CHAPTER IV

CONCLUSIONS AND RECOMMENDATION

Developments in SMC confirm that a system can be used successfully for studying many parameters in compounding. However, there are three components which may affect mechanical properties; these are: polyester resin, glass fiber reinforcement and $CaCO_3$ filler. It is essentially in selection of optimum combination of each these effective components for specific applications and for technical service.

The strength of SMC has essentially been incorporated by the fiber reinforcement. The fiber structures in SMC system are randomly arranged as glass fiber bundles with a fiber length of 25 to 50 mm (29). Glass fiber content has the greatest influence on SMC in that, it is directly proportional to mechanical strength of SMC. In this system, the chopped strand mat of glass fiber aligned in a random manner within the resin, the SMC product exhibits relatively uniform mechanical strength in all directions (approaching isotropic characteristics) rather than a strength concentration in one or two directions.

Mechanical properties are greatly influenced by the amount of reinforcement. The glass fiber contributes the high strength and modulus to the SMC which provides resistance to breakage and flexure under applied load. The main roles of the resin are to transmit and distribute stress among the individual fibers, and to maintain the form and separation of fiber. The resin also provides protection against both fiber abrasion and fiber exposure to environmental conditions, and holds the fibers in resisting to failure or deformation under load (31).

However, the mechanical properties of SMC, from the results obtained, generally increased with glass fiber and filler contents. Treated $CaCO_3$ filler with fatty acid, can homogeneously disperse in the resin mix, and provides better resistance to craze and cracking after molding. It provides resistance at higher impact loading and increases the tensile and flexural strength. Since the main function of glass fiber is to provide superior mechanical properties to the resin; in addition, the filler also provides the auxiliary properties to improve the flow during molding, dimensional stability and enhances a magnitude in mechanical properties.

The fiber-resin interface which is the critical factor that determines, to a certain extent, the desired properties of the SMC will be achieved and maintained during use. The interface must have appropriate chemical and physical features to provide the necessary load transfer from the resin to the glass fiber. The use of a coupling agent can provide improved interfacial conditions, i.e. better wettability and adhesion. The fracture surface of the specimen obtained by the scanning electron microscopic technique showed good bonding at the fiber-matrix resin interface. Thus, this bonding enhances the mechanical properties. A significant increase in tensile and flexural strengths, and moduli was achieved in the case of increased glass fiber content.

The adhesion between the resin-filler matrix and fiber influences several mechanical properties. Interlaminar strength has been accepted as an indication of the fiber-matrix bond strength. The strain or elongation to failure of the matrix is a measure of the toughness and ductility of SMC. The results of the experiments showed that the SMC samples were the brittle material at high strength with low strain or elongation.

Due to the fact that several ingredients are involved in the formulation of SMC, it is virtually impossible for one to investigate completely the role of each ingredient and their interactions. The rheological properties of the molding compound play an important role in determining the processing conditions, which in turn affect the end-use properties of the SMC.

The technical breakthrough has been the development of thickening systems which permits a reasonably long storage life of the product. The desired thickening system exhibits viscous characteristics that provides good flow of both the glass reinforcement, resin and $CaCO_3$ filler as a homogeneous material into all parts of the mold. In addition, both the thickener and the presence of the filler content can affect viscosity rather than the addition of the thickener alone. Too high a filler content results in high mixture viscosity which is critical to the working condition of molding compounds. Impregnation techniques, a critical stage, is reached at this point because the resin mix has started to thicken and completed fiber wet-out at which impregnation must be finished before the thickening end point is reached.

Information on the rheological properties of the resin mix and molding compound would be helpful in establishing the "moldability" of the SMC product. In practice, too high a viscosity will result in incomplete filling of the mold cavity, thus upsetting the balance between the speeds of the flow and and curing processes.

Many of the formulations of SMC are proprietary to the research and development but the general outlines of the developments can be followed to study further. The complete details on the production of SMC system are beyond the scope of this thesis. It is difficult to select the best formulation : due to the limited chemicals available locally, processing machines and supporting apparatus. Many considerations are involved in the *science and art* of formulating and fabricating the SMC product which are quite time consuming.

Future trends to new developments ;

The use of fibers as reinforcement can bring about superior materials, the choice of the fiber reinforcement will depend entirely on the requirements of the desired properties of end products. At the present time, the highest volume in fiber reinforcements is glass fiber, however in the near future, the trends will probably be the increasing use of other competitive materials, such as carbon-graphite fibers. As industrial competition becomes more severe, and end use application demands better performance and lower cost, it is thus appropriate to persuade-in depth details of this technology.

Nevertheless, work is underway to develop SMCs, using resin matrices that will maintain properties for extended periods of time at temperatures above 200°C. So far, it has not been possible to develop structural SMCs using fibers other than glass and carbon fibers. The SMCs with a high-level aramid fiber would be very interesting. The SMC manufacturing process currently requires the fiber to be chopped integrally with sheet formation. A practical way to do this with aramid fibers has not as yet been disclosed (32). High performance polyolefin fibers might be another type of candidate, but their properties are degraded during exposure to the typical 150°C molding temperatures. Some of the newer high-temperature thermoplastic fibers may become useful for reinforcing SMCs. In addition, the recent technology in reinforced plastics is Glass mat thermoplastic (GMT), it is a new choice for the research and development today.