Experimental Investigation on Techniques to Improve Properties in Ablative Liner

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Abstract: ***In this study an experimental investigation is carried on manufacturing and testing of ablative phenolic laminate by varying the different parameters with and without reinforcement of micro silica powder as filler material by changing the ply orientation of 0° and 35° rosette. The filler material of up to 15% is added to find out physical properties of an ablative phenolic laminate and these properties have been compared among those prepared materials of varying stacking sequence as well as filler material. Therefore this study involves enhancement of properties of E-glass laminates by addition of filler material as well as changing ply orientations, so that the properties can be comparable with S-Glass laminates.***

Keywords: Ply, Rosette, Laminate, Ablation and Filler

1. Introduction

Composite materials are consolidate from two or more individual materials which have different physical or chemical properties that when combined, produce a unique product which is better, effective, efficient, qualitative in practical usage than the individual materials. The ablation process is a combination of surface melting, sublimation, charring, evaporation, decomposition in depth and film cooling, progressive layers of the ablative material undergo an endothermic degradation, that is, physical and chemical changes that absorb heat [1]. Applications of ablative liners are Jet deflector [2], Rocket motor casing [3].

1.1 Jet deflector

Rocket is a vehicle based on the application. One way is ballistic missile and the other is cruise missile. Ballistic missile, which is positioned perpendicular to the earth surface and cruise missile is positioned at an angle to the earth surface. Jet deflector is a device which redirects the high energy of exhaust gases developed by the combustion of propellant in rocket motor casing to deliver safely to atmosphere. The exhaust gas impinges on the deflector from the rocket. Depending on the type of rocket, the deflector is classified as inclined and wedge shape. Inclined shape deflector may be flat or curved. Wedge shape deflector is in form of sinusoidal shape. Ballistic missile uses sinusoidal wedge shape deflector.

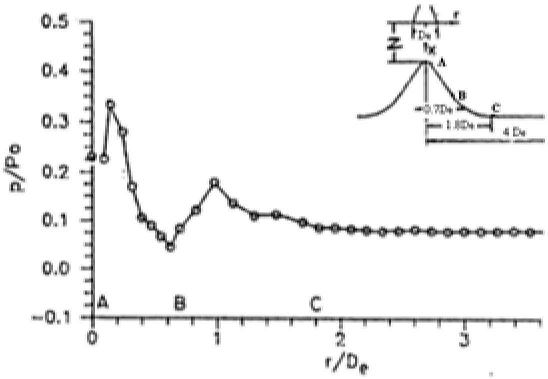


Figure 1: Pressure distribution on Jet deflector [5]

1.2 Rocket motor casing

A solid rocket or a solid-fuel rocket is a rocket with a motor that uses solid propellants (fuel/oxidizer). Based on the applications, the rocket motor casing material will be depends. Few of the rocket casings are made with thermo setting plastic composite materials and few of them are made with light metals like 15CDV6, SAE4130 [6, 7].

2. Experimentation

2.1 Preparation of phenolic resin with reinforcement of micro silica powder

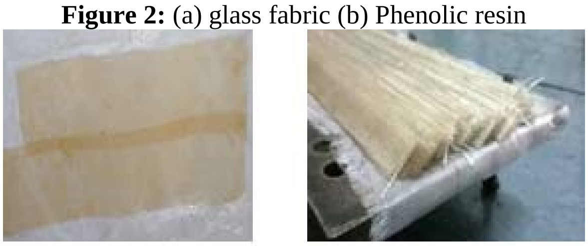
Phenolic laminates are manufactured with and without filler materials. Based on the type of filler material and % of mixing of filler, the strength of material will be depends. [8] Studied and wish to finding out few mechanical properties that, the composite specimens are manufactured from bi-directional woven ceramic fiber and ultra light micro silica filled Phenolic resin using traditional hand layup method. The percentage of weigh of ultra light micro silica varied from 5-20% in the Phenolic resin. Initially, micro silica is mixed with pre calculated Phenolic resin. Then this mixture was stirred slowly and thoroughly for about 30 min by using handheld electrical stirrer.

2.2 Materials

Polymers are number of repeatable molecules connected by a covalent bond. Due to the repeatability, polymers have high molecular mass. A monomer has low viscosity, but by adding catalyst or heat viscosity increases. The reactions of phenolics are by exothermic. It will continue heat and the viscosity goes down for a specific stage and then goes increases [19]. The Phenolic resin as a matrix and E glass fabric is used as reinforcement to make a laminate. The properties of reinforcement, matrix and filler are mentioned in the Table 1.

