Irradiation influence on a new hybrid hemp bio-composite

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The paper approaches theoretical and experimental issues regarding the behavior at static bending due to irradiation of a new hybrid composite reinforced with glass and hemp fibers, used especially in automotives industry. The advantages of fibers-reinforced composites are given by their high optimization capability, so that the final material's properties can be imposed according to a given application by choosing of a unique combination between matrix and fibers that lead to manufacturing of a light and ergonomic structure. A composite material may be subjected to radiations because it is part of a constituent material operating in an environment with radiations or can be subjected to radiations deliberately, in order to obtain higher properties of the material. In this second sense, the challenge is related to reach high static and dynamic structural performances by accomplishment of composite materials with enhanced properties that put as well value to the concept of composite structure.

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1. Introduction

The products manufactured from polymer matrix biocomposites use environmentally raw materials that after use, through biodegradation will be given to the nature's circuit. Polymer matrix biocomposites will play in future an increasingly more important role in manufacturing of important low weight products specific to interior parts as well as engine and suspension parts. Analyzing the implications regarding the replacement of metals with such materials, it should be mentioned that the advantage does not limit only to reduce weight but often at equal or superior operation. It is known that fibrous structures can be used as strength structures, only inserted in a support material called matrix. In composite constructions, most of the times, entirely different substances may be combined in such a way that their individual properties should achieve an optimal action. Usually, it is the pair of materials in which one has a bearing function, while the other is intended to contribute to the take over of moment of inertia. În hybrid constructions, the strength and rigidity of the various functions are taken over from many different materials, and at fibers-reinforced polymer matrix composite structures, the composite properties depend essentially on the type, orientation and fibers volume fraction. In such structures, the most used are laminates reinforced with glass, carbon and aramid fibers [1]. Generally there is a particular fascination for natural fiber composites, and even more in manufacturing automotives, composites prove competitive in terms of both price and the possibilities of substitution and successful completion of traditional materials (metals, ceramics, glass etc..), thus carrying out a great weight reduction of the vehicle [2], [3], [4]. Most applications include the construction of car body elements such as wings, doors, pavilions, hoods, etc. [5].

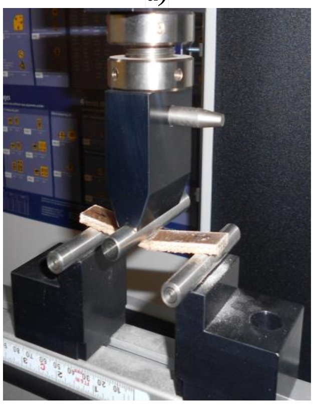
2. Material and method

In order to investigate the mechanical behavior of hemp-glass hybrid composite, it was irradiated (sterilization) with Gamma ray in order to achieve a composite material having good mechanical properties, composite that can be tailored to achieve bio-composites used in automotive industry, so auto parts will ensure a reduction in mass of transport vehicle. Irradiation of samples for testing have been conducted on IRASM irradiator (www.irasm.ro) and absorbed dose has been measured with the ECB dosimetry [M6], [M7], [M8]. Irradiations have been performed in the 1-250 kGy range, covering the doses used in most applications of radiation technology, but very high doses also, in which the effects of degradation can be put into evidence with certainty. Thus, specimens made of composite materials based on thermosetting resin and hemp fibers have been irradiated some with a dose of 2 kGy and a some with a dose of 56.7 kGy.

The new glass-hemp fabric hybrid composite consists of four layers of thermosetting resin reinforced with glass fibers having 35% fibers volume fraction and hemp fabric with the fibers volume fraction of 20%. The process for producing the glass-hemp fabric hybrid composite material consists that to form layers, hand lay-up technology has been used which provides the use of a roller to impregnate with resin both glass fibers and hemp fabric. The mechanical characteristics of the thermosetting resin with hardener are: tensile stress at break: 86 MPa; Youn's modulus: 3200 MPa; resistance to impact: 40 kJ/m^2.

