FPCM-9 (2008)
The 9th International Conference on Flow Processes in Composite Materials
Montréal (Québec), Canada
8 ~ 10 July 2008

DEVELOPMENT OF HOLLOW STRUCTURAL MEMBER USING NEW SMC MOLDING METHOD

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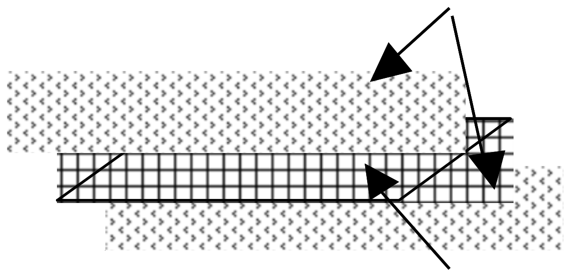
SUMMARY: The Sheet Molding Compound (SMC) is composite material composed of the compound and reinforcement of short fibers. The SMC has features that good product with high modulus and dimensional stability is obtained. And molding of products with uneven thickness, rib, and boss structure is possible. The SMC has flexibility of configuration design and cost performance is excellent, therefore SMC has been widely used in the automotive field. This research aims to develop a new SMC which has simultaneously the high modulus, high strength and high toughness for usage as an automobile structure member. Here, proposed new SMC is consists of both continuous woven fabrics and chopped-strands, and continuous woven fabrics are sandwiched by chopped-strands during the SMC manufacturing process. In addition, utilizing two technologies, tried SMC hollow molding which is the world first fabrication method. The hollow molding structural member which has the high strength-to-weight ratio this technology is produced. The fabrication method can obtain a hollow product by setting the SMC material to die beforehand and applying inner pressure. In this paper the fabrication method of Hybrid SMC was proposed and the mechanical property of the composite with Hybrid SMC was examined.

KEYWORDS: Sheet Molding Compound (SMC), molding, hollow member

INTRODUCTION

The most profitable market of SMC is automobile industry, because SMC has high potential of short molding time and high volume fabrication and SMC is cost effective material system which contains large amount of fillers. We have developed two different SMC; those were Glass chopped mat SMC (GF-SMC) and Carbon chopped mat SMC (CF-SMC). GF-SMC has large deflection and CF-SMC has higher modulus, even though they have same strength values. In order to apply SMC to automobile parts higher modulus, higher strength and higher toughness (larger fracture deflection) are required. For that purpose, Hybrid SMC which has glass chopped-strand mat and continuous carbon fiber woven fabric has been developed as shown in Fig. 1. The target properties exist just between GF-SMC and CF-SMC. In this paper fabrication system of Hybrid SMC was mentioned first.

1inch glass chopped strand



Carbon fiber woven fabric

Fig. 1 Hybrid SMC.

FABRICATION OF HYBRID SMC

Normally, raw SMC making machine was adapted to chopped glass fibers. That means the glass fibers at constant length and also uniform device was equipped. The uniform device distributes the chopped glass fibers uniform on the surface of resin layer. The two sets of these glass fiber distributor devices for one layer SMC, therefore one SMC layer has 5 layers such as resin – fiber mat - resin - fiber mat – resin. The metal mesh belt is also important for impregnating the resin into the fiber mat. For Hybrid SMC only continuous fabric supplying device was added as shown in Fig. 2. Therefore in Hybrid SMC carbon continuous fabric was placed between glass fiber mats. During compression molding of SMC, material flow occurs in the die. However, the continuous fabric should be obstacle of material flow. The material flow enable to create complex shape products such as rib and boss, on the other hand scatter of mechanical properties become large due to changing fiber orientation. Here, we proposed “No flow- SMC” molding because of continuous fabric; that is charge ratio is 100 %. The deviation of mechanical properties should be decreased and small parts can be filled up by chopped glass layers. The common knowledge in SMC molding is that the material flow should be occurred. Our proposal here was opposites of common knowledge.

