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DEGRADATION OF SMC MOLDING IN HOT WATER: EFFECT OF IMPREGNATION ON MECHANICAL PROPERTIES WITH SPREADING GLASS FIBER

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SUMMARY: The Sheet Molding Compound moldings have been applied to the water section in recent years. For this reason, it is important that the degradation of SMC moldings in hot water is considered. In this study, two types of glass fiber were used for reinforcement. One was the normal glass fiber, and the other was the spreading glass fiber. The purpose of this study is to clarify that the effects of impregnation on mechanical properties with spreading glass fiber. The flexural properties and internal structure of the SMC moldings before and after the hot water degradation test were investigated.

KEYWORDS: Sheet Molding Compound (SMC), spreading glass fiber, impregnation, degradation

INTRODUCTION

SMC (Sheet Molding Composites) is high volume and high speed composites, so that mass production can be adopted. Also the surface of SMC moldings has very smooth than other normal composites fabricated by hand-lay up method and so on. The most important market of SMC is bathtub and automobile parts. According to recent requirements of high quality bathtub very fine and smooth surface are required. The fiber bundles existed near the surface of SMC products, so that matrix shrinkage is not uniform. This phenomenon would cause the weaving of surface which might give rough surface impression. One of solution from materials development is spread fiber bundles. In this paper spreading glass fibers were used for further smooth surface SMC products and also the effects of new type of fiber on degradation behavior in hot water of SMC products were examined.

In SMC impregnation state resin into fiber bundles is important factor for not only surface quality of products but also mechanical properties. For example, when a non impregnated region remains in the fiber bundles, this region would become initiation part of fracture. It also affects fatigue properties of SMC products. During raw SMC fabrication process large amount of glass fibers are distributed on resin sheet and another resin sheet was placed on the glass fibers mat. Normally this stacked material is set between double belt for impregnation and during double belt process complete impregnation should be accomplished. Because during compression process for final products high pressure is applied and also material flow occurs, it is believed that impregnation state of raw materials would not important. However, the non impregnated region in the fiber bundles of raw SMC might not be removed in final products during compression process.

IMPREGNATION MACHINE

In order to develop SMC materials in short time we developed a new impregnation machine for raw SMC materials. Fig. 1 shows overview of impregnation machine and in Fig. 2 processing method of raw SMC materials. First glass fibers are distributed uniformly on the plastic sheet. On another plastic sheet rein part is coated uniformly. Two plastic sheets are stuck together and after that resin part is coated on a new plastic sheet again. This rein part is placed on the glass fiber layer on the opposite side; so that raw SMC materials are resin-fiber-resin 3 layer structure. In order to impregnate resin part into fiber bundles 3 layers materials are introduced into impregnation machine which has double mesh metallic belt. This machine can accept 50 cm width sheet and the distance of mesh belt reduced. In this paper 6 times impregnation process was repeated with changing the distance of mesh belt. By using this impregnation machine 25wt% SMC can be fabricated.

Fig. 1 Impregnation machine.

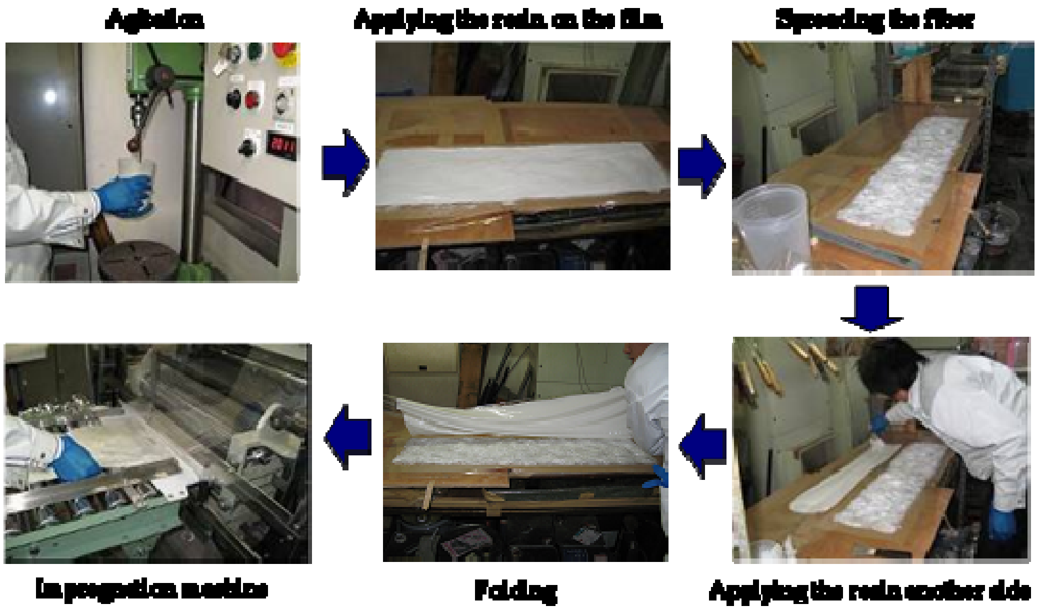


Fig. 2 Flow chart for making raw SMC.