(a) (b)

Figure 2: (a) glass fabric (b) Phenolic resin



(a) (b)

Figure 3: (a) Prepreg (b) Shingle Rosette

Table 1: Raw materials properties

Reinforcement		Matrix: Phenolic resin	Filler : Micro silica powder
10 mil	7 mil		
Weave: Plain Width [9] : 1042 mm Mass per unit area [11]: 301 g/cm^2 Warp / Weft [10]: 31 / 24 Thickness [12]: 10 mil	Weave: Plain Width [9] : 1028 mm Mass per unit area [11]: 216 g/cm^2 Warp / Weft [10]: 44 / 31 Thickness [12]: 7 mil	Color: Honey red Specific gravity: 1.15 Point of trouble: 8.1 ml of water Volatile content: 35.41% of wt. Solid content: : 64.58% of wt.	Appearance: Snow white SiO_2> 99 % LOI 0.28% Specific gravity: 2.2 Particle size: 4 µm (avg)

2.3 Prepreg preparation & laminate manufacturing:

The term prepreg is a short form of preimpregnated fibers. A prepreg is in the form of a lamina. Prepregs thus represent an intermediate stage in the fabrication of a polymeric composite component. The prepreg generally has the resin in a partially cured state with a moderately self-adhesive tack. The properties of prepreg are mentioned below. [4] has shown the style of curing.

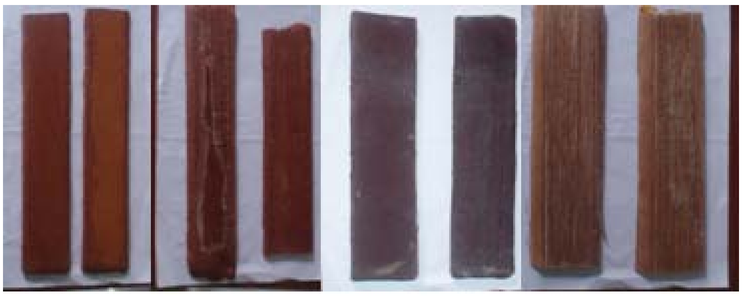


Figure 4: Cured laminate at 0° & 35° with reinforcement and unreinforcement filler laminate respectively.

Table 2: Prepreg PropertiesParameter (% wt)	Unreinforcement of micro Silica filler laminate					Reinforcement of micro Silica filler laminate						Actual limits [2]
	0° - parallel		35° - Shingle rosette			0° - parallel				35° - Shingle rosette		
	01 & 02		03	04		05		06		07& 08		
Volatile content [15]	7.27	5.0	4.28	8.33	7.89	10	6.37	8.19	6.3	5.7	5.4	4-9
Resin content [16]	25.45	23.34	20.32	22.18	15.78	26.67	25.71	25.13	26.07	20	27.04	25-30
Fiber content [16]	67.27	71.66	75.52	69.44	76.39	66.28	70.27	66.67	67.62	74.28	67.56	70-75

Table 3: Ply sequence

Parameter	Unreinforcement of micro Silica filler				Reinforcement of micro Silica filler			
	Parallel (0°)		Shingle rosette (35°)		Parallel (0°)		Shingle rosette (35°)	
	1	2	3	4	5	6	7	8
0° (in number)	27	25	2	2	37	34	2	3

Build up to get	-	-	22	26	-	-	33	33
35° rosette	-	-	118	105	-	-	135	125

Table 4: Acceptance test on Laminate Conclusion

Parameter / sample no.	Parallel layup				Shingle (Rosette) layup			
	Un reinforcement of micro Silica filler		Reinforcement of micro Silica filler		Unreinforcement of micro Silica filler		Reinforcement of micro Silica filler	
	01	02	05	06	03	04	07	08
Resin content (% wt) [13]	18.68	22.48	26.8	23.93	15.36	23.05	24.5	22.88
Fiber content (% wt)	81.31	77.51	73.2	76.06	84.63	76.95	75.5	77.07
Specific gravity$ [18]	1.575	1.61	1.95	1.95	1.66	1.67	1.90	1.86
NDT$	Test has been conducted with the probe of SPT 10-2 (0.5 MHz, Ø 10 mm) threshold level of 90% with the system of Dry Scan Sonatest 410D, at gain of 90%& get cleared for further process.							
Void content [17]	23.91	19.33	4.6	8.87	22.68	15.91	8.433	11.7

