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COMPOSITE MATERIALS – THEIR POTENTIALITIES AND APPLICATIONS IN AUTOMOTIVE INDUSTRY

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ABSTRACT: Modern car design and production trends are demanding continually decreasing of car weight. The decreasing of weight is strong connected with fuel consumption. This connection put pressure on the designers to apply unconventional materials in the car construction. Simultaneously the safety demands are increasing. One from many options to synchronize these requirements is an application of composite materials. Their properties are fated to using in machine industry. Submitted paper brings closer an example of composite materials using for chosen car component weight decreasing.
KEYWORDS: Composite materials, automotive industry, applications, testing

INTRODUCTION

Decreasing of car weight together with increasing of car safety is a big challenge in the car construction processes. One from many options is to use and apply the composite materials. Using of these materials for example in F1 constructions suggests the right way. Composite materials wide varieties of usage in combination with their universal utilization are the material engineering future. In our project, we decided to focus on composite materials based on resin and carbon fibres.

Carbon fibres are characterized via high toughness and low weight. In connection with resin, it can be made tough and light material, that can be shaped (in the production process) into required shapes and structures (Figure 1). Production technologies of these composites allow us to produce practically any product. Disadvantage of carbon composites is their predisposition on fragility. After material break, the product is no longer functional and it became corrupt. It is possible to eliminate even these negative characteristics, by addition of another material with proper properties like aramid fibres etc.

Figure 1: Axon carbon fibre frame [1]

Application of composites in serial production is currently financially no bearable a so it isn't much exploited yet. Though, the unstoppable technologies development gets good assumption for progressive introduction of composites into the conventional cars. Progressive substitution of individual components with composites, warranting the required component parameters and also the safety requirements, is one from many options by which one can the automotive industry with increasing requirements set out.

We tried to compare and test a possible substitution of classic component with composite component in our project.

APPLICATION OF COMPOSITE MATERIALS - Component selection

During the preparation phases of the experiment it was required to define suitable car component. It's to be a component witch could be real replaced by composite component and there should be possibility to test and compare the new component with original.

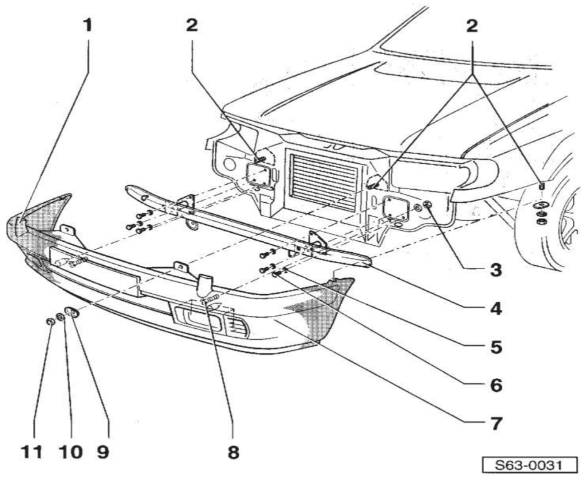

Figure 2: Front bumper reinforcement - position 4

For the proper component was chosen the front bumper reinforcement of Skoda Felicia (Figure 2). As *this component isn't visible from outside of the car, it allows us to focus on the function side of component. This fact allows us simplification and accelerating of composite component production.*

Decomposition of the component showed us some problematic parts those must be solved. It bargains about the drawbar hook attachment and the horn attachment. These parts should be relocated to the main car body. They functionality doesn't have any effect on the bumper reinforcement and so they are irrelevant for our project.

Final component was simplified. CAD model of chosen component can be seen on Figure 3.

Figure 3: CAD model of bumper reinforcement

Mould production

Introductory step for component production is mould production. It's highly necessary to prepare the original component surface for mould production. These preparations have determining effect for resultant mould parameters and that's why it's so necessary to put adequate care.

Single mould production begins with precise surface separation of the original component. For the first layer we have used gentle glass fibre (220g/m^2) for high surface quality of the mould. Another four layers are from rough glass fibre mat (450g/m^2). This mat gives required weight and toughness to the mould. After this manner produced mould (Figure4), it's separated from the original component and it edges and surfaces are mechanically adjusted (Figure5).

