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LAMINATED THERMOPLASTIC COMPOSITE MATERIAL FROM RECYCLED HIGH DENSITY POLYETHYLENE

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KEY WORDS: thermoplastic composite, high density polyethylene, laminate, glass fiber fabric, ASTM standards, tensile test, ultimate tensile strength.

PREREQUISITE KNOWLEDGE: The student should understand the fundamentals of polymer processing and mechanical property testing of materials. The ability to use ASTM standards is also necessary for designing material test specimens and testing procedures.

OBJECTIVES: To understand the concept of laminated composite materials, processing, testing and quality assurance of thermoplastic composites; to observe an application example of recycled plastics.

EQUIPMENT AND SUPPLIES:

1. Recycled one-gallon milk containers
2. One glass fiber fabric of 127 × 127 mm
3. Steel rules and compass (or a specimen template)
4. Scissors
5. Thermoforming or compression machine for plastics
5. Tensile test machine.

PROCEDURE:

1. Collect and clean recycled milk containers.
2. Cut four (4) flat sheets of high density polyethylene from the milk containers. The sheet size is approximately 130 × 130 mm.
3. Cut a piece of glass fiber fabric of 127 × 127 mm.
4. Place two sheets of high density polyethylene on both sides of the glass fiber fabric, as shown in Figure 1.
5. Compress the above combination of sheets under a normal load of 2/9 tons and a temperature of 135 ^{O}C for 5 minutes.
6. Turn off the heater of the mold, turn on the circulation pump and maintain the same normal load until room temperature.
7. Remove the laminated composite from the mold.
8. Cut the tensile test specimen from the laminate according to dimensions specified by ASTM standards [1], as shown in Figure 2.
9. Test the tensile strength of the laminated composite.

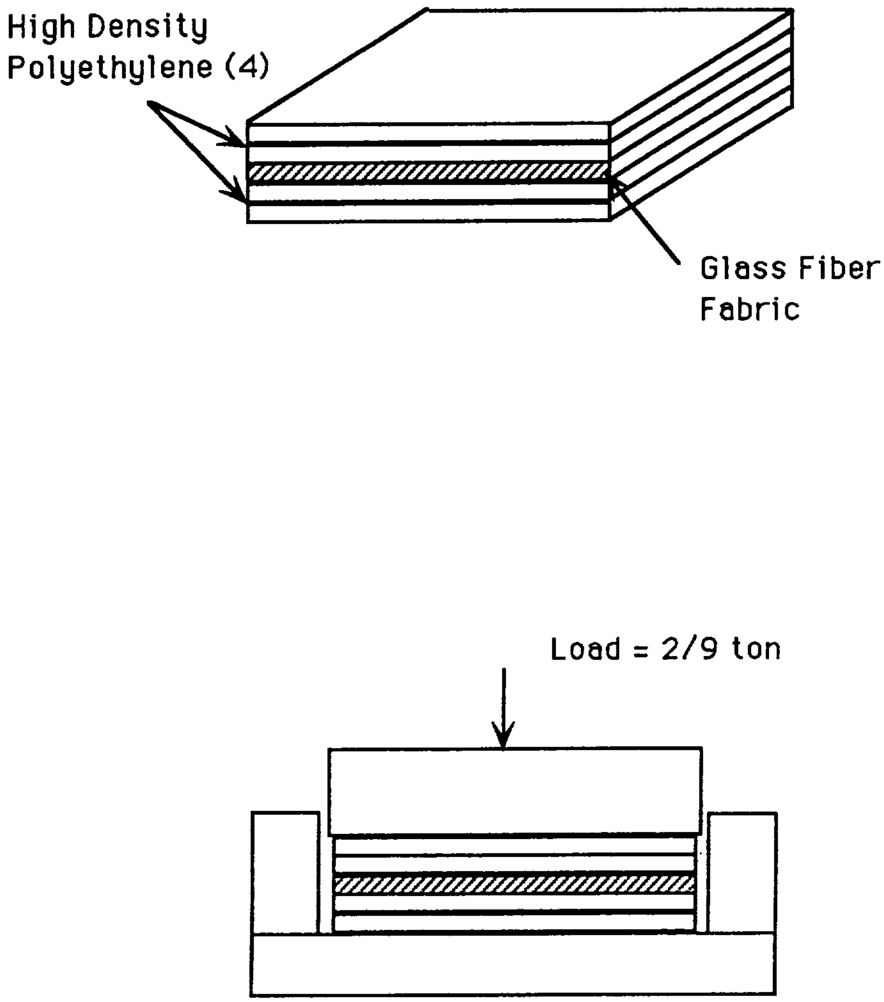

Figure 1. Configuration of laminated composites: two layers of HDPE on both sides of glass fiber.