3. Conclusion

1. From literature survey, it is revealed that S-Glass fabric with Phenolic exhibits significant mechanical properties.
2. Even though S glass fabric posses high strength and low density, due to high cost & unavailability of the material, trials have been made on E glass fabric to improve the properties.
3. E glass, Resole Phenolic resin laminates is successfully manufactured.
4. Different types of qualification test and acceptance tests have been carried out and result showed that there is improvement in properties.
5. In comparison with unreinforced filler laminate, % specific gravity is increased at 20.87% & 12.76% for 0° overlap & 35° rosette reinforced filler laminate respectively.
6. Parallel ply orientation fabrics of reinforced filler laminate decreases the void content at 68.84% as compared to unreinforced filler parallel ply laminate.
7. Shingle rosette ply orientation fabrics of reinforced filler laminates decreases the void content at 48.85% as compared to unreinforced filler shingle rosette laminate.

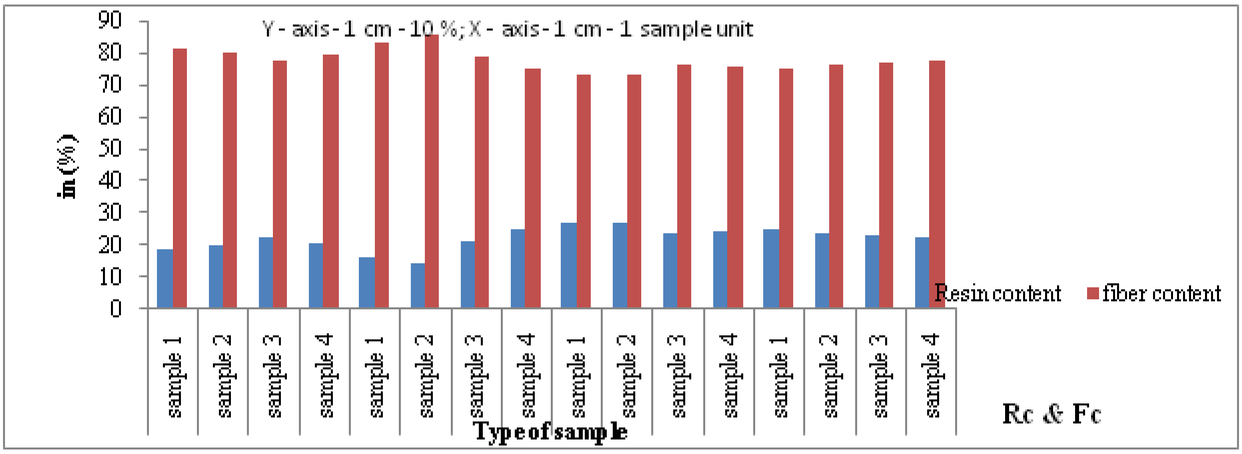


Figure 5: Percentage of resin content and fiber content

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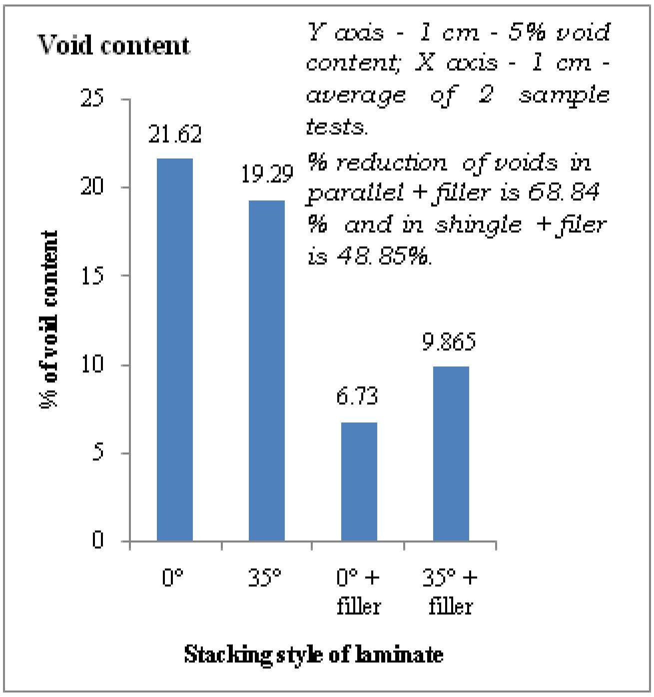

Figure 6: Percentage reduction of void content in reinforcement of filler laminates with unreinforcement of filler laminate.

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