Figure 4: Mould production

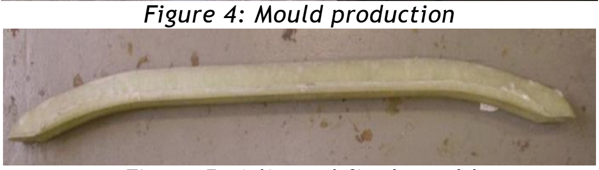

Figure 5: Adjusted final mould

Despite modifications of the original component surface, isn't the mould surface totally smooth. This can cause a surface defectiveness of the produced component. Therefore it's necessary to modify the mould surface before another usage. This phase is even more necessary for production of high quality surface products. Mould modified like this is prepared for another usage.

Component production

We elected following material composition for final component production (Table 1):

Table 1: Material composition

Layer	Fibre orientation	Material
1.	90°	Carbon 160g/m^2
2.	45°	Carbon 160g/m^2
3.	90°	Carbon 160g/m^2
4.	45°	Glass-fiber 450g/m^2
5.	90°	Carbon 160g/m^2
6.	90°	Kevlar-Carbon 165g/m^2

We have selected vacuum technology for composite component production and applied resin and fibres into the mould by help of conventional methods in the order of Table 1 (Figure 6).

Figure6: Kevlar-carbon fibre laying in the mould

Prepared and saturated fibres have been placed into vacuum and they got hardened (Figure 7). After the material hardened, the work layers were getting off. The surface of one side was adjusted for deformation elements connection and the other side for better look.

Figure 7: Vacuum pressed technology

Deformation elements production

Deformation elements are consisted of:

- *plate – this part made the connection surface for bumper reinforcement connection to car body*
- *tube – main deformation element (Figure 8)*

Single parts were made separately and thereafter they were connected in one piece (Figure 9). The complete units were mounted to the bumper reinforcement (Figure 10).

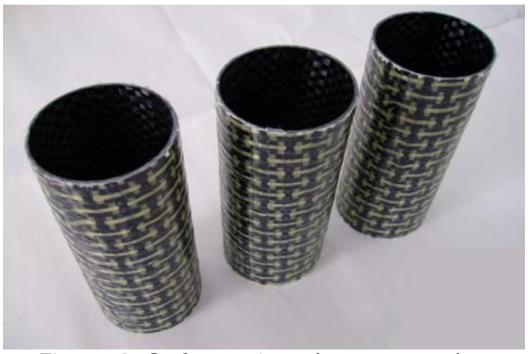

Figure 8: Deformation elements - tubes

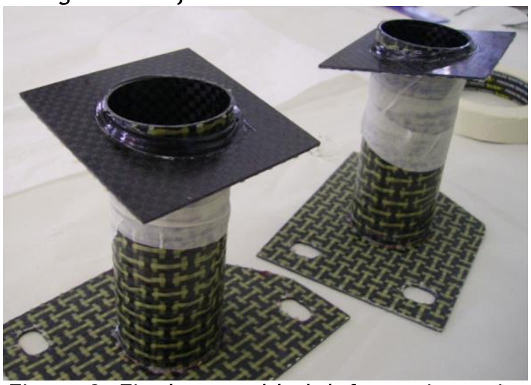

Figure 9: Final, assembled deformation units

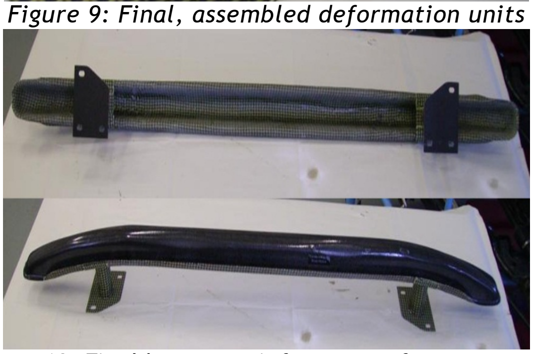

Figure 10: Final bumper reinforcement from composite

TESTING

Two testing methods were for testing chosen:

- *material tension test*
- *deformation element pressure test*

Composite material tension test

Composite material tension test was realised by static tension test. Test principle is to charge the specified testing sample till its breaking. There were four samples with specific dimensions - 250 x 25 mm and 1.4 mm thickness (Figure 11).

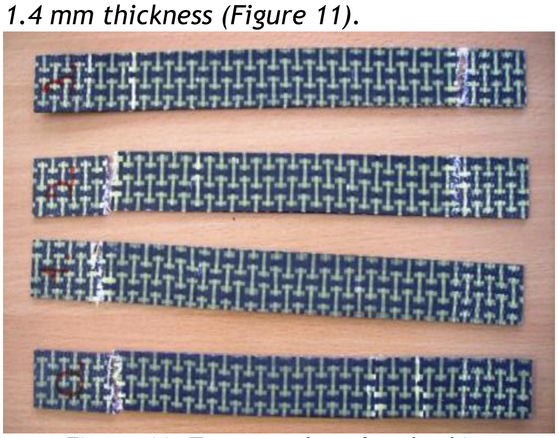

Figure 11: Test samples after braking

From the next table results, that the general measured strength of used composite material, which was averaged from the results of the 4 samples, is 387 MPa.

