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The Study of Fire Reaction and Fire Resistance of Composite Materials

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ABSTRACT

This presentation is to deal with "The Study of Fire Reaction and Fire Resistance of Composite Materials". Many efforts have been devoted for assessing and reducing fire hazards. The fire properties of various composite materials have been analyzed and it depends on the combustion mechanisms of the composites such as the reaction rates, smoke and toxic gases of organic polymers and fibers and flammable volatiles, ignition time, heat release rate. The fire resistive properties of composite materials are also mentioned like burn-through rate and mechanical withstands during and after the fire. A diverse range of composite materials used in automotive interiors of land, marine and also in aerospace. Also in chemical industries and mechanical and civil engineering infrastructures. In response to the increasing fire hazards in transportation systems causing fatal to life, lots of research work is being carried out across the world. So, the main aim of our project to develop p hybrid composite m aterials that offers fire resistance properties when it is subjected to fire up to an extent possible in very innovative and challenging and thought provoking process.

Keywords: Hybrid composite, E- glass fabric, Hemp fabric.

1. INTRODUCTION

An extensive research on fire safety and related subjects of automotive interiors was conducted as the part of this project. So it is important to identify the predominant automobile fire scenarios and consequences that resulting to fatalities and to gain a better knowledge/ understanding of the growth of fire mechanisms and associate thermal exposure conditions in automotive interiors. With the recentscenarios, we have observed that the fire accidents in buses or any automotives has been fatal to life. So, we come up with an idea of using composite materials and thereby minimizing the fire accidents to a level extent possible in the interior designs of automotives which has comparatively higher resistance properties than the previous materials being used in the automotive interiors.

1.1 Flame Spread

Flame spread is the propagation of a flame alone a material surface. As Shown schematically in Fig. flames may spread down, up or across a vertical surface or along a horizontal surface. All types of flame spread; the flame is pre heating un-ignited material. The below figure provides a comparison of different flame spread rates. The most rapid flame spread over a material is wind aided frame spread. In the wind aided flame spread frame extends out beyond the burning region of the contact surface and pre heats the un-ignited material. Examples for wind aided flame spread include vertical frame spread on walls and flame spread along ceilings. In horizontal and downward flame spread the flame preheat the material only by the radiation causing head fluxes to lower. So this sometimes refer to as opposed flow flame spread. As a result horizontal and downward frame spread rates are typically less than wind aided frame spread. Based on the theory from the one-dimensional models, multidimensional flame spread models have been developed to predict flame spread in a corner configuration, in the below figure 1.1. Before examining the models and detail, it is important to understand the sequence of events that occur when a compositematerial is exposed to high temperatures fire. When a head flux is applied to one-side of a polymer composite, then the first event to occur is the conduction of had into the material. The rate of heat conduction is governed by the incident heat flux and the thermal diffusivity of the composite. The thermal diffusivity of most types of composite is low, particularly in the through-thickness direction, and therefore a steep temperate gradient can develop through the material. For example, when a thick composite is exposed to a medium-to-high head flux (i.e. above -50 kW/m²) the hot surface can heat-up at a rate approaching or exceeding-1000°C/min whereas the back surface is heated by conduction at a much slower rate of typically 1-20°C/min. Heat conduction through composites is complicated by the highly anisotropic nature of their thermal properties. Most types of fibers have a higher thermal conductivity than the polymer matrix. For example, at room temperature the axial thermal conductivity of carbon and glass fibers is about 20 to 80 and 1 W/m K. As a result, the rate of heat conduction along the lamina (i.e. fiber direction) is much than in the through thickness direction. Before examining the models and detail, it is important to understand the sequence of events that occur when a composite material is exposed to high temperatures fire. The rate of heat conduction is governed by the incident heat flux and the thermal diffusivity of the composite. The thermal diffusivity of most types of composite is low,particularly in the through-thickness direction, and therefore a steep temperate gradient can develop through the material. For example, when a thick composite is exposed to a medium-to-high head flux (i.e. above -50 kW/m²) the hot surface can heat-up at a rate approaching or exceeding-1000°C/min whereas the back surface is heated by conduction at a much slower rate of typically 1-20°C/min. Heat conduction through composites is complicated by the highly anisotropic nature of their thermal properties. Most types of fibers have a higher thermal conductivity than the polymer matrix. For example, at room temperature the axial thermal conductivity of carbon and glass fibers is about 20 to 80 and 1 W/m K. As a result, the rate of heat conduction along the lamina (i.e. fiber direction) is much than in the through thickness direction.