The materials used in this study were resin compound and chopped glass fibers which have been used in normal SMC and carbon fiber cloth for Hybrid SMC. Three different stacking sequences were adopted as shown in Fig. 3. All of them were three layers, and CF cloth position was different in each specimen. In the case of S, CF cloth was set between GF-chopped fiber layers, on the other hand in UC and C, CF cloth was set out most layer. The difference of UC and C, in UC CF cloth was set at the tensile side of bending and in C CF-cloth was set at both compressive and tensile side. In order to fabricate SMC panel, 100 ton compression machine was used. Table 1 gives the molding conditions. A 300 mm square panel was fabricated with two GF-chopped fibers layers and one layer of CF cloth.

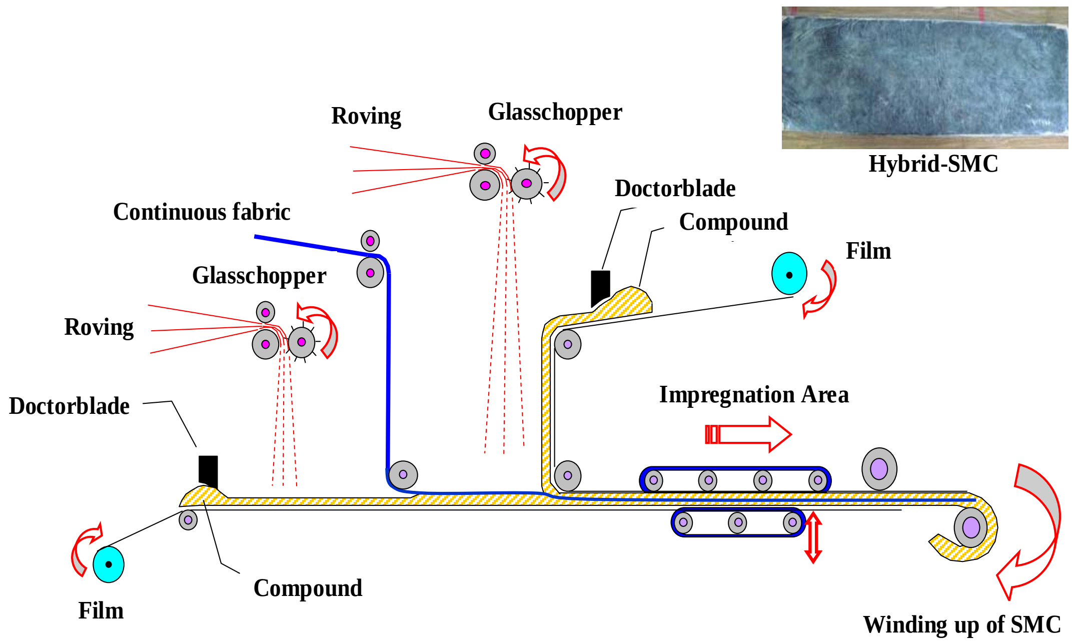


Fig. 2 Schematic illustration of Hybrid-SMC process.

