

Submitted: 2016.12.13

Accepted: 2016.12.16

Published: 2016.12.26

UNCONVENTIONAL MATERIAL PART FEM ANALYSIS

Michal TROPP¹, Michal LUKAC²

¹ Eng. Michal Tropp, University of Zilina, Mechanical Engineering Faculty, Department of Design and Mechanical Elements, Slovakia, e-mail: michal.tropp@fstroj.uniza.sk

² Eng. Michal Lukac, PhD., University of Zilina, Mechanical Engineering Faculty, Department of Design and Machine Elements, Slovakia, e-mail: michal.lukac@fstroj.uniza.sk

ABSTRACT

The article covers the usability of alternative materials in vehicles construction. The paper elaborates upon the setup of the process and analysis of the results of carbon composite component FEM model. The 3D model, used for the examination, is a part of axle from alternative small electric vehicle. The analysis was conducted with the help of MSC Adams and Ansys Workbench software. Color maps of von Mises stress in material and total deformations of the component are the results of calculation.

KEYWORDS: FEM, carbon fiber, composites, suspension

ANALIZA MES ELEMENTU Z MATERIAŁÓW NIEKONWENCJONALNYCH

STRESZCZENIE

Artykuł dotyczy możliwości wykorzystania alternatywnych materiałów w konstrukcji pojazdów z wykorzystaniem symulacji MES. Praca opisuje proces przeprowadzanego eksperymentu oraz analizy wyników elementów wykonanych z kompozytu węglowego. Do badań wykorzystano model 3D elementu osi z małego pojazdu elektrycznego o napędzie alternatywnym. Analiza została wykonana przy pomocy oprogramowania MSC Adams i Ansys Workbench. Wynikami obliczeń są mapy naprężeń materiałowych von Misesa oraz całkowitych odkształceń elementu.

SŁOWA KLUCZOWE: MES, włókno węglowe, kompozyty, zawieszenie

1. Introduction

According to the statistical data from 2012, about 84 million vehicles were produced worldwide every year. This number has been increasing every year [1, 2]. This is closely related to the problems of environmental pollution and at the same time reduction of oil reserves, which are the main source of fuel for more than 99% of the vehicles. Manufacturers and governments want to reduce fuel consumption. One of the current trends is called "Downsizing". This is about engine downsizing strategy and improvement of their energy balance, for example with the use of turbocharger. Other manufacturers are moving towards the use of alternative energy sources, hybrid technology or going the way of the weight reduction of vehicles using unconventional materials such as aluminum alloys, high strength steels or the use of carbon and other composites [3].

2. Analysis characteristics

The article covers the calculations of vehicles body strength made from unconventional material, specifically carbon fiber. Design and calculations are made by using the CAD system Creo Parametric 2.0, Catia and FEM software ANSYS Workbench, which includes the necessary functions to calculate the composite structural FEM model [4].

The process of creating a 3D model with next necessary modifications is described below.

3. 3D model creation

As a first step, the model and shell structure were created in the Creo Parametric 2.0 software. The shell thickness was the same as the thickness of composite, which the component was made from. The part is a component from an assembly of a small vehicle frame shown in fig. 1.

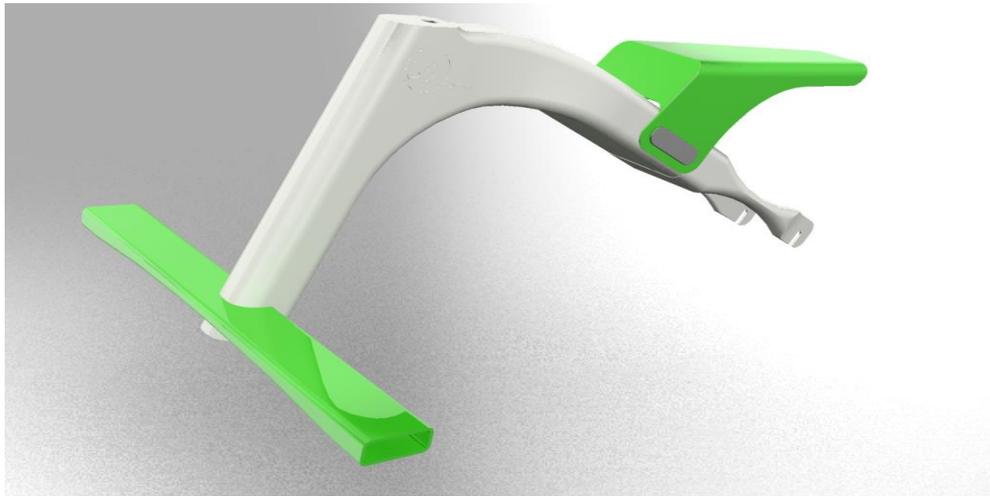


Fig. 1. The shape of the frame assembly

The model of the solved part is shown in fig. 2.

