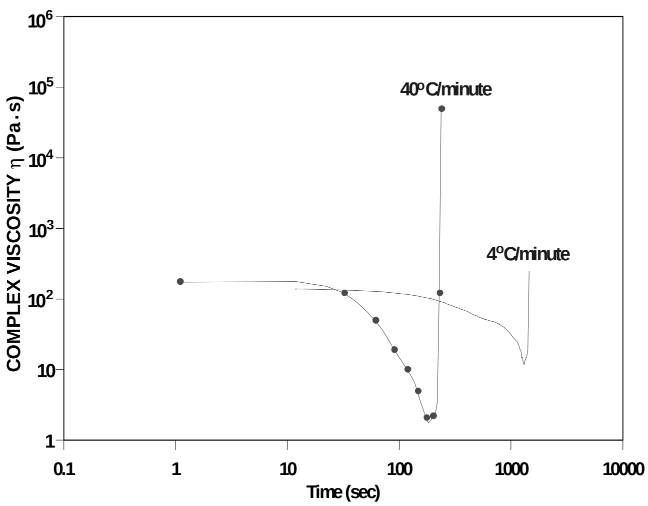
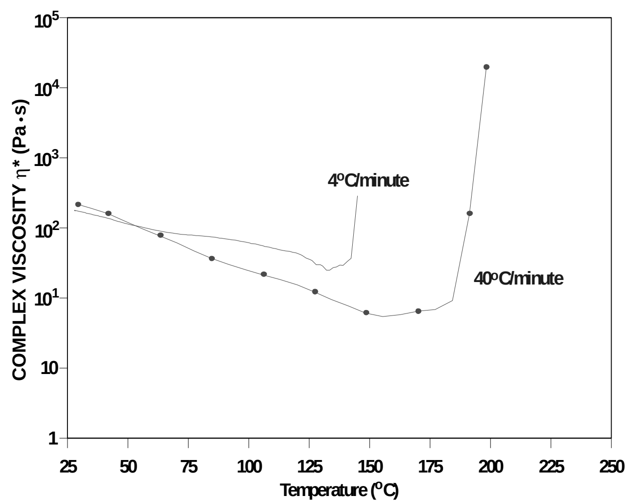


Figure 3. CURING OF SHEET MOLDING COMPOUNDS



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