

Simpres[®] M960, a unique VE Prepreg highly suitable for Crash Helmets

Introduction:

GCM assisted a helmet manufacturer company to transfer its production from wet hand layup process to using Simpres[®] Prepreg materials. As helmet weight is a critical factor for commercial success, the number of layers and the prepreg resin content are two important parameters for a successful configuration.

Simpres[®] M960 prepreg has relatively short curing cycles 7-20 min @ 120-140°C, medium to high tack and excellent resin flow control when subjected to pressure and heat. Cured laminate should demonstrate superior toughness and impact resistance.

Simpres[®] M960, impregnating different E-glass fabrics (R.C.: 30% by weight), has been selected for preliminary comparative impact penetration testing. The right fabric will be recommended for helmet manufacturing and standard helmets testing.

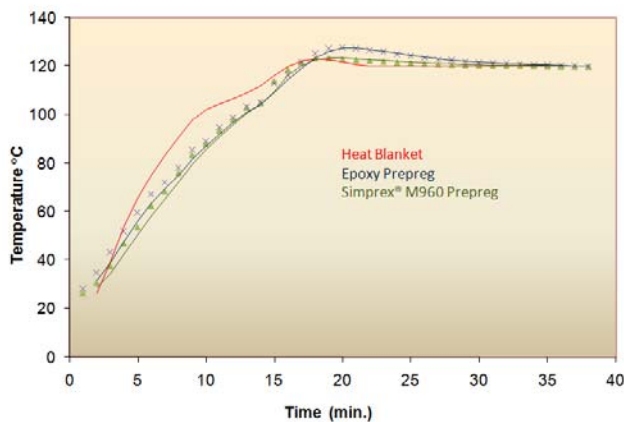
Experimental Study:

A helmet manufacturing process, using prepregs, involves a pre-heated mold @ 120-140°C and inflatable bladder to generate a pressure of around 5 bars. The prepreg lamination is getting heated only from the mold side. To simulate this prepreg curing with heating from a single side, heating blanket was used and assisted with vacuum bagging.

- Four sets of glass laminates, 20 cm X 20 cm were prepared for vacuum molding, using Simpres[®] M960, and a competitive epoxy prepreg.
- One Heat Blanket was used on the top of the laminates to bring their temperature up to 120°C.



- Below picture is showing three Simpres[®] M960 laminates and the epoxy laminate (black), using E-Glass fiber.
- A high resin flow was observed in the case of the epoxy prepreg. Epoxy curing was also accompanied by a high exothermic reaction, as illustrated in the following graph.



For crash helmets, standard impact penetration tests (Snell or DOT or AS1698), use the following specifications:

- Weight: 3 kg;
- Hardness: 60 Rockwell;
- Cone Angle: 60 Degree;
- Strike Point Radius: 0.5 mm;
- Drop Height: 3 m.

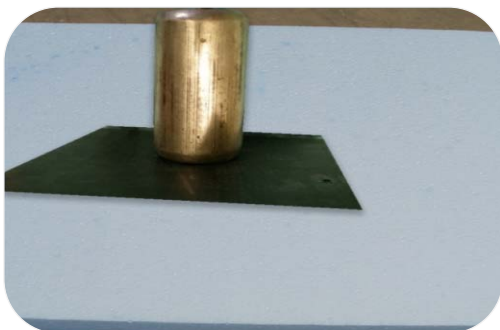


To run a comparative impact penetration trial, as illustrated in the right picture, an in-house experiment was conducted with respect to weight, cone angle, strike point radius, and drop height.

Results:

The following table summarizes the specifications of each laminate. Simprex® M960 laminates were about 2 mm thick and have an average resin content of 27%, by weight. The epoxy laminate was 2.6 mm thick and has around 39% resin content by weight.

Laminate	Prepreg	Fiber	Weave	Areal weight (gsm)	Number of layers	Total weight (g)	R. C. (% by wgt)	Thickness (mm)
1	M960	E-Glass	7781	300	9	149.4	26-28	2.05
2	M960	E-Glass	PW	308	9	149.2	26-28	2.00
3	M960	E-Glass	PW	450	7	164.8	26-28	2.15
4	Epoxy	E-Glass	Twill 2X2	300	9	176.8	38-40	2.60



As shown in the epoxy picture, the falling object (weighing 3 kg, dropped from a 3 m height, with a strike point radius of 0.5 mm and a cone angle of 60 degrees) penetrates completely the laminate and sticks into it.



As shown in the right picture, Simprex® M960 laminates have shown clear superiority over the epoxy laminate, although their average thickness was only 2 mm, compared to 2.6 mm.

In fact, in the three Simprex® M960 laminates, the falling object was not able to stick and remain in the impact hole. Leaving a much smaller initial penetration, compared with epoxy laminate, the falling object bounced off from the three Simprex® M960 laminates.



Conclusions:

1. Simprex® M960 vinyl ester prepreg was superior to the epoxy prepreg, in term of Impact Penetration resistance.
2. According to visual evaluation, woven roving fabric, 450 gsm, was equivalent or slightly better than the PW 308 gsm, which was slightly better than 7781 8 harness 300 gsm, also in term of Impact Penetration resistance.
3. Simprex® M960 / woven roving E-glass fabric (450 gsm), was selected to manufacture prototype helmets and to conduct standard SNEL specification tests.
4. As shown in the following picture, the helmet manufactured from Simprex® M960 / E-glass woven roving fabric passed successfully the SNEL Impact Penetration test.
5. The prototype helmet, weighing 672 grams, passed also the Chin Guard tests.

