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IMPACT BEHAVIOUR OF THE COMPOSITE MATERIALS RANDOMLY REINFORCED WITH *E*-GLASS FIBRES

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ABSTRACT
The paper analyses the effects of the type of resin on the impact characteristics in case of four composite materials randomly reinforced with E-glass chopped fibres. Therefore, four kinds of polymer resins were used to manufacture the composite materials: polyester Heliopol 8431 ATX, polyester Polylite 440-M880, and epoxy LY 554, vinyl-ester ATLAC582. The volume ratio of E-glass fibres was the same for each composite analysed. The specimens for Charpy test were cut from the composite plates. The paper presents and analyses the results of the Charpy tests (failure energy U and resilience K) in case of the composite materials tested. Some important remarks concerning the areas of failure are presented. Finally, the paper graphically shows the effects of the resin type on the dynamical characteristics obtained in Charpy test.
Keywords: composite, Charpy test, failure energy, resilience.

1. INTRODUCTION
Charpy test has been used for many years [1, 2] to determine the energy absorption, notch sensitivity, fracture toughness and fracture behaviour of the composite materials through information obtained from standardised type pendulum breaking standardised specimens in a bending mode. For these tests, swinging a weight from a fixed height toward an unnotched or notched specimen, produces an impact load. The failure energy is recorded during the *Charpy* test. Finally, the resilience denoted by *K* may also be computed. It represents the ratio between *the failure energy in Charpy test* and the area of the notched cross-section of the specimen.
The main objective of this paper is to characterize the effects of the resin type on the impact behaviour of the composite materials randomly reinforced with chopped E-glass fibres.
Thus, four kinds of specimens reinforced with of *E*-glass fibres were manufacture by using four different types of resins. *Charpy* tests showed that an improvement of the resilience *K* was detected in the case of the composite materials with polyester resins.

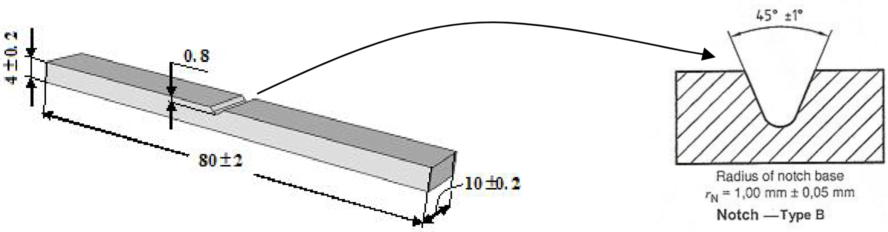


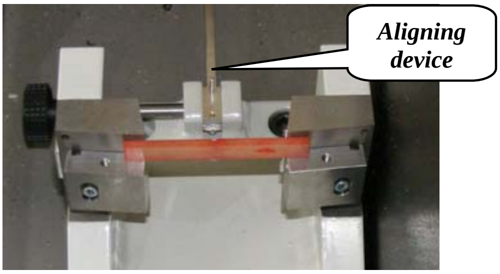
Figure 1. Shape and dimensions of the composite specimen used in Charpy test

2. MATERIALS AND WORK METHOD

In this paper, *E*-glass fibres (50 *mm* length) were used to randomly reinforce four kinds of resins: two polyester resins (*Heliopol 8431 ATX*, *Polylite 440-M880*); an epoxy resin (*LY554*); a vinyl-ester resin (*Atlac 582*).

The first of all, four composite plates having six layers were manufactured by using the hand lay-up technology. The average volume fibre ratio of the composite materials tested, was equal to 26 %, while the weight fibre ratio was 40 %. The conditioning time was two weeks at room temperature. Then, the plates made of composite materials were cut to obtain the specimens whose dimensions are shown in the figure 1, according to [5]. A total number of 20 *specimens* were manufactured.

The notch is usually introduced into the material specimen in order to produce a stress concentration and thus promote failure in the case of the ductile materials. Herein, the notch type *B* is made in case of all specimens tested (fig. 1). Moreover, the notch may be used to align the *Charpy* specimen with respect to the simple supports of the *Charpy* pendulum (fig. 2, a) so that the pendulum hammer hits the specimen on the opposite side of the notch.



a.

b.

Figure 2. Composite specimen simply supported on the Charpy pendulum:
a. aligning of the specimen with respect to the supports; b. specimen before impact.

The dimensions of the cross-section were recorded for each specimen before impact testing.

Then, the specimens were subjected to *Charpy* test by using the experimental stand shown in the figure 2. The distance between the simple supports was 60 *mm*.

The impact is produced by swinging the pendulum hummer against the test specimen from a height *h*. When it is released the hammer swings through an arc, hits the target specimen and after fracturing, it reaches a height *h'*. The difference between the initial energy and the remaining energy represents a measure of the energy required to fracture the specimen. This quantity is called *failure energy in Charpy test* and it is denoted by *U*.

The failure energy denoted by *U*, was recorded in case of each specimen tested. Finally, the resilience of each composite specimen was computed by using the following formula:

$$K = \frac{U}{A}, \qquad (1)$$

where *A* represents the aria of the specimen cross-section where the notch is manufactured.

3. RESULTS

The table 1 shows the experimental results recorded during *Charpy* test. To easily analyse the values obtained for the resilience *K*, the last column of the table 1 is graphically represented in the figure 3.

The scattering factor of the values of resilience *K* is quite small in case of each composite material tested.

The greater values of the failure energy (table 1) were measured in case of the composite materials made of polyester resins (*Heliopol 8431 ATX* and *Polylite 440-M880*). On the other hand, one may note that the smallest values of the failure energy were obtained in case of the composite *C3* manufactured by using of the epoxy resin *LY 554*.

