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ANALISYS OF MECHANICAL BEHAVIOUR FOR COMPOSITES BASED ON KEVLAR FIBRES

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Abstract: *Composite materials emerged as a substitute for classic materials from the desire to offer manufacturers other raw materials, with superior properties, that are easier to materialize. By designing them according to the requirements, the properties of these raw materials are clearly superior to those of each component taken separately acting that synergy like that of teamwork. Often, strong materials are relatively dense; also, increasing strength or stiffness generally results in a decrease in impact resistance. Kevlar has a network of hydrogen bonds between the polymer chains that give it great stiffness. This study focuses on the mechanical proprieties of Kevlar fiber based composites that can replace standard materials in various products.*

Keywords: *composite materials, Kevlar, stiffness*

INTRODUCTION

Composite materials emerged as a substitute for classic materials from the desire to offer manufacturers other raw materials, with superior properties, that are easier to materialize. By designing them according to the requirements, the properties of these raw materials are clearly superior to those of each component taken separately acting that synergy like that of

teamwork. This saving solution that leads to obtaining the requirements of the producers, however, also has negative aspects because part of the plastic components in their structure are not degradable and are not friendly to the environment.[1]
Often, strong materials are relatively dense; also, increasing strength or stiffness generally results in a decrease in impact resistance. The combinations and ranges of material properties have been and are still being extended by the development of composite materials. In general, a composite is considered to be any multiphase material that exhibits a significant proportion of the properties of both constituent phases such that a better combination of properties is achieved. According to this principle of combined action, combinations with a better property are formed by combining two or more distinct materials.[4]
Kevlar has a network of hydrogen bonds between the polymer chains that give it great stiffness. The specific modulus (related to density) in tension is higher than that of steel, but lower than that of carbon fibers or polyethylene.

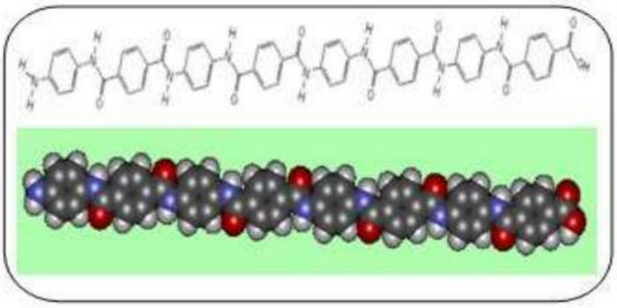

Figure 1: A section of an individual kevlar chain [24]

Due to the presence of the phenyl group in the poly-para-phenylene terephthalamide molecule, there is no free rotation around the C-N bond, the s-cis conformation is impossible (steric hindrance). The s-trans conformation is therefore more generally observed. Chains are well aligned, regular and oriented. Therefore, Kevlar is particularly crystalline, which explains its stiffness (E) and breaking strength (σ).

1. TECHNICAL REQUIREMENTS

The equipment used is a testing machine with constant traction speed, according to ISO 5893, consisting of: a fixed part, equipped with specimen fixing clamps and a mobile part equipped with 2 fixing clamps and the drive mechanism.
The testing machine is of the LS100 type (Fig. 3.1) produced by Lloyd's Instruments, Great Britain.

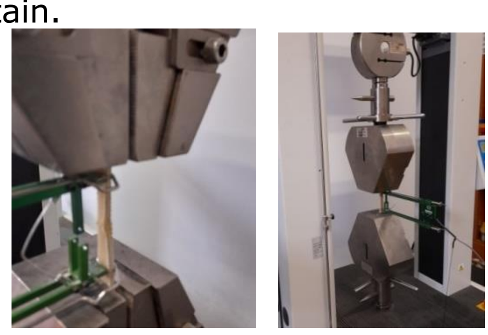

Figure 2: The universal testing machine with the specimen mounted between the clamps of the tensile testing device

Figure 3: Kevlar samples after testing

During the test, the load borne by the specimen and its elongation were automatically measured and recorded. With the help of the specialized software, the tensile strength, the modulus of elasticity of the composite material were calculated and the force-deformation curves were drawn. Tensile test results for Kevlar fiber reinforced composite material are summarized in Table 1.

Table 1. The values of the parameters of the samples subjected to tension

	K1	K2	K3	K4	K5	K6	K7
Length of the calibrated region [mm]	50	50	50	50	50	50	50
Speed [mm/min]	2	2	2	2	2	2	2
Sample width [mm]	11.5	11.4	10.3	11.7	11.7	11.5	11.6
Sample thickness [mm]	3.6	3.6	3.5	3.2	3	3	2.9

Table 2. proprieties of the material after traction tests

Sample	Critical force	Displacement	Strain	Stress	Elasticity modulus	Stiffness
	F	ΔL	ε	σ	E	k
	[N]	[mm]	[-]	[MPa]	[MPa]	[N/mm]
K1	4121	0,168	0,203	101	4831	3965
K2	5526	0,142	0,173	153	7102	5121
K3	2932	0,077	0,131	86	6345	4345
K4	4473	0,096	0,159	127	6221	4367