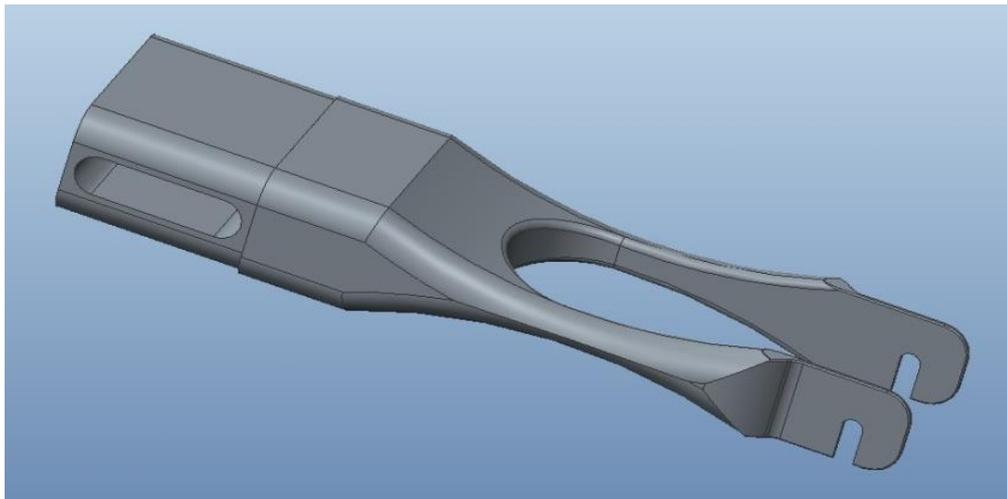


Fig. 2. The shape of the 3D model of the calculated frame part

4. Extraction of the 3D surface model

By using CATIA V5 software, the outside surface of the 3D model was extracted. The extracted geometry of the calculated part is shown in fig. 3.

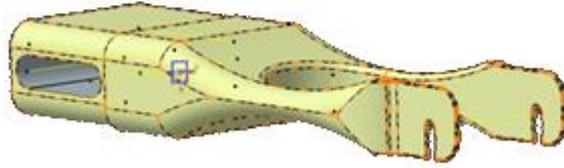


Fig. 3. The Shape of surface model used for the calculation

Extraction was performed by using the "Multiple Extract" feature. Consequently, it was necessary to save this area in STEP format and define it in ANSYS Workbench as the basic geometry [5, 6].

Second part of this section described the procedure of definition of boundary conditions in ANSYS Workbench software.

5. Defining the boundary conditions

After the transfer of the extracted areas from the 3D model into the ANSYS Workbench, defining the boundary conditions of component-size or location of a burdensome power, the location and number of degrees of freedom withdrawal of component is needed (Fig. 4).

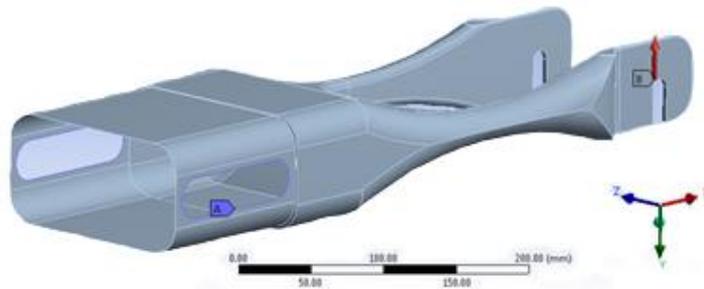


Fig. 4. Boundary conditions of the calculation

6. Definition of material properties

The component was simulated as an element made of the carbon fiber composites. Selection of a predefined material from the software library which characteristics correspond with used carbon fabric is needed [7]. The next step was to create a fabric with a thickness corresponding to the thickness of the carbon fabric offered by different manufacturers. Creation of the laminate followed the determination of the type and thickness of the fabric (Fig. 3).

It is important to choose the order of layers and the orientation of the carbon fibers correctly, when entering the laminate in it [8, 9].

The next part of the article describes the procedure of strength calculations of the components in ANSYS Workbench, in order to obtain the values of tension and deformation of the desired structure.

