Modeling and strength analysis of the prototype of the multi-tasking car trailer

Bogdan Posiadała[1,*], *Piotr* Ladra[1]

[1]Institute of Mechanics and Machine Design Fundamentals, Czestochowa University of Technology, ul. Dąbrowskiego 73, 42-201, Częstochowa, Poland

Abstract. The subject of the paper is modeling and strength analysis of the prototype of the multi-tasking car trailer. The innovativeness of the solutions applied consists in the combination of several single-purpose trailers into one, allowing for multitasking and the combination of several specialized trailers. Using the author's solution, the prototype of a multi-purpose trailer has been developed, which has the characteristics of several specialized trailers, such as for the transportation of general cargo, kayaks, motorcycles, quads etc. The model has been created by using SolidWorks package and it has been used for full strength analysis by simulation module. The sample analysis results cover various load configurations with respect to selected trailer construction components.

1 Introduction

The issues about the road transportation have been considered in this paper. This work is a result of progress of considerations of the studies described in [1-7]. By presenting in the paper an object of research, the proposal solution, answering the questions with difficulties occurring during the work of the car trailers, have been described.

An usual car trailers meet with problems of carrying the load intendent to a specialist trailers. In this context, the design of construction the special multi-tasking car trailer, which in its construction combines few one-tasking trailer, has been included in [2, 3]. This paper is a continuation of the proposed solution. The proposed construction solution is based on a traditional car trailer, which due to its modularity is able to transform into a specific application. What distinguishes it from other trailers is multitasking achieved thanks to innovative solutions. The composite trailer does not differ much from a standard trailer of this type, it is 1300 mm wide and 2200 mm long. But thanks to modifications, it can get dimensions of 2000 mm in width and 4000 mm in length (as platforms). GVW (gross vehicle weight) this construction is 1350 kg, what with the weight of the trailer not exceeding 300 kg, allows to load 1000 kg of cargo. The trailer frame is made of structural steel S355 with the following properties: 220 HB, Rm = 490-630 MPa, Re = 335 MPa.

* Corresponding author: bogdan.p@imipkm.pcz.pl

Reviewers: *Jozef* Bocko, *Grzegorz* Domek

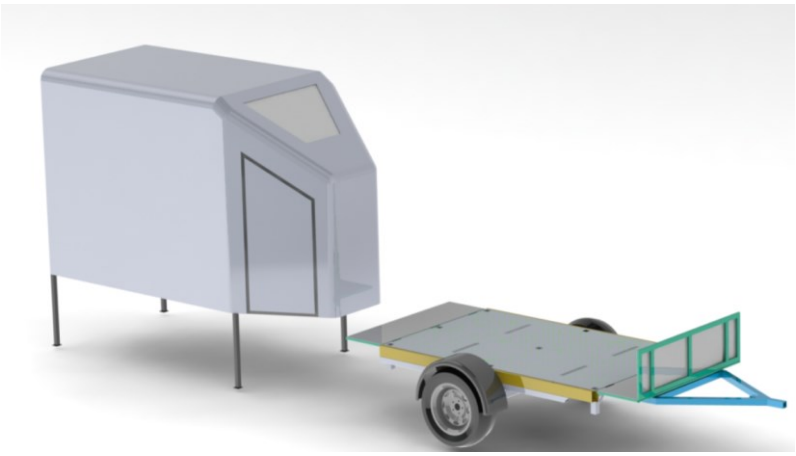

Fig. 1. Model of the car trailer – one of the applications

The trailer is adapted for various tasks, including specialist tasks, such as transporting large loads, motorcycles or kayaks. It has a hinged platform enabling entry of small vehicles, e.g. mowers or quads. One construction replaces several other trailers.

The strength analysis of the prototype of a multi-tasking car trailer has been performed in scope of this work.

This trailer in its construction contains some innovative solutions which haven't been used in designing such machines yet. The model of the prototype have been made in SolidWorks 2015 environment and it has been used as a basis to the strength studies in module: Simulation. The innovative constructional solutions have been reserved at the Patent Office of the Republic of Poland.

The proposed solution have been made as a result of the needs to design one universal trailer combining purposes of transporting in example: kayaks, gates, windows, or the self-propelled vehicles (lawn mower or quads), and motorcycles. The applied in the prototype solutions significantly expands the functionality of the system. Furthermore, by designing this construction, the adaptation of the different type od the superstructures is possible. There is a need to transform the car trailer to be used of the other purposes, among others to modify a car trailer into a panel van (wagon) or carriage of horses.

2 Strength analysis of the selected construction nodes of the prototype

The designed prototype has been made in SolidWorks 2015. The static analysis has been made on the basis of the frame model, and it has been performed in the Simulation Module. The frame model has been designed with all its components and all the system has been subjected to the analysis. Since the prototype has been composed of the two main subsections: external (see Fig. 2) and internal (see Fig. 3) frames, the two cases of the analysis has been performed. Cases of the analysis:

- Test no. 1- the external frame,
- Test no. 2- the internal frame.