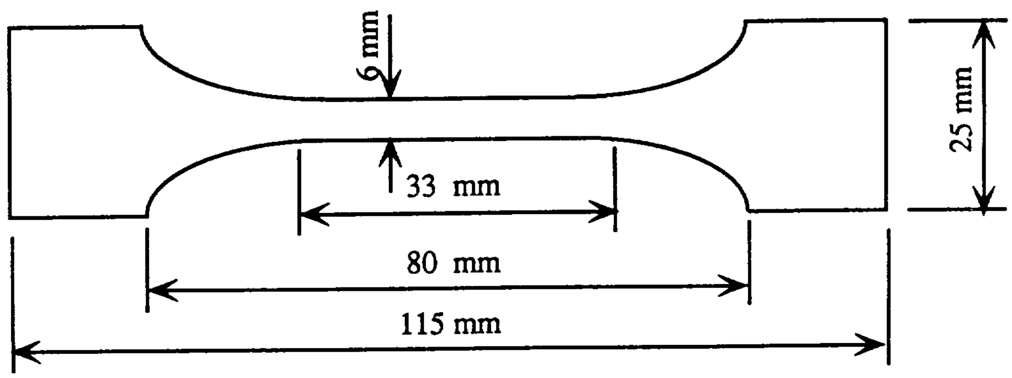

Figure 2. Dimensions of the tensile test specimen per ASTM standard D 638M-89.

SAMPLE DATA SHEETS

Students can record the experimental results using the following table. The data in the table are examples.

Sample #	Forming Load (t)	Temperature (°C)	Specimen Thickness (mm)	Specimen Width (mm)	Max. Load (N)	Tensile Strength (MPa)
1	2/9	135	1.44	6.46	237.9	25.6
2	2/9	135	1.28	6.43	191.9	23.3
3	2/9	135	1.30	6.62	284.7	33.1

INSTRUCTOR NOTES:

Students can perform investigative studies on the effects of forming temperature on the strength of the laminated composite [2,3]. Figure 3 shows a typical relationship between the compression temperature and ultimate tensile strength. As the temperature increases, the strength of laminated composite increases. This increase may be due to several reasons. One of the reasons is that as the temperature increases, better bonding may take place between the glass fibers and the plastic sheets. Another possible reason is that as the temperature increases, the thickness of the laminate decreases, which actually increases the percentage of glass fiber relative to the polymer. Glass fiber is stronger than high density polyethylene matrix. Therefore, material strength increases with increasing temperature.

The reinforcing effect of glass fiber is seen in Figure 3. The strength of recycled high density polyethylene is improved by laminating it with glass fiber. With the improved mechanical properties, the application of recycled plastics could be expanded, and therefore the amount of solid waste going to landfills can be reduced.

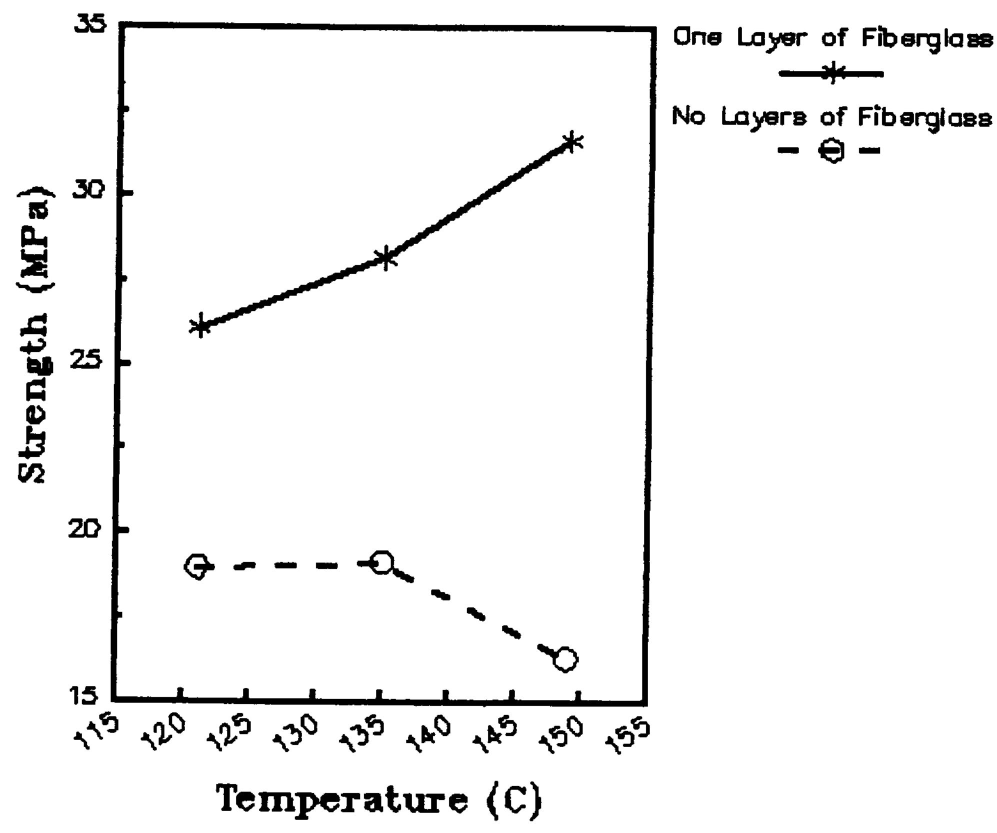

Figure 3. The relationship between the compression temperature and the tensile strength of recycled high density polyethylene laminated with glass fiber and recycled high density polyethylene without reinforcement.