K5	4343	0,156	0,188	126	6067	4186
K6	4073	0,177	0,165	121	5577	3752
K7	4639	0,126	0,173	137	5953	4036

Table 3. Medium values of the mechanical characteristics for the tested samples

Force [kN]	3,628
Stress [MPa]	104.6
Strain [mm]	0.159
Rigidity [N/mm]	4266
Elasticity modulus [MPa]	6144
Normal Stress [MPa]	126.67
Maximum deformation [mm]	0.173
Mechanical work [N*mm]	3137

Characteristic force-displacement curves were also obtained by processing the experimental data. Similar curves generated by the test car software are observed.
By centralizing all the graphs above, we were able to obtain on the same graph all the representative stress-strain, respectively force-displacement curves for all 7 samples from the Kevlar-based composite material.
It can be seen that there are no big differences between the characteristic curves of the 7 studied samples.

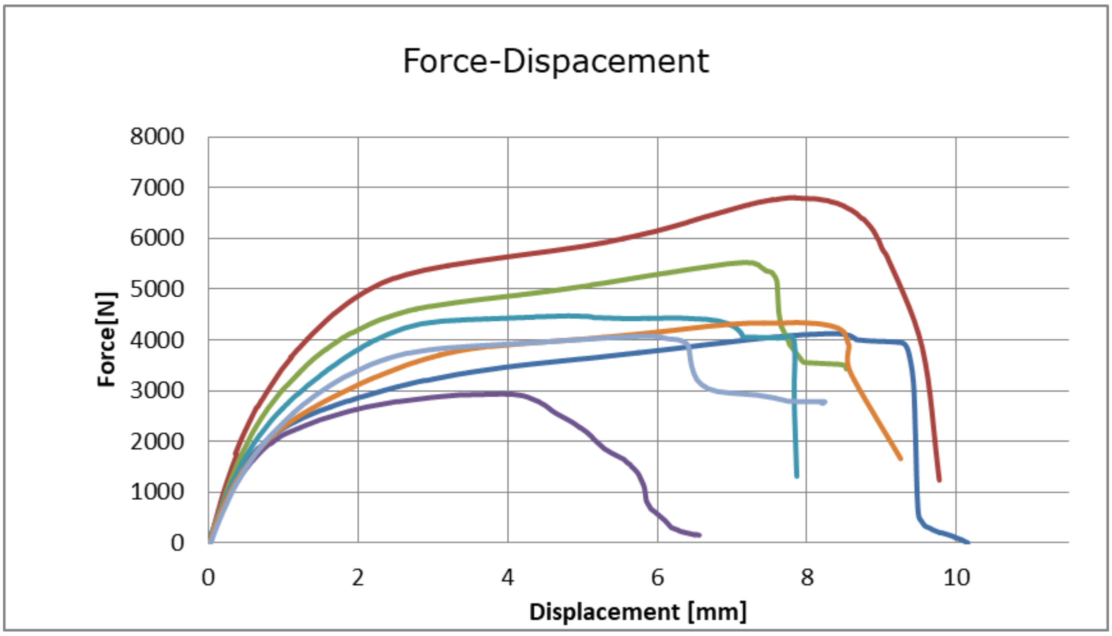

Figure 4: Characteristic curve for Kevlar specimens – Force-Displacement

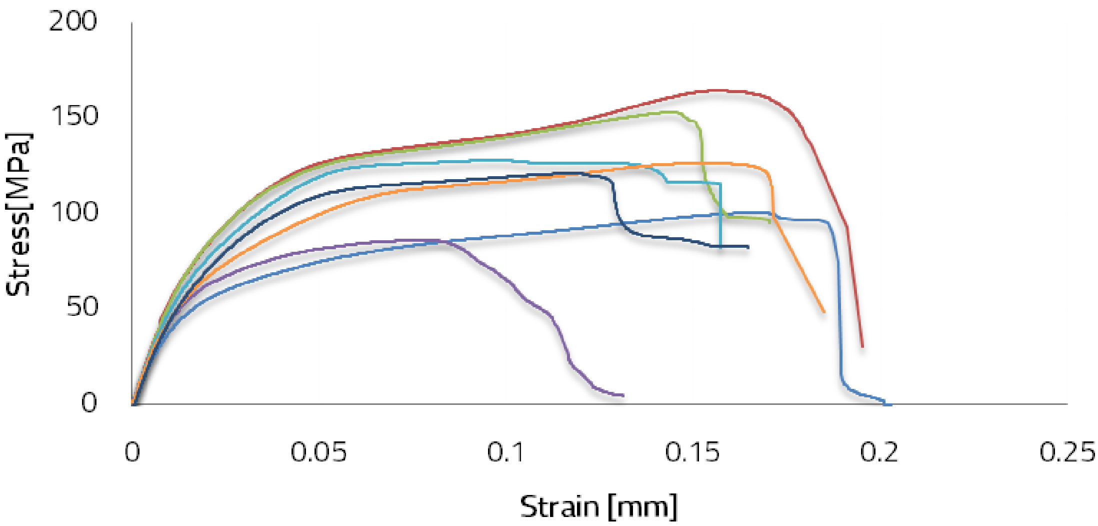

Figure 5: Characteristic curve stress train for Kevlar samples

Based on the experimental data centralized in tab. 4.1-4.3 the variation of the breaking force, the variation of the stiffness as well as the variation of the elasticity mode for all 7 tested specimens could be realized in Excel as can be seen in the graphs below.