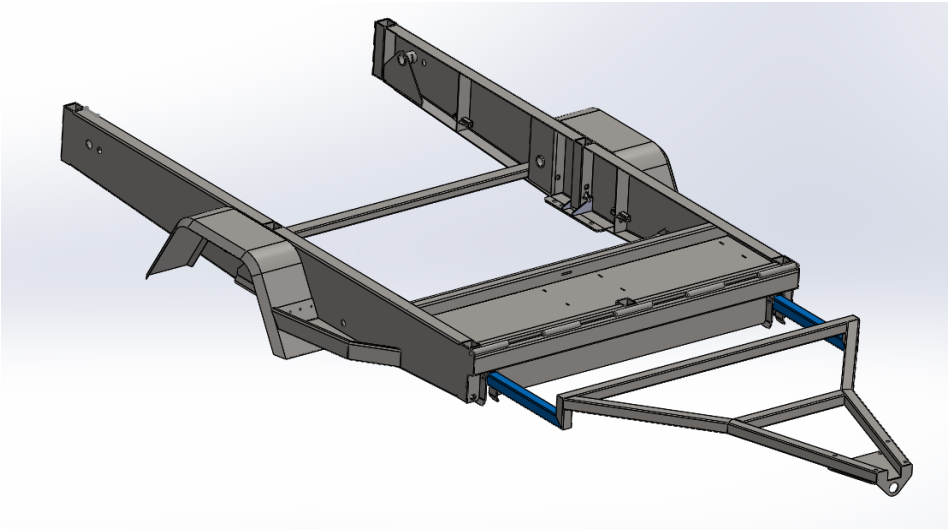

Fig. 2. Model of the external frame of the car trailer

By entering the description of boundary conditions of the model, the trailer's working conditions were reflected. These conditions are shown in Figure 4. The boundary conditions include the area for attaching the trailer axis and towing hook. The calculation model reflects the full nature of work while the trailer is in operation.

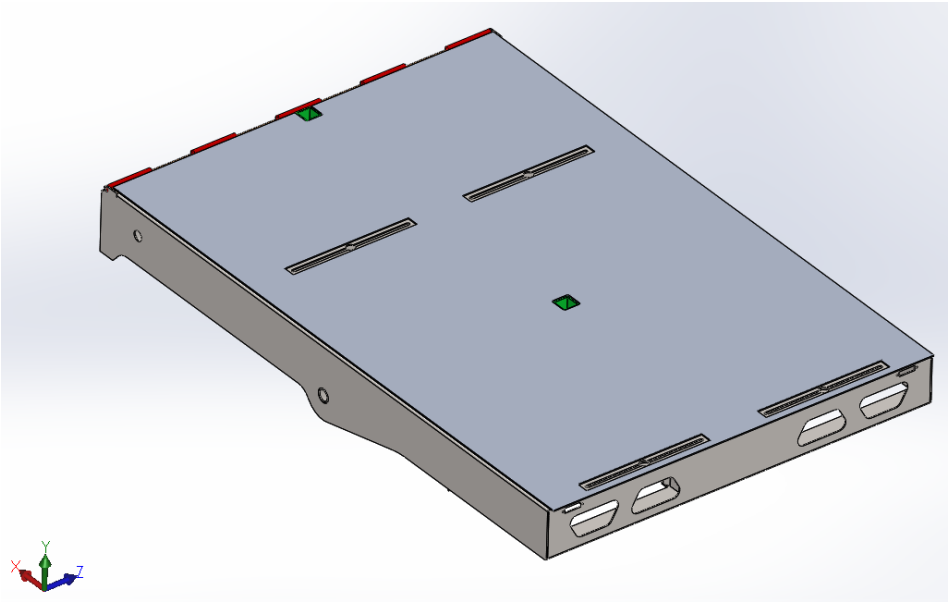

Fig. 3. Model of the internal frame of the car trailer

The static analysis, which included the distributions of displacement, reduced stresses and strains, have been considered. The two tasks have been described below.

2.1 Task no. 1 – the external frame

The external frame has been subjected to load on the external stringers with force equals 1500 N. Such a loading represents the situation, when the superstructure will be mounted to the trailer's frame. The boundary conditions as well as the load have been presented in the Fig. 4.

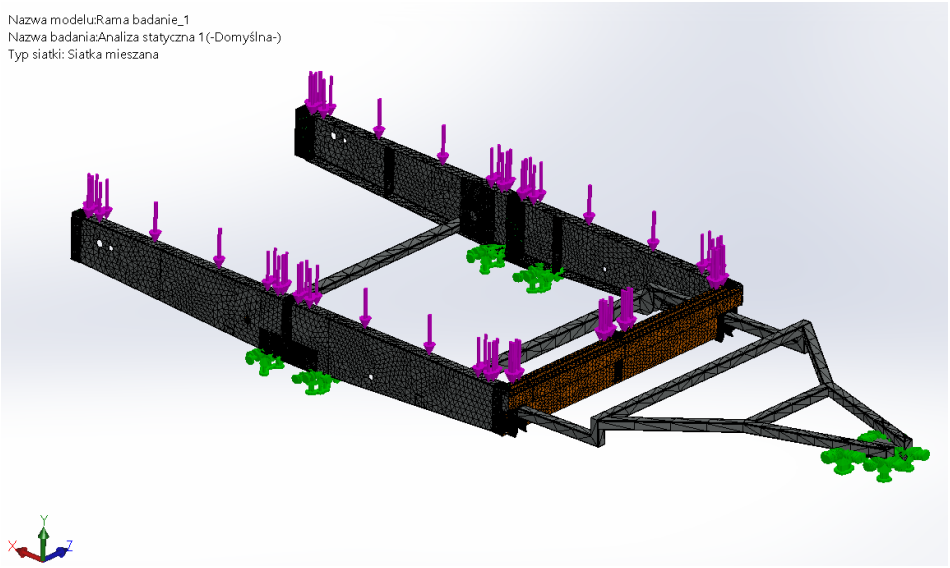

Fig. 