Table 2. Composite material tension test results

Sample	0	1	2	3	Averaged result
Volume of the limit strength F_m (N)	14904	11865	13833	15694	14074
Extension after breaking ΔL_c (mm)	1.02	4.73	1.79	2.77	2.58
Strength R_m (MPa)	442	321	370	414	387

Deformation element pressure test

Deformation element is the main reinforcement part, which is deforming yourself during crash. This deformation absorbs most of crash energy. This was main reason to make s test. The test was made by hydraulic test machine ZD40, which can forces 400kN or 40 tons. The test machine counteracted the test fair sample of deformation element, and the process was graphical recorded (Figure 12).

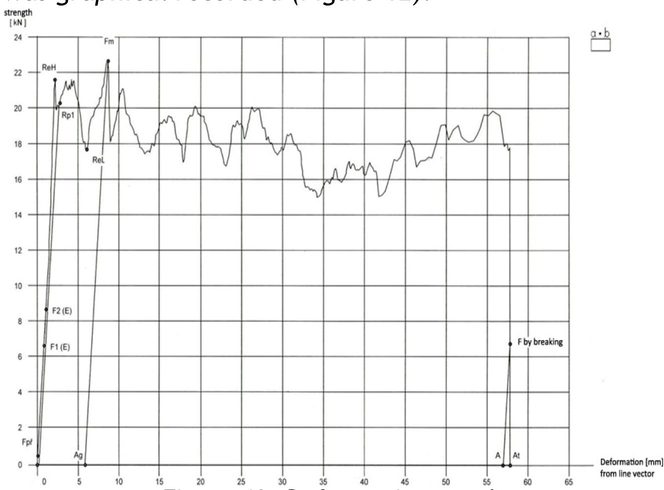

Figure 12: Deformation graph

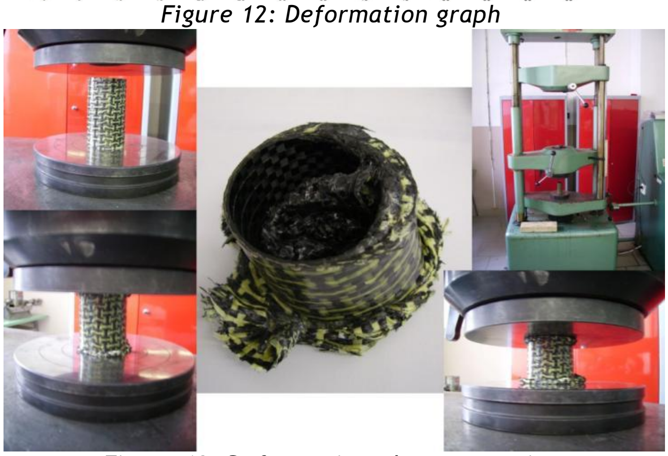

Figure 13: Deformation element testing

As you can see in table Table 3, the sample was deformed/compressed about 58 mm with average loading of 1818 kg, whereby the maximum loading reached 2270 kg.

Table 3. Deformation element test results

Sample length (mm)	100
Sample diameter (mm)	45
Compression (mm)	58
Max. loading strength (N)	22700
Max. loading (kg)	2270
Average loading strength (N)	18184
Average loading (kg)	1818

CONCLUSIONS

As shown in Table 4, measured mechanical parameters values of composite are comparable with metal reinforcement. The most important results and comparing with original component are shown in the next table.

Table 4: 1Final results

	Composite reinforcement	Metal reinforcement
Weight (g)	650	3700
Pull strength (MPa)	387	380
Maximum def. element loading (kg)	2270	-

Primary result indicator of our project is component weight decreasing with maintenance of mechanical properties. To show this property was out goal. The composite component weight is about 3050g lower as the metals.

Usage of composites in the car production gives us a very good option to decrease the car weight. Though not every component can be substituted, it can decrease the car weight up to dozens of kilos. This is the way we should go on for decreasing the fuel consumption. This way is also important for electric cars those need to be light for increasing of the endurance distance.

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