The composite laminate panel is accomplihed from a glass fibers layer with a thickness of 1.5 mm alternating with a second layer of hemp fabric with a thickness of 0.5 mm, the operation is repeated to obtain a composite board consisting of four layers. Finally, the composite laminate panel thickness is 4 mm. The panel thus obtained has been kept at room temperature for two weeks after which the eight specimens have been cut corresponding to the shape bending test in accordance with EN ISO 527-2 standard [9]-[14] (Fig. 1).

a)



b)

Fig. 1. Hybrid glass-hemp specimens, before (a) and during the three-point bend test (b)

The specimens being carried out as an alternating structure, the first four specimens have been tested on "glass face" (Fig. 2) and the next four on "hemp face".

a

b

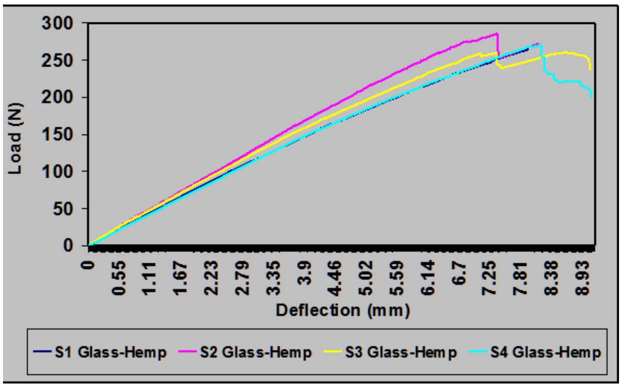
Fig. 2. Hybrid glass-hemp specimens after bending tests.

3. Results

After processing the data summarized in Table 1, following distributions have been illustrated in Figs. 3-4.

Table 1. Mechanical properties of hybrid glass-hemp composite determined in bending tests.

Specimen	Load at max. load [kN]	Stress at max. load [MPa]	Rigidity at bending [Nm^2]	Young's modulus [MPa]
1	0.26	105.7	0.26	3251.5
2	0.28	114,21	0.23	295.0
3	0.26	104.02	0.20	2611.8
4	0.27	108.05	0.21	2691.4
5	0.23	93.34	0.20	2537.6
6	0.32	129.26	0.12	1620
7	0.35	141.94	0.03	379.1
8	0.26	105.7	0.20	3251.5



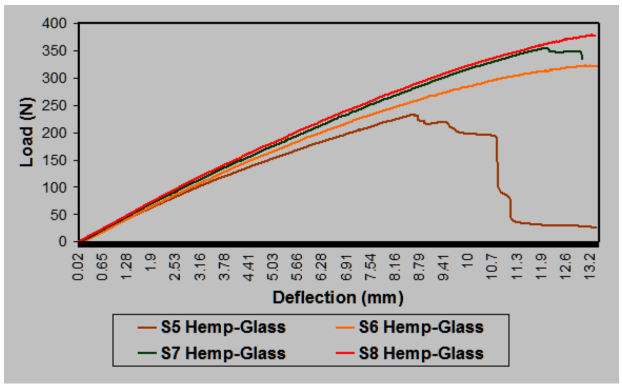
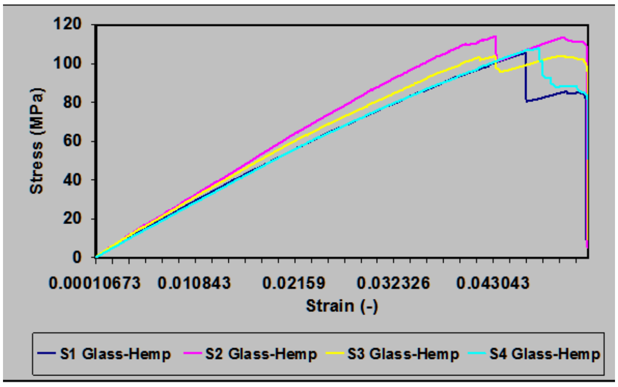


Fig. 3. Load-deflection distributions of hybrid glass-hemp specimens.