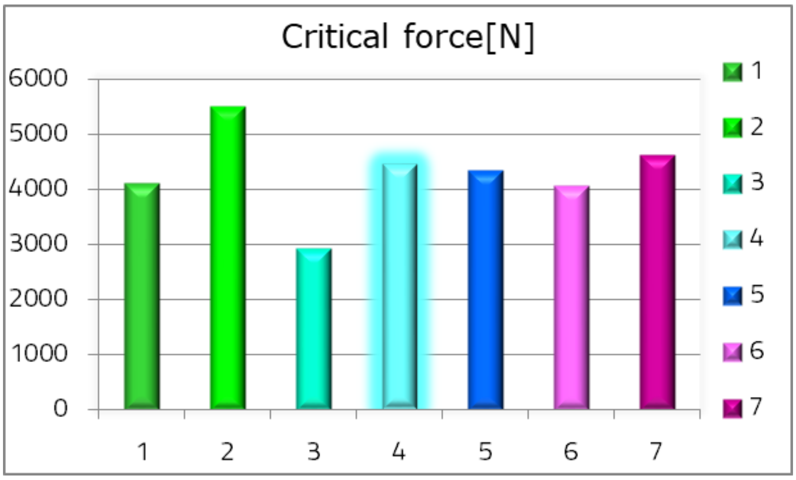

Figure 6: Force variation

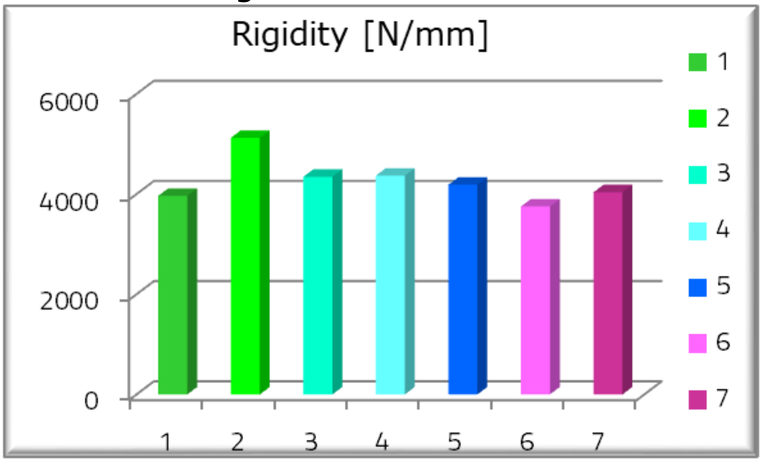

Figure 7: Rigidity variation

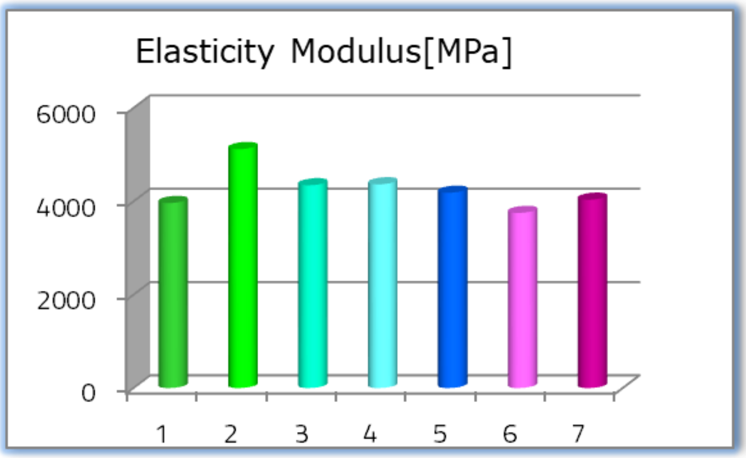

Figure 8: Variation of the Elasticity modulus

2. CONCLUSIONS

The aspects of the force-displacement curves on the yield zones show random variations that can be attributed to the detachment of the fibers from the matrix or to the flow of the matrix (its fracturing being prevented by the presence of the fibers). At the same time, it could be said, in this hypothesis, that the presence of fibers reduces the stiffness of the matrix.

The current study cannot be considered more than a beginning in terms of analyzing the mechanical properties of Kevlar-based composites. Any subsequent study will have to consider the method of obtaining the samples so that their cutting is done as precisely as possible, thus avoiding edge irregularities and, above all, their deformations.

Based on the experimental tests to determine the mechanical properties and especially the ratio between force and displacement, it was found that there are differences between the resulting values for each individual sample, the values falling as follows: in traction, on the X axis, the displacement varied between 0 –0.171 mm, and on the Y axis the force varied between 0 – 127 kN varying due to the geometric differences of the specimen.

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