Table 1. Experimental results recorded for all specimen tested in case of the Charpy test

No.	**Composite material**	**Number of specimen**	**Dimensions of the specimen** *b* (*mm*)	*h* (*mm*)	**Remaining thickness at notch** h_n (*mm*)	**Area of the cross-section** *A* (mm^2)	**Failure energy** *U* (*J*)	**Resilience** *U / A* (kJ/m^2)
C1	E-glass / polyester Heliopol 8431 ATX	1	10.10	4.30	3.50	35.35	4.04	114.29
		2	10.10	4.30	3.50	35.35	3.75	106.08
		3	10.10	4.40	3.60	36.36	4.20	115.51
		4	10.10	4.50	3.70	37.37	4.06	108.64
		5	10.20	4.30	3.50	35.70	4.13	115.69
C2	E-glass / polyester Polylite 440-M880	1	10.10	4.10	3.30	33.33	3.34	100.21
		2	10.10	4.10	3.30	33.33	2.90	87.01
		3	10.20	4.10	3.30	33.66	3.91	116.16
		4	10.20	4.10	3.30	33.66	3.25	96.55
		5	10.20	4.10	3.30	33.66	3.42	101.60
C3	E-glass / epoxy LY 554	1	10.10	4.10	3.30	33.33	1.79	53.71
		2	10.10	4.10	3.30	33.33	1.79	53.71
		3	10.30	4.10	3.30	33.99	1.82	53.55
		4	10.20	4.00	3.20	32.64	1.74	53.31
		5	10.10	4.10	3.30	33.33	1.81	54.31
C4	E-glass / vinyl-ester ATLAC 582	1	10.00	4.20	3.40	34.00	2.62	77.06
		2	10.10	4.00	3.20	32.32	2.54	78.59
		3	10.10	4.30	3.50	35.35	2.70	76.38
		4	10.00	4.40	3.60	36.00	3.00	83.33
		5	9.50	4.30	3.50	33.25	2.41	72.48

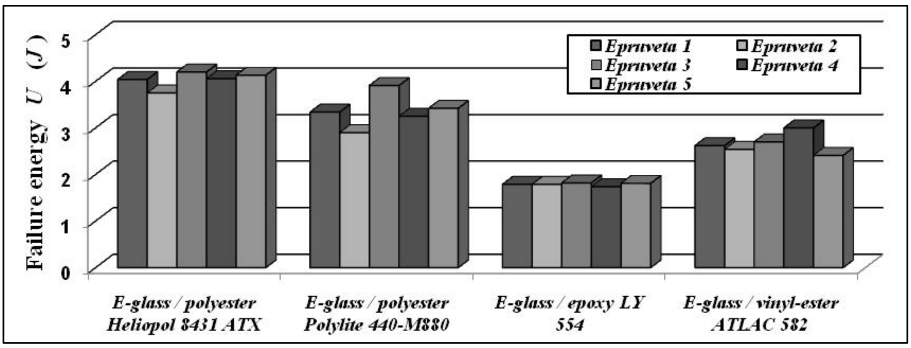


Figure 3. Mean values of the resilience U / A in case of the composite materials tested

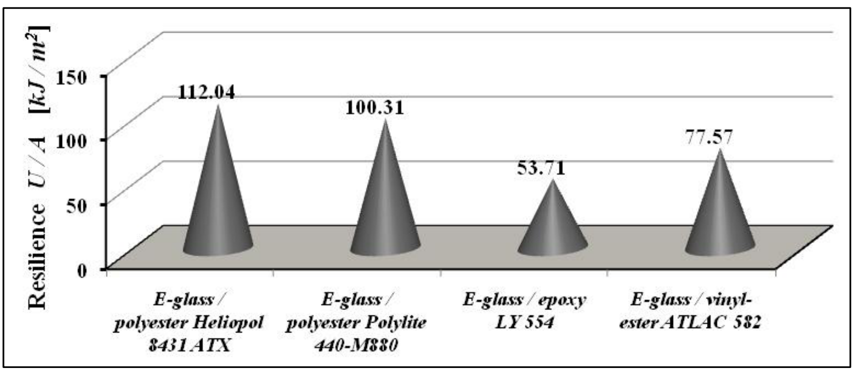


Figure 4. Mean values of the resilience U / A in case of the composite materials tested

Finally, the average values of the resilience *K* were computed (fig. 4). One may observe that in case of the composites C1 / *C2* made of polyester resins, the resilience *K* is approximately twice greater than the corresponding value obtained in case of the composite *C3* with epoxy resin *LY 554*.

C1 C2 C3 C4

Figure 5. Composite specimens after Charpy test

Figure 6. Delaminating developed at the breaking area

A photo of the composite specimens after *Charpy* test is shown in the figure 5. All specimens tested were partially broken during the impact test. This happened because the composite specimen was excessively deformed during the impact so that the hummer catched the specimen and dropped it before its complete rupture. This is the reason that only the first layers were completely damaged after impact test.

Expanded image of the failure area (fig. 6) shows that delaminating occurred at the level of the interface of the layers in case of some specimens.

4. CONCLUSIONS AND DISCUSSIONS

To improve dynamical properties (resilience *K*) of the polymeric composites reinforced with *E*-glass chopped fibres, polyester resins should be used to manufacture these kinds of composite materials.

Comparing the results of the paper with the ones obtained in a previous work concerning the *Charpy* test of some composite materials reinforced with *E*-glass woven fabrics [3], it could be remark that the strain energies *U* are greater in case of the composites reinforced with E-glass chopped fibres. It follows that the impact behaviour of composites analysed within this paper is better.

The remark regarding the partially broken of the specimens was also recorded in case of the composite materials reinforced with *E*-glass woven fabrics [3].

5. ACKNOWLEDGEMENT

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