EXPERIMENT

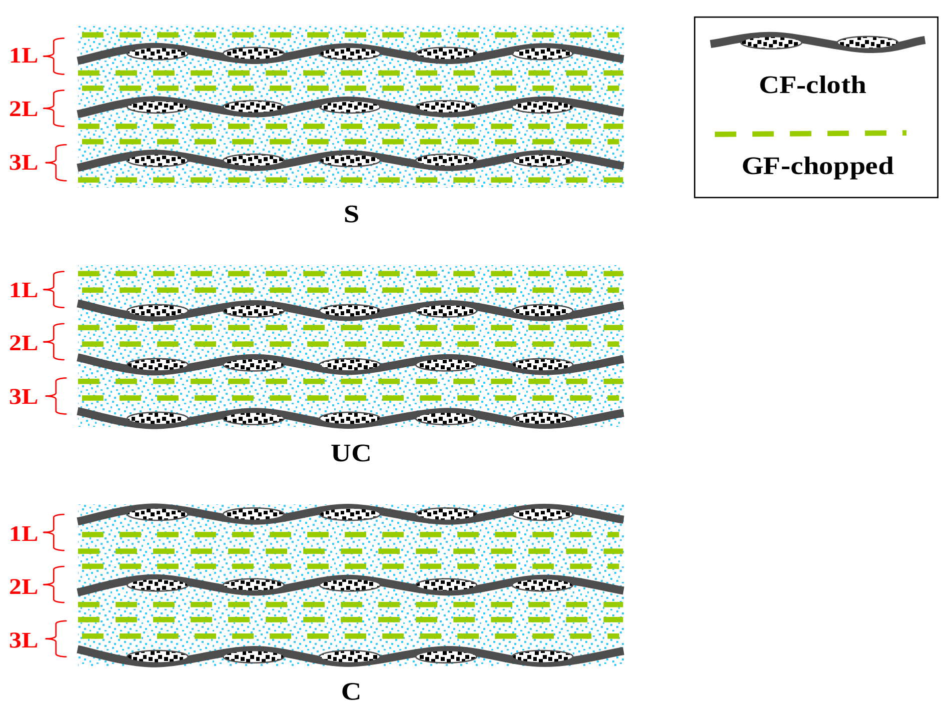


Fig.3 Laminated constitution of hybrid SMC

Table 1 Compression molding conditions

Molding Condition		MPa	15
Temperature	Upper		140
	Lower		155
Cure Time		sec	600
Rate of Change Area		%	80

RESULTS

Fig. 4 shows flexural stress and deflection curves of S, UC and C, and Table 2 was summarized mechanical properties results as well as break energy. Flexural strength of UC was the highest value; however that of C was lower than that of S although CF cloth was set at tensile side. Flexural modulus of C showed the highest value and that of S and UC was almost same. The deflection at the break and breaking energy of UC showed the highest value and those of C was the lowest.

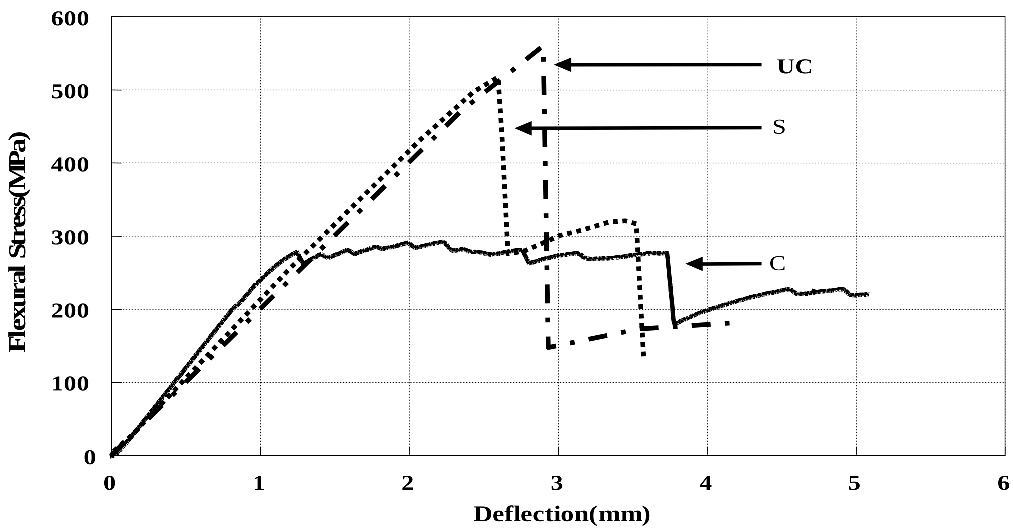


Fig. 4 Flexural Stress-Deflection curves of SMC

Fig. 5 shows fracture aspects through thickness direction and schematic drawings of fracture was also shown. Fiber rupture and interlaminar delamination were observed. In the case of C interlaminar delamination was occurred at both compressive and tensile side, on the other hand the delamination could not be observed at compressive side in the case of UC. The strength difference would be caused by the different fracture aspects. Fig. 6 shows an outside view of the hollow structure, which will be used as a car component.