7. Selecting the direction of orientation of the layers of laminate

It is necessary to select the area that will define the shape and orientation of the neutral axis of the filaments. Fig. 5 shows the distribution of fibers within the laminate and directional laminate stiffness which depends on the angle of rotation of the individual layer of fabrics neutral axis. Dimensions of layers are on the left side of the picture and the stiffness characteristic on the right side.

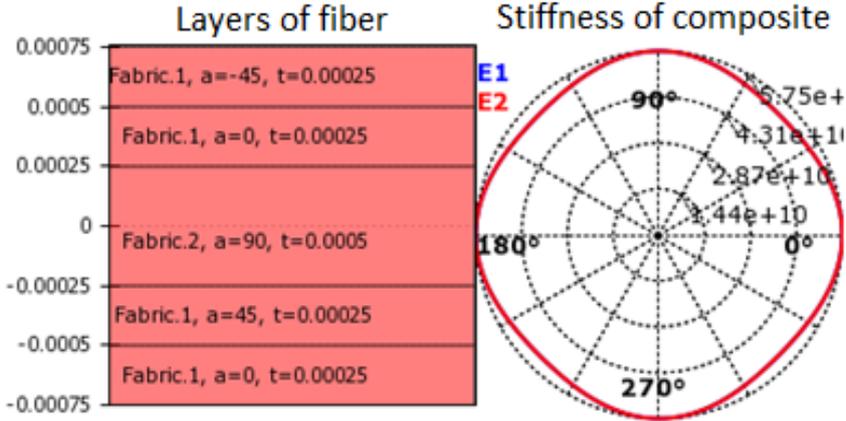


Fig. 5. The layers and stiffness diagrams

Fig. 6 shows the direction vectors coating the selected surface in the laminate. Yellow arrow points the neutral axis (direction) orientation of the fibers of each layer of the laminate, purple arrow represents the direction normal storage layers with the respect to the selected face.

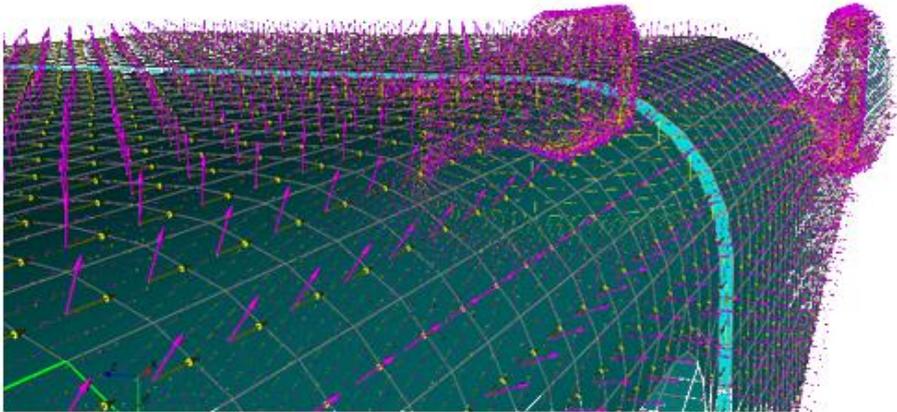


Fig. 6. The distribution of fibers in the material

8. Results analysis

The results analysis of classical strength calculations of material's stress (Fig. 7) and total deformation of the component (Fig. 8) was necessary to achieve the goal of the research. The maximum von Mises stress value was detected in the thinnest area of the frame part (881 MPa) and the maximum deformation in the y-axis at the end of the part (51.104 mm).