It is also noted that the strength of the laminate increased with increasing temperature. To further investigate the reason, Figure 4 was created to show the relationship between the thermocompression temperature, specimen thickness and strength. It is believed that with increasing temperature the bonding between the fiber and the plastic was improved. As the thickness decreased with the increased temperature, the actual percentage of load-bearing glass fiber in the composite was increased. Therefore, the tensile strength increases with the thermocompression temperature.

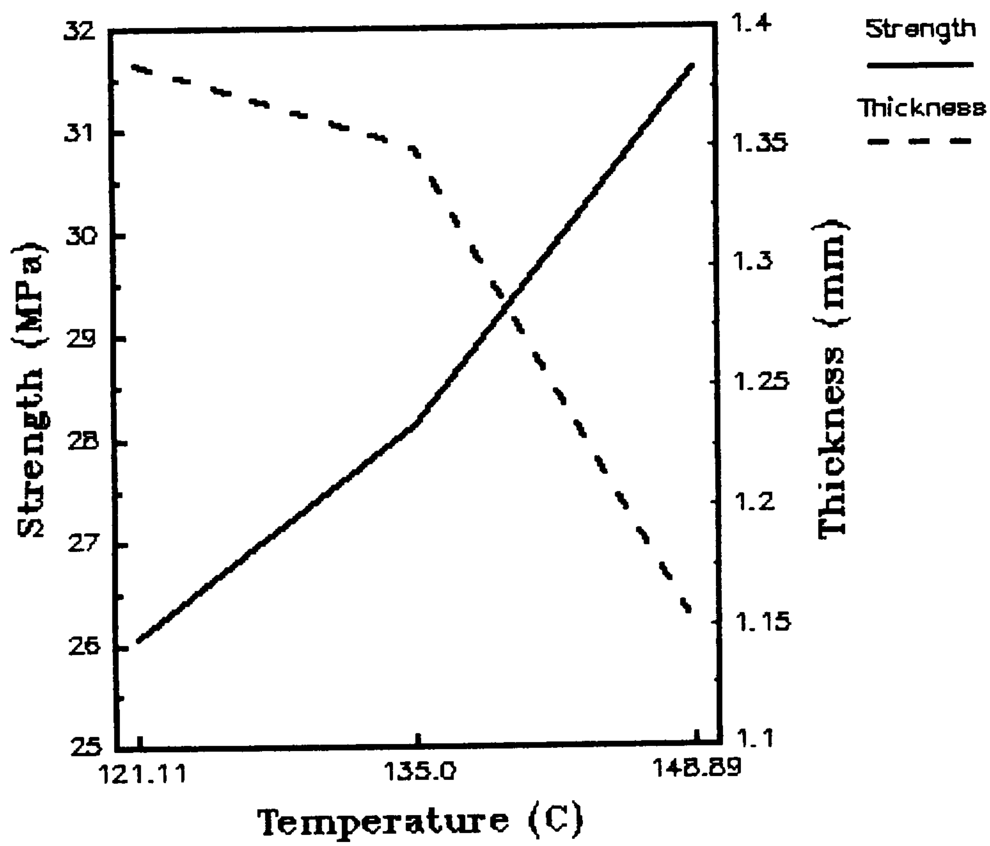

Figure 4. Variation of laminate strength and specimen thickness with thermocompression temperature.

In summary, this experiment provides an understanding of the reinforcing role of continuous fibers in thermoplastic composites. It also illustrates a possible application of recycled plastic, and increases the student awareness of the importance of materials recycling for solving solid waste crisis in the nation.

REFERENCES:

1. ASTM: 1989 Annual Book of ASTM Standards, Vol. 8.01 Plastics (I), American Society for Testing and Materials, Philadelphia, 1989.

2. Carlsson, Leif A.: Thermoplastic Composite Materials, Elsevier Science Publishers, 1991.

3. Agarwal, B.D.; and Broutman, L.J.: Analysis and Performance of Fiber Composites (2nd edition), John Wiley & Sons, Inc., 1990.

SOURCES OF SUPPLIES:

The high density polyethylene is obtained from milk containers which can be recycled by faculty and students without any cost. The cost of glass fiber fabric is the lowest among all engineering fibers, which is \$2.65 - \$6.25/ m^2 (Fibre Glast, 1-800-821-3283).

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