Table 2 Flexural properties of SMC

		S	UC	C
Flexural Strength	**(MPa)**	**491.6**	**530.4**	**291.8**
Flexural Modulus	**(GPa)**	**18.2 (29.2)**	**18.4 (30.3)**	**23.1 (38.7)**
Deflection at Break	**(mm)**	**2.6**	**2.7**	**2.2**
Break Energy at Peak Load	**(KJ)**	**2.9**	**3.1**	**1.9**

(Theoretical value)

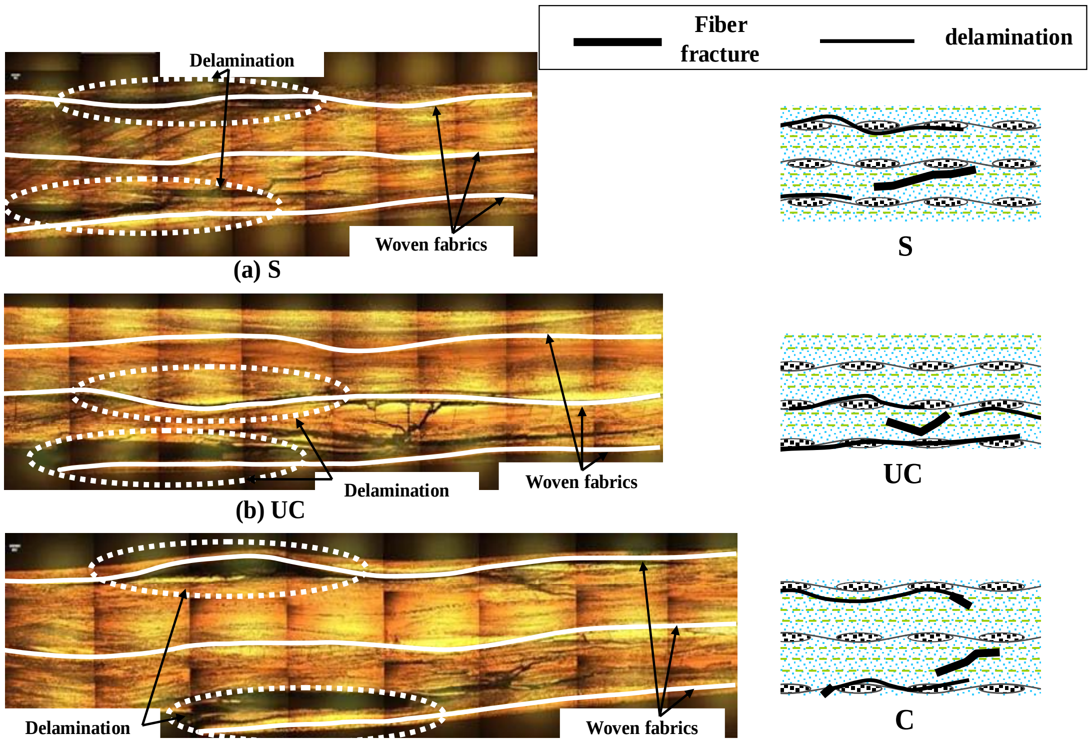


Fig. 5 Cross sectional photos after flexural tests

Fig. 6 Outview of hollow structure

CONCLUSION

In this paper a new SMC material was developed. The important points of this SMC were

- Continuous CF fiber fabric was inserted.
- During compression no material flow occurred.

Finally, high strength and large deflection SMC panels can be obtained by this approach.