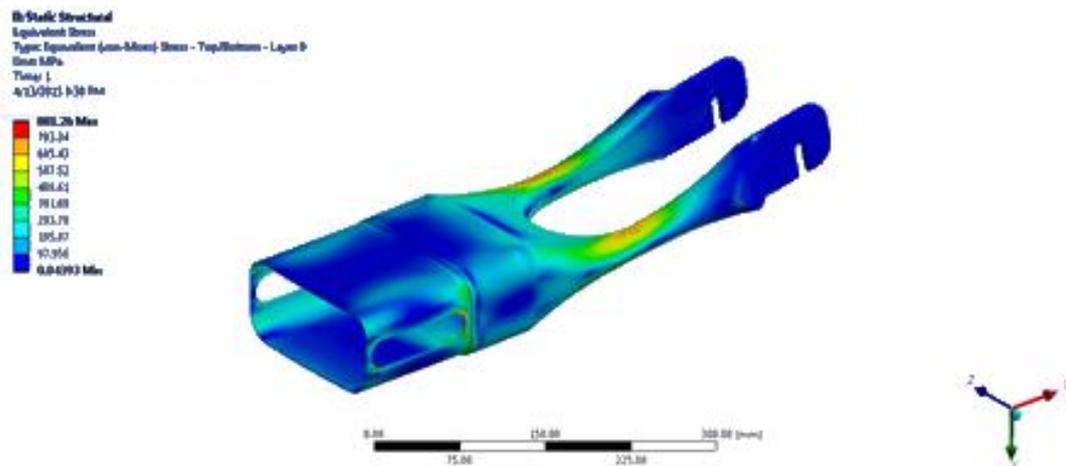


Fig. 7. Von Mises stress in material

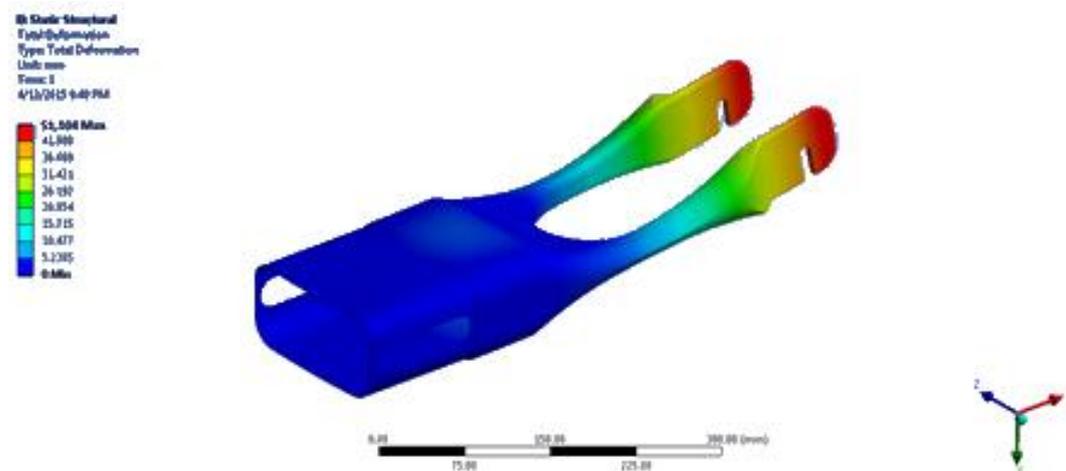


Fig. 8. Total deformation of the component

9. Conclusions

The results of simulation of the frame part made from a carbon composite had shown the possibility of usage of this type of material for small vehicle suspension without the need of the classical spring arrangement.

10. Acknowledgment

This paper presents results of work supported by the Slovak Scientific Grant Agency of the Slovak republic under the project No. VEGA 1/0077/15.

11. References

- [1] P. Drozdziel, L. Krzywonos, *The estimation of the reliability of the first daily diesel engine start-up during its operation in the vehicle*. Maintenance and Reliability 1(41), 2009, pp. 4-10.
- [2] R. Kohar, S. Hrcsek, *Usage of dynamic analysis to determine force interactions between components of rolling bearings*. Communications, Vol. 14, Issue 3, 2012, pp. 62-67.
- [3] J. Caban, P. Drozdziel, D. Barta, S. Liscak, *Vehicle Tire Pressure Monitoring Systems*. Diagnostyka, vol. 15, No. 3, 2014, ISSN 1641-6414.

- [4] R. Kohar, S. Hrcek, *Dynamic analysis of a rolling bearing cage with respect to the elastic properties of the cage for the axial and radial load cases*. Communications, Vol. 16, Issue 3A, 2014, pp. 74-81.
- [5] L. Jedlinski, J. Caban, L. Krzywonos, S. Wierzbicki, F. Brumerčik, *Application of vibration signal in the diagnosis of IC engine valve clearance*. Journal of Vibroengineering, Vol. 17, No. 1 (2015), pp. 175-187.
- [6] M. Martikan, F. Brumerčik, R. Bastovansky, *Development of Mechatronic Deformation System*. Applied mechanics and materials, Vol. 803 (2015), pp. 173-178.
- [7] F. Brumerčik, E. Brumerčikova, B. Bukova, *Mechatronic and Transport System Simulation*, Vol. 803 (2015), pp. 201-206.
- [8] S. Hrcek, R. Kohar, S. Medvecký, *Determination on the maximum roller bearing load with regards to durability thereof using FEM analysis*. Communications, Vol. 14, Issue 3, 2012, pp. 55-61.
- [9] A. Nieoczym, *Application of a transportation flux for determining qualitative indices*. Communications, Vol. 7, Issue 1, 2005, pp 47-48.