Specimens made of hybrid glass-hemp composite have been irradiated with the same dose of 2kGy, respectively 56.7kGy, after which they have been tested in bending on the materials testing machine of type LR5K Plus, that provides maximum force of Fmax = 5 kN (Figs. 5-6). They have been subjected to bending with a constant speed of 5 mm/min until break, or until the stress (load) and deformation (deflection) have reached a predetermined value (Figs. 7-9). Bending test results for the hybrid glass-hemp composite material irradiated with 2kGy and 56.7 kGy are based on the data summarized in Tables 2-3.



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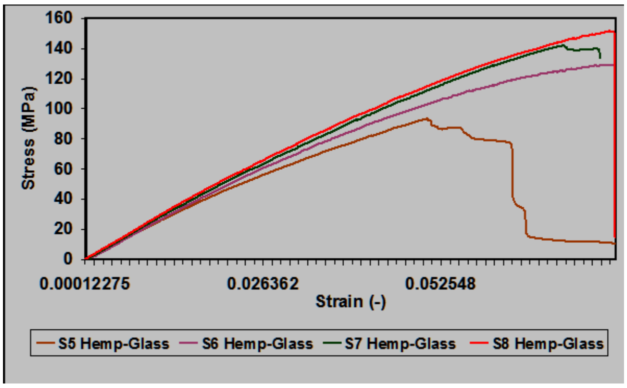

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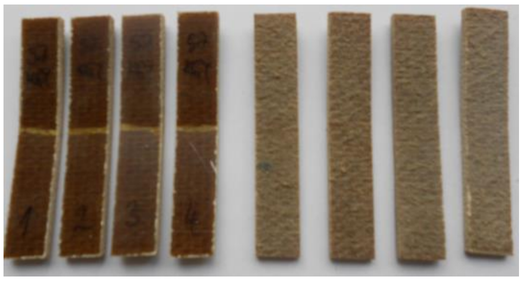
Fig. 4. Stress-strain distributions of hybrid specimens.

a

b

Fig. 5. Specimens irradiated with 2 kGy dosis.



a

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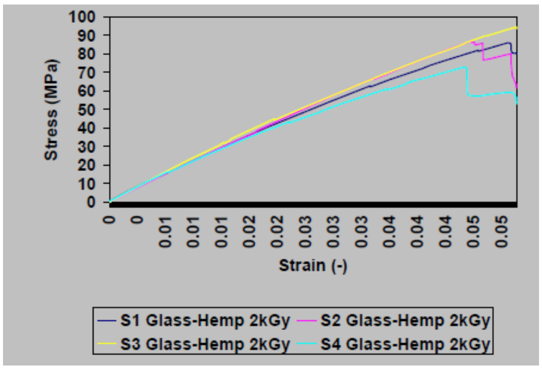
Fig. 6. Specimens irradiated with 56.7 kGy dosis.

Table 2. Mechanical properties of hybrid glass-hemp composite irradiated with 2 kGy dosis subjected to bending tests.

Specimen	Max. load [kN]	Stiffness [N/mm]	Strain [-]	Young's modulus [MPa]
1	0.14	21726.9	0.05	2224.8
2	0.14	19310	0.05	1977.3
3	0.15	22956.3	0.05	2350.7
4	0.12	20833.6	0.04	2133.3
5	0.21	20168.4	0.07	2065.2
6	0.16	18889.3	0.05	1934.2
7	0.15	19777.9	0.06	2025.2
8	0.18	21400	0.06	2191.3

Table 3. Mechanical properties of hybrid glass-hemp composite irradiated with 56.7 kGy dosis subjected to bending tests.

Specimen	Max. load [kN]	Stiffness [N/mm]	Strain [-]	Young's modulus [MPa]
1	0.18	31259.9	0.05	2134
2	0.22	36880.4	0.04	2517.7
3	0.24	38258.4	0.04	2611.7
4	0.20	31932.9	0.05	2179.9
5	0.34	27759.4	0.06	1895
6	0.28	23240.6	0.08	1586.5
7	0.30	31044.4	0.05	2119.3
8	0.32	31605.5	0.06	2157.6



