Feature Project

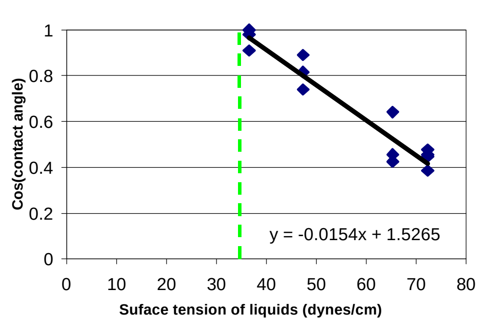
Fiber Wetting in SMC Formation and Molding

by Shoujie Li (Lee)

Defects such as surface porosity and blisters in SMC parts are still a major problem in the SMC industry. A great deal of effort has been applied to minimize these defects using vacuum bag molding and in-mold coating. However, little attention has been given to fiber wetting behavior and void formation in the SMC sheet formation process. In this study, we characterize the wettability of fiber bundles and high viscosity resin pastes. The fiber wetting process in the SMC sheet-forming machine is also investigated. The goal is to better understand the dry fiber problem in SMC formation and to minimize surface porosity and blisters in molded SMC parts.

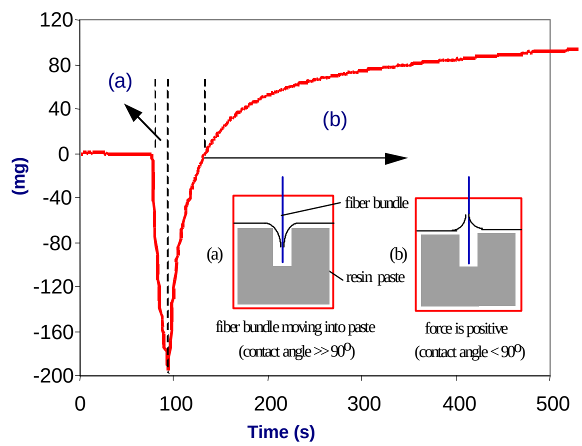
Wettability of a solid surface by a liquid is often characterized by the contact angle. The Zisman method is followed in this study, in which the critical surface tension serves as a measure of wettability for fiber bundles. The contact angle between fiber bundles and liquids is measured using several low viscosity liquids with different surface tensions. The critical surface tension, denoted by σ_c, is defined as the intercept of the horizontal line of cosine value = 1 and the extrapolated straight line plot of cosine value vs. surface tensions of liquids. When the surface tension of a liquid is less than the critical surface tension, the liquid spreads spontaneously across the solid surface. The larger the critical surface tension of the fiber bundle, the easier it is for the fiber bundle to be wetted by the resin paste. A typical Zisman plot is shown in Figure 1. In this case the critical surface tension is 35 dyne/cm (roughly the same as that of a pure polyester resin), showing that this fiber bundle can be easily wetted by a pure resin.

Fig. 1. Critical surface tension of fiber bundles (OCF 433)



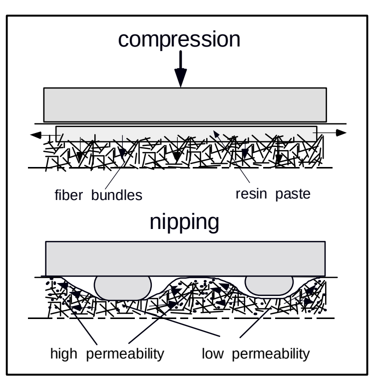
Although fiber bundles are wettable by unsaturated polyester resins, the actual wetting process depends on the time-dependent wetting rate. Figure 2 gives a schematic of the wetting process. As a fiber bundle is immersed into the resin paste, the contact angle is larger than 90^0. The contact angle gradually decreases when the fiber bundle stops moving. Using a Dynamic Contact Angle Analyzer, the wetting curve of high viscosity resin pastes can be measured as seen in Fig. 2.

Fig. 2. Force vs. time for paste with 0.5 pbw MgO (after mixing)



In the SMC machine, fiber bundles are sandwiched by the resin paste as they pass through the compaction zone. The resin paste impregnates the fiber bundles under compression and nipping motions as shown in Figure 3. The purpose of these motions is to force the viscous resin paste into the center of the fiber stack to wet the fiber bundles and maintain a constant fiber/resin ratio throughout the SMC sheet. However, the compression motion tends to force the resin paste to flow more toward the edge of the sheet than into the fiber stack, leading to a non-uniform distribution of resin/fiber ratio. While the nipping motion forces the resin paste to flow locally, it can result in localized resin-rich and fiber-rich areas. Consequently, the production of high quality SMC sheets requires careful design of the compaction zone.

Fig. 3. Resin paste impregnation under compression and nipping



SMC Compression Molding and In-Mold Coating Simulation and Processing Studies

by Lisa Abrams and Xu Chen (Castro)

A method has been developed to predict molding forces for simple parts. The approach was tested experimentally at Omnova Technical Center. A set of charts was developed to predict the steady state cure time for SMC Compression Molding of automotive and truck parts. The model developed for IMC of thermoplastic substrates for simple parts is being extended to more complex parts.