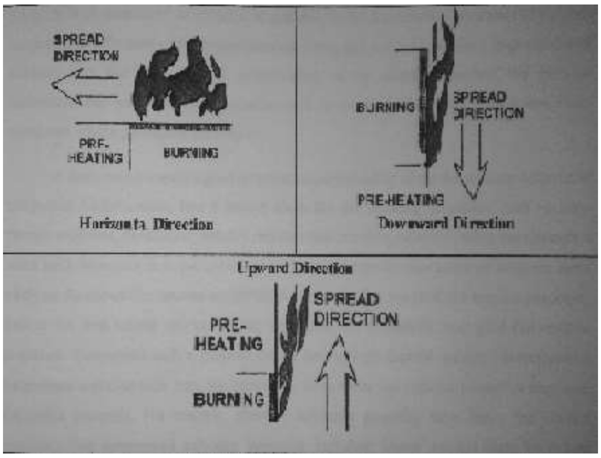


Figure 1.1: Different directions of fire spread

1.2 E-Glass Fiber

E-Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiber glass. Properties that have made E-glass so popular in fiberglass and other grass fiber reinforced composite include: low cost, high production rates, high strength, high stiffness, relatively low density, non-flammable, resistance to heat, good chemical resistance, relatively insensitive to moisture, able to maintain strength properties over a wide range of conditions and is a good electrical insulation.

1.3Hemp Fiber

The fiber is the most valuable parts of the hemp plant. It is commonly called as Ballast, which refers to the fibers that grow on the outside of the woody interior of the plant's stalk, and under the outermost part (the bark). Ballast fibers give the plants strength. The length of the hemp fibers very between 0.91 m (3 ft) to 4.6 m (15 ft) long and running the lengths of the plant stem. The color of the hemp fiber is creamy white, brown, gray, black or green depending upon the method of process used to remove the fiber from the plant stemcontent here. Paragraph comes content here. Paragraph comes content here. Paragraph comes content here.

2. EXPERIMENTAL PROCEDURE

2.1 Method of Fabrication

Hand lay-up technique was used for preparation of the specimen. The hand lay-up process is the oldest, simplest, and most labor intense fabrication method. The process is most common in FRP marine construction. In hand lay-up method liquid resin is placed along with reinforcement (Glass-Jute fiber) against finished surface of an open mould. Chemical reactions in the resin harden the material to a strong, light weight product. The resin serves as the matrix for the reinforcing jute fibers. The percentage of fiber and epoxy was 70:30 in weight ratio.

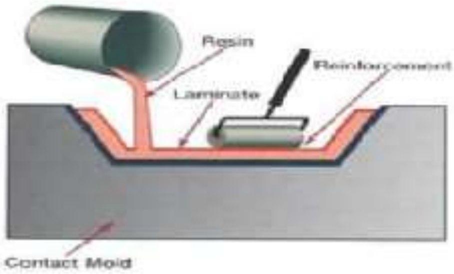


Figure 1.2: Hand lay-up technique

2.2 Testing Of Composites for Fire:

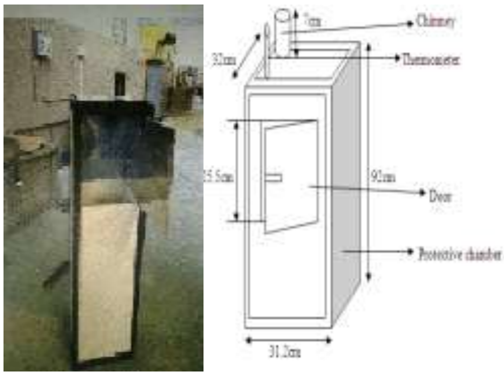


Figure1.3: Experimental setup

2.3 Flame Test Specimen as Per ASTM E-1354

The test specimen is generally prepared according to the procedure in ASTM E1354 for products that are at least 4.5 mm in thickness that without a substrate.

Figure 1.4:Standard size of the Specimen(Hybrid and E-Glass)

2.4 Preparation of Specimen According To the Standards

Figure 1.5: Preparation of Hybrid Composite.

2.5 HORIZONTAL POSITION TESTING

2.5.1 Conduction of Horizontal Fire Test of Hybrid

- Catches fire slowly
- Bubbles occur on hybrid composite surface at 3 min. 27 sec.
- Emits smoke
- It takes 8 min.12 sec. to burn
- There is no ash formation
- First layer de-lamination occurs at 5 min, 45 sec.