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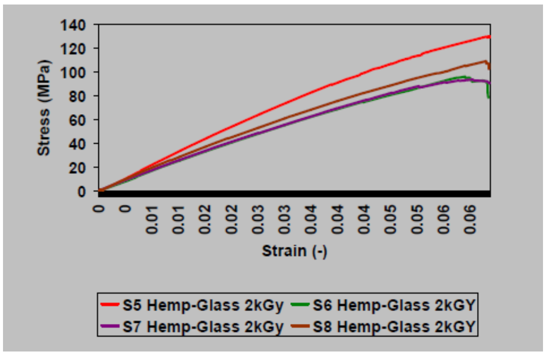

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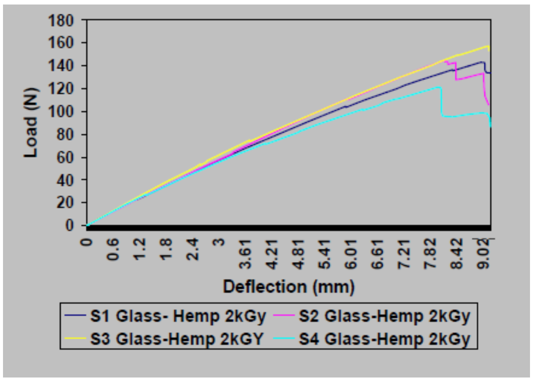
Fig. 7. Stress-strain distributions of hybrid glass-hemp specimens irradiated with 2 kGy dosis.



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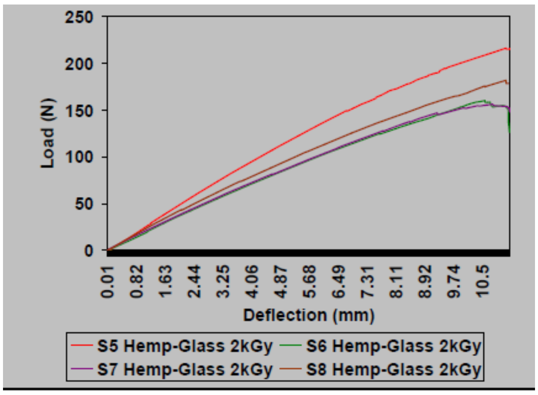

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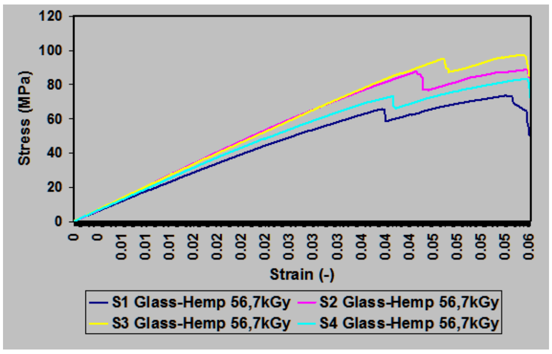
Fig. 8. Load-deflection distributions of hybrid glass-hemp specimens irradiated with 56.7 kGy dosis.



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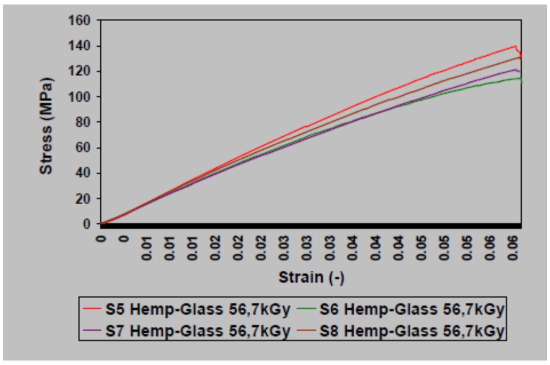

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Fig. 9. Stress-strain distributions of hybrid glass-hemp specimens irradiated with 56.7 kGy dosis.

4. Conclusion

From Table 2 can be seen that the stiffness is directly related to the material's structure. Analyzing the stress-strain characteristic curves we can see that their distribution is nearly linear due to the elasticity of the glass fibers (see Fig. 7).

Regarding to the comparison of specimens made of the hybrid glass-hemp composite material, graphics have been carried out from which it result the properties of irradiated hybrid composite with both dosis of 2 kGy and 56.7 kGy as well as a comparison regarding the non-irradiated and irradiated hybrid composite (Figs. 10-13).