OBSERVATION OF FIBER BUNDLE STATE IN SMC PANEL

In this paper two different glass fibers were used; one was normal chopped glass fiber and another was spread fiber bundles. After making raw SMC materials 100 ton compression machine was used to fabricate the 30 cm x 30 cm panel. Molding conditions are: Mold temperature 140 ℃ (for bottom), 155 ℃ (for top), molding pressure 5 MPa. The thickness of the panel was 2 mm.

Soft x-ray observation and also cross section observation were performed. Fig. 3 shows X-ray photos and Fig. 4 shows cross sections. In the case of normal fiber strand the thickness of fiber bundles were large, on the other hand in spread fiber case, very fine lines were seen an also fiber distributed uniformly. Therefore it can be said that fiber spread was done. According to cross section fiber bundles were observed and important point; unimpregnation region can be found in the normal fiber bundles, instead we can not see any unimpregnation region in spread fiber case. The spread fibers are very effective to create complete impregnation raw SMC materials.

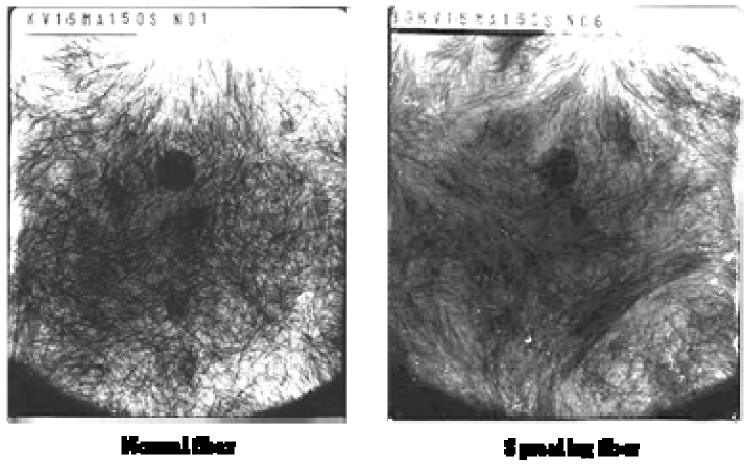


Fig. 3 X-ray photos of SMC moldings.

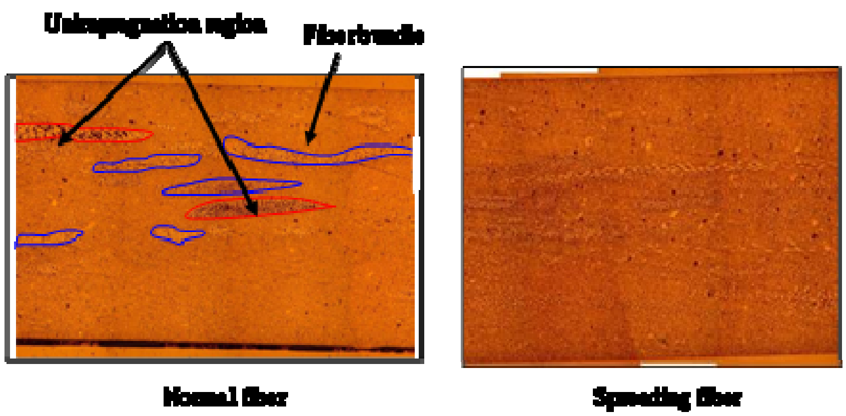


Fig. 4 Cross-section photos of SMC moldings.

MECHANICAL PROPERTIES

Three point bending specimens were cut out from fabricated SMC panels. The dimension of specimen was 60 mm x 15 mm x 2 mm. Fig. 5 shows flexural stress-displacement curves for both normal glass fiber bundle materials and spread fiber material cases. At the first maximum stress decreased abruptly in both cases, and from the drop off point stress increased gradually. In the case spread fiber bundles the stress exceeded over the first maximum stress, on the other hand the stress after drop off point in normal materials were lower than the first maximum stress. Table 1 indicates the bending test results for three specimens in each case. The elastic modulus was almost same in both materials but the bending strength of spread materials was higher than that of normal materials.