Figure 1.6: Conducting Fire Test on Hybrid Composite.

2.5.2 Conduction of Horizontal Fire Test of E-Glass Specimen:

- Fire catches slowly
- Bubble formation at 2 min. 5 sec.
- Emits smoke
- Physical geometry of the material does not change

Figure1.7**:** Conducting Fire Test on E-GLASS

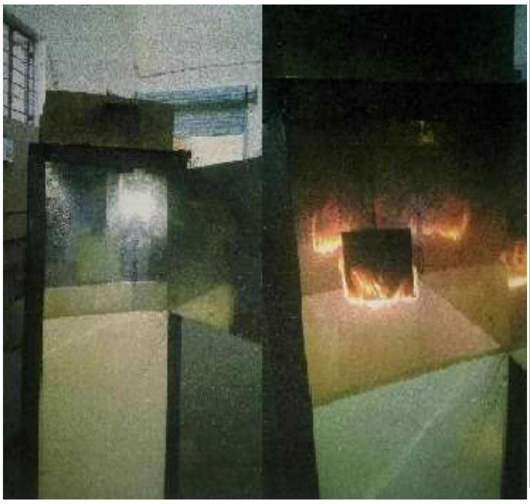
2.6 VERTICAL POSITION TESTING

2.6.1 Conduction of Vertical Fire Test of Hybrid Specimen

- Catches fire early compared to horizontal position
- Bubbles formation occurs at 2 min. 25 sec.
- Emits smoke
- Total time of burning process is 5 min.16 sec.

Figure1.8: Conducting Fire Test on Hybrid Composite.

2.6.2 Conduction of Vertical Fire Test of E-Glass Specimen



- Fire catches early compared to horizontal position of E-glass composite
- Bubble formation occurs at 1 min, 30 sec.
- Total burning time 4 min. 9 sec.
- Physical geometry does not change.

Figure1. 9: Conducting Fire Test on E-GLASS.

2.7 OBSERVATIONS

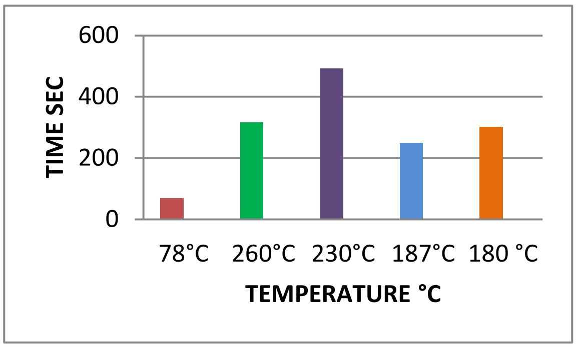
Table 1.1: Weight loss of the specimen

Initial weight of the cimen(before fire test)	**Final weight of the ecimen(after fire test)**
rid composite (vertical- 88.06grams)	rid composite (cal – 60.5 grams)
Hybrid omposite(Horizontal)- 89.66grams	Hybrid composite orizontal)70.24grams
-glass (vertical)-87.88 grams	-glass(vertical)-60.82 grams
ass(horizontal)-88grams	E-glass(horizontal)- 75.42grams

Table1.2: Time taken to burn the composite

	Plastic
	Hybrid composite(Vertical)
	Hybrid composite(Horizontal)
	E-Glass (Vertical)
	E-Glass (Horizontal)

*Experiment was conducted at room temperature, 27°C



2.8 CALCULATIONS

- Burning rate (Sq-cm/min) = Area of Specimen / Time taken in Min.
- Horizontal (Hybrid composite) = 100/8.2 =12.19 cm²/min
- Vertical (Hybrid composite) = 100/5.267 = 18.98 cm²/min
- Burning rate (sq-cm/min) = Area of specimen / Time Taken in Min.
- Horizontal (E-Glass) = 100/5.033 = 19.86 cm²
- Vertical (E-Glass) = 100/4.15 = 24.096 cm²/min

3. CONCLUSIONS

In all prepared specimens, the hybrid composite material offers more fire resistance properties when it is subjected to horizontal flame. Under the test conditions, we have observed that it can sustain up to 8 min. 12 sec. and temperature at 230^{0}C. Hence, hybrid composite materials could be used as a replacement in the automotive interiors because of its high fire resistance properties.

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