CHAPTER V

CONCLUSIONS AND SUGGESTION

5.1 Conclusions

One of the main requirements for high volume manufacture is a short cycle time, but this cannot be achieved at the cost of reduced part quality or reduced material properties (29).

In order to eject the part from the mold, it is necessary that an adequate elastic modulus has been attained. The conversion of the material near the walls is more relevant for its greater efficiency that every point of the slab has reached a certain result, i.e., it is required that every point of the slab has reached a certain critical conversion, then a higher viscosity than the value at the gel point is obvious (28).

The gelation of curing of unsaturated polyester resins is experimentally correlated with the curing conditions such as curing temperature, catalyst concentration, and inhibitor concentration. In theory, the curing process of styrene-unsaturated polyester resins before gelation is expressed by four stages: induction, microgel formation, transition, and macrogelation, based on the microgel formation mechanism (13).

Molding trials with the SMC using different types and concentrations of the catalysts produced contradictory results when comparisons are made through the results from flexural test performed under the 1 and 2 minutes of curing time. The present 1 minute of curing time does not produce high mechanical strength material from the SMC at the cycle time used. The experiments indicated that it is possible to reduce the curing time of the SMC by adding the parabenzoquinone (PBQ) inhibitor in the composition of the SMC. This indicates that the PBQ inhibitor is required to enable a complete cure to occur in such a range of short cycle times.

Conclusion can be drawn on the effect of 3 types of catalysts: t-butyl perbenzoate (TBPB), 1,1-di-(t-butyl peroxy) cyclohexane (DTBC) and dual systems, and benzoyl peroxide (BPO) on the different conditions for the SMC as follows:

5.1.1 Effect of t-Butyl Perbenzoate (TBPB)

According to the experiments, the TBPB catalyst was found to be an appropriate catalyst for SMCs because of the following benefits:

1. The maximum shelf life of the SMC was about 45 days. The appropriate storage time before processing the SMC in the mold should be within 17-30 days.

2. The appropriate concentration of the TBPB catalyst was about 2 phr, since the viscosity of the paste containing this concentration was not too high. Thus, it was convenient and easy to impregnation the paste on glass fiber.

3. The SMC could be processed in the complicate mold because gel time of the TBPB catalyst was long enough for the material to flow to every part of the mold before completion of the curing or crosslink reaction to occur.

4. The mechanical properties of the SMC with a 1 minute curing time could be increased by a selective addition of PBQ inhibitor in the concentration range of 0.025-0.05 phr. This was resulted from the inherent property of the PBQ inhibitor, the induction period, to retard/inhibit the curing reaction before the material could fill completely in the mold.

5.1.2 Effect of 1,1-di-(t-Butyl Peroxy) Cyclohexane (DTBC)

The DTBC was also an appropriate catalyst for preparing the SMC, although the obtained paste had somewhat higher viscosity than the TBPB catalyst. The results show the significant effect of DTBC catalyst on mechanical properties of the SMC, the suitable condition for the fabrication of the SMC by using the DTBC catalyst were as follows:

1. The curing time of the SMC depended significantly on the concentration of the catalysts. The suitable concentration of the DTBC catalyst providing the highest mechanical properties to the SMC was about 1 phr.

2. The shelf life of the SMC for better mechanical strength should be about 17 days although it could be kept as long as 30 days.

3. The suitable curing time should be about 1-2 minutes.

4. The dual catalysts system of the DTBC catalyst in conjunction with the TBPB catalyst provided a faster cure than did the TBPB catalyst alone.

5.1.3 Effect of Benzoyl Peroxide (BPO)

Although the BPO catalyst in the SMC gives benefits to the SMC processing as to reduce the energy, since it facilitates the radical formation at lower temperatures than do the TBPB and DTBC catalysts. However, the BPO catalyst also imposes some disadvantages as follows:

1. The storage time of the SMC was relatively shorter than the TBPB or DTBC catalyst, its shelf life was about 10 days.

2. The viscosity of the paste was very high although the concentration of the BPO catalyst was less than 1 phr. The mechanical properties of the material obtained were low, due to that the high viscosity of the paste normally caused the wet-in or wet-through between resin and glass fiber resulting in poor impregnation and consequently poor interfacial adhesion.

3. The fast gel time caused the material on the surface of the SMC to be cured faster than that in the middle. The exothermic heat from this curing reaction could not be transferred or dissipated easily and the surface was then scorched.

5.2 Suggestion

5.2.1 Maturation or Post Cure

The mechanical properties of the SMC can be enhanced through a maturation or post cure. When a short storage time of SMC is needed, one can basically use the maturation technique to speed up the thickening behavior in order that the corresponding mechanical strength can be achieved.

Accurate methods to detect the end of cure would be very beneficial and would permit opening the mold as soon as the material has cured, avoiding unnecessary waste of time. From the relation between the curing time and mechanical properties of the SMC, the material with 1 minute of curing time had low mechanical strength. The reason for this might be the incomplete cure at the middle of the SMC. To overcome the difficulty, a post cure procedure is normally used. After the normal curing reaction, the SMC is subject to a 60-70°C oven for a few minutes. In some cases, the material is passed into the heating zone along the conveyor after the curing reaction.

5.2.2 Replacement of the Thermoplastics Cover Sheet

In this research, polyethylene (PE) film was used as the cover sheet for the SMC. Since PE is air permeable, styrene monomer as part of the formulation can evaporate and permeates through the pores of PE cover sheet during storage. The loss of styrene monomer which is a comonomer leads to low mechanical strength of the material when the SMC is kept for a long time. A plastic cover sheet with low or non-permeability such as a polyester sheet, or MYLAR can be used instead. This type of plastic sheet will lessen or even prevent the loss of volatile chemicals including styrene. By such a prevention, a higher mechanical strength material can be achieved easily.

5.2.3 Further Research Work

Since wetting between the interface of polymer matrix and glass fiber promotes better interfacial bondings leading to the better interfacial adhesion and greater mechanical strength, the technique to increase the above-mentioned properties should include an appropriate formulation and effective dispersion and adhesion through chemical and physical modification. Besides the induced better interfacial adhesion, a good dispersed system generally accelerates the gel time. Color appearance of the finished product is an important point of attraction. Research in additives controlling the color consistency and aesthete should be pursued.