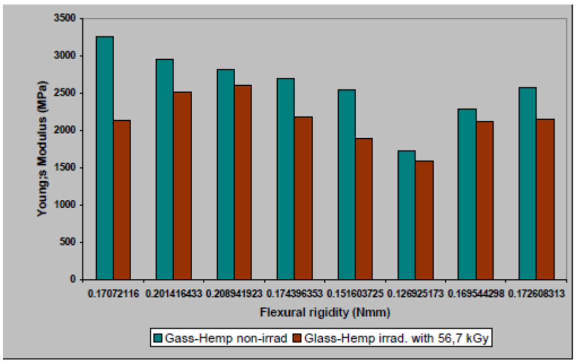

Fig. 10. Comparison between Young's modulus distributions of both types of specimens non-irradiated and irradiated with 56.7 kGy doses.

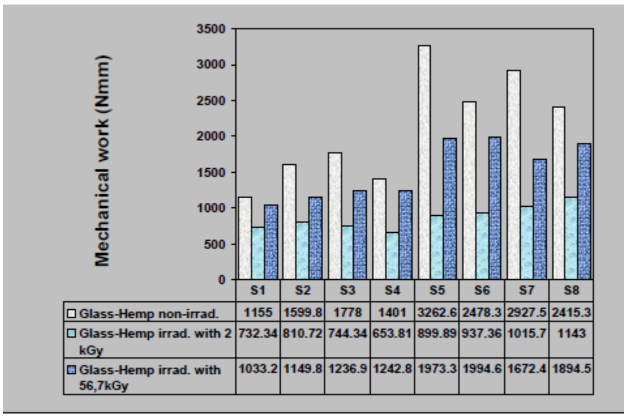

Fig. 11. Mechanical work distribution compared on irradiated and non-irradiated composites.

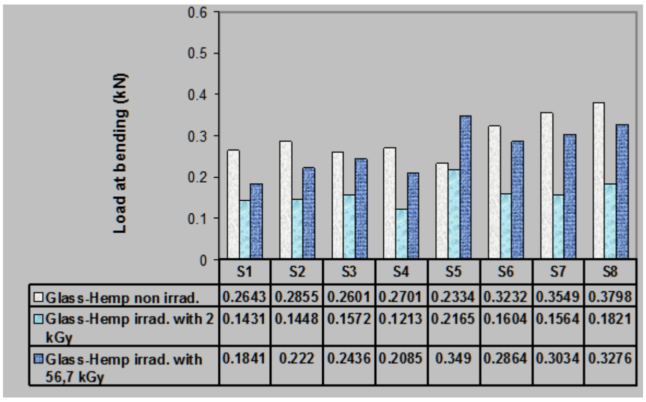

Fig. 12. Load at bending distribution compared on irradiated and non-irradiated composites.

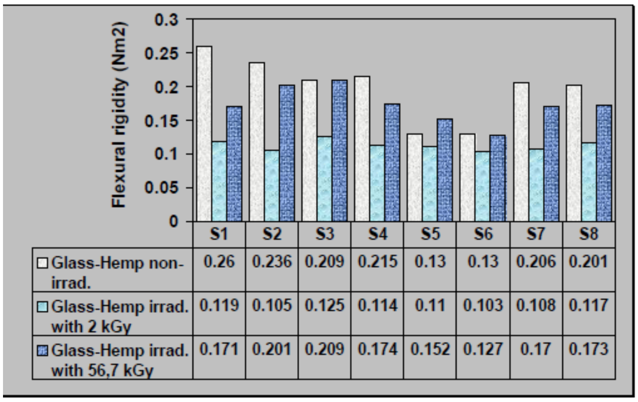

Fig. 13. Rigidity at bending distribution compared on irradiated and non-irradiated hybrid glass-hemp composite.

As shown from the above representations, the hybrid glass-hemp composite presents better mechanical properties at bending in case of irradiation with a higher dose (56.7 kGy) than in the case of irradiation with a lower dose (2kGy).

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