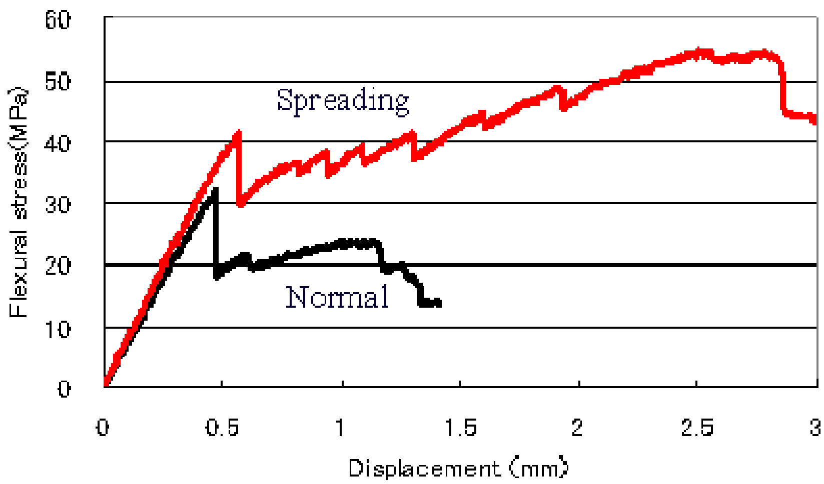


Fig. 5 Flexural stress – deflection curves.

Table 1 Results of flexural tests

Fiber	Flexural Modulus (GPa)	Flexural Strength (MPa)
Normal	5.3	30.8
Spreading	6.0	47.8

DEGRADATION BEHAVIOR

Three point bending specimens were immersed in the hot water, 80 ℃ and 98 ℃. Fig. 6 shows relation between water absorption index Mg and immersion time. For both materials water absorption values at 98 ℃ was higher than that at 80 ℃, however there are any differences between both materials. Fig. 7 shows bending strength change with increase of immersion time. At 80 ℃ bending strength kept same value for both materials, on the other hand at 98 ℃ from 600 hours bending strength decreased. The tendency of the decreasing of spread fiber materials was larger than that of normal materials. This result might depend on the interfacial properties of SMC because basically in spread SMC interfacial region was quite larger than that of normal materials.

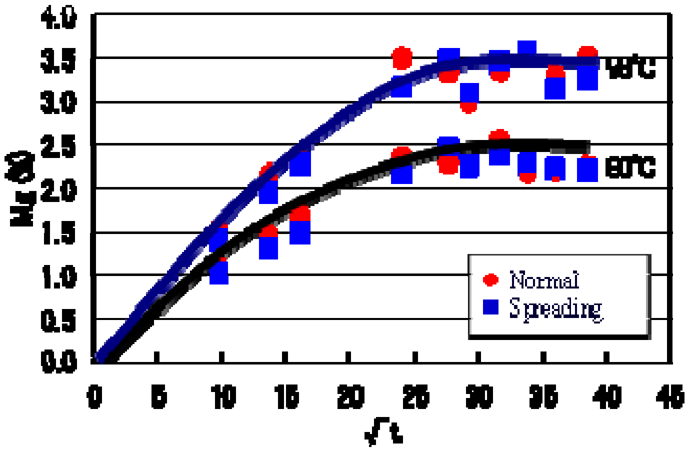
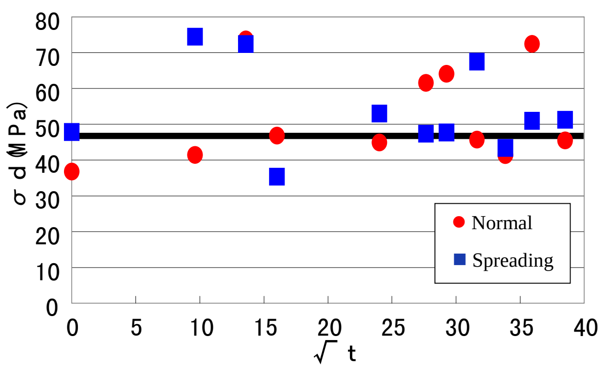
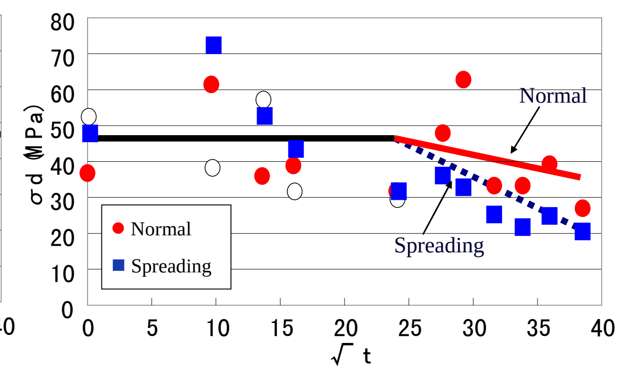


Fig. 6 Relationship between Mg and immersion time.



(a) 80 ℃



(b) 98 ℃

Fig. 7 Relationship between flexural modulus and immersion time.

CONCLUSIONS

For accelerating developing SMC materials a new impregnation machine was made. In order to create very smooth surface SMC products spread fiber bundles were introduced. Mechanical properties of spread fiber materials were equivalent with that of normal materials. From degradation tests interfacial properties might affect bending strength decrease tendencies.