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COMPOSITE MATERIALS APPLICATION IN AUTOMOTIVE INDUSTRY

Abstract: This article presents the possibilities that provide modern composite laminates used in the automotive industry provide [1]. The use of appropriate engineering software allowed the definition of epoxy carbon laminate for the purpose of strength verification. The passive safety element made of materials commonly used in car production together with modern laminate has been compared. This verification shows the behavior of the car bumper beam during a simple road collision.

1. Introduction

The dynamic development as well as favorable forecasts of the automotive industry's expansion obtained on the basis of car market research constantly pose new challenges for manufacturers. These challenges apply to materials used in their construction, ranging from bodywork and plating to finishing materials, the type of drives and systems used. The automotive industry opens a wide field of development opportunities, combining electronics, mechanics and many other fields of science. Decreasing the weight of the vehicle along with the increase in safety is undeniably one of the better steps towards development. It is analogous to replacing steel with lighter aluminum, as well as composite materials that are increasingly displacing the raw materials used so far. Wide application and countless possibilities make their shares in car construction surely will be bigger and bigger. The safety of travelers is the key aspect when designing a car for serial or mass production. This is what makes engineers look for new materials for passive safety components. Ensuring proper car aerodynamics or reducing the load on the drive system, and finally reduced combustion, require specific properties from the materials used. The use of composite materials instead of materials used in recent years has many benefits.

2. Epoxy resin laminate reinforced with carbon fiber

Composite materials with an epoxy resin matrix and carbon fiber reinforcement are popular due to the successes achieved in the aerospace industries. The variety of methods of their production provides manufacturers the possibility of obtaining shapes and unattainable strength using conventional materials. To ensure the desired properties, it is very important to choose the right warp and reinforcement. In addition to choosing these materials, one must also choose the form of the reinforcing phase. In the case of composite materials, there is a whole range of different materials that successfully play the role of the reinforcing phase. The most common are glass, aramid and carbon fibers. The next step after choosing the material is to choose the form of reinforcement. Depending on the properties, which should have the finished product, it is needed to choose the right form of reinforcement. The best strength properties are exhibited by long continuous filaments. They allow to transfer almost all loads without transferring them to the matrix. Short continuous fibers, staple fibers, dispersions, reinforcing mats or fabrics are just a few items from the range of possibilities provided by the reinforcing phases. The fiber diameter, the cross-sectional shape of the fiber and the positioning of the fibers relative to each other are also available. Both long and short fibers can be laid unidirectional or bidirectional. The bidirectional arrangement allows different fiber interleaving combinations. For the purpose of determining the properties resulting from the laying of reinforcing fibers, a coefficient of the efficiency of fiber utilization was introduced. Figure 1 shows the value of this coefficient depending on the distribution of the reinforcing phase. It was assumed that successive layers are located one above the other at an infinitesimal distance.

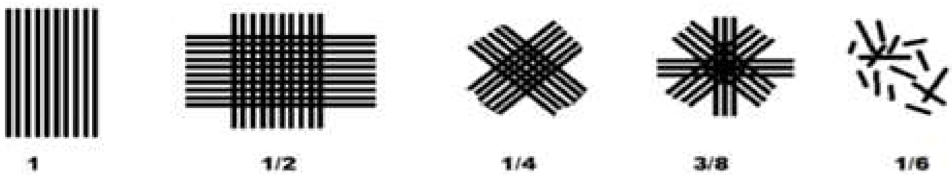

Fig. 1. The values of the fiber utilization coefficient depending on their arrangement

We use this coefficient when we want to determine the strength of the material with the reinforcing phase in a specific direction for a given type of load. By substituting the load parameters to the appropriate formula and multiplying the whole by the value of the coefficient, we are able to determine the yield limits of the material. The mathematical dependence is defined by equation [2].

$$\sigma_k = \gamma[\sigma_w V_w + \sigma_o \varepsilon_w (1 - V_w)] \quad (1)$$

where: σ_k- tensile strength of the composite [MPa]
γ- coefficient of reinforcement use
σ_w- tensile strength of fibers [MPa]
V_w- volume fraction of fibers
σ_o- tensile strength of the matrix [MPa]
ε_w- distortion of fibers

After selecting the appropriate reinforcement, it is also important to choose the appropriate warp. Depending on the type chosen, for example, increased resistance to high temperatures, flexibility, stiffness or resistance to aggressive substances can be achieved. The substance that shows the best properties on the matrix material is epoxy resin. Unlike other types of resins, this material exhibits the lowest shrinkage after hardening, has very good strength properties and provides quite high geometric accuracy after forming. The disadvantage of the resins is their thermosetting. This excludes recycling to the original form. It is recommended, however, to use thermoplastics to make it possible to re-use the raw material after its period of use. However, polymers belonging to the group of thermoplastics as the matrix material have worse properties than duroplastics. Their plasticity is higher and their durability is lower. Unfortunately, all fibrous composites in the polymer matrix are characterized by a relatively low maximum working temperature. Increased working temperature leads to the destruction of the matrix, which after some time is destroyed as a result of material fatigue. Regardless of the type of warp or reinforcement, many defects of the structure are possible already at the production stage. Figure 2 shows the structure of the laminate with a reinforcing phase.

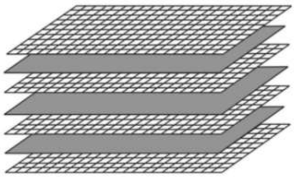

Fig. 2. Laminate structutre

The high costs of components made of carbon composites make them only used in luxury cars. Car manufacturers, trying to limit the price increase of the product, try to use these materials in places where their properties will be properly used. In addition to decorative elements in the interior, external covers, there are also composites forming load-bearing structures. For these purposes, ultra-strong fibers and warps with improved strength properties are used. The implementation of the correct composite requires time and precision, and machining or joining is also difficult. All this makes prices of such products often exceed the prices of traditional elements several times

3. Strength testing

In order to carry out the strength verification of the element made of laminate, it is necessary to be able to correctly model the laminate in a computer program. The Siemens NX computer program with its laminate modeling module provides excellent opportunities for this type of research. This software enables not only verification of isotropic, but also anisotropic materials. Proper definition of the laminate allows, therefore, to examine the properties of the element made, for example, of a carbon fiber reinforced composite. The structure of the modeled and real laminate is shown in Fig. 3.

4. Conclusions

In order to obtain the right strength of the material, it is important to choose a warp and reinforcing fiber. The configuration of the position or thickness of individual layers also reflects on the strength properties. Thanks to CAE engineering programs, it is possible to carry out strength tests of both isotropic and anisotropic materials. Proper definition of the material allows to obtain information on the distribution of stresses in individual layers. This knowledge will allow you to properly prepare the laminate before starting production. Computer research should be confirmed by research of real elements, because only they can make us sure that the obtained results are correct and are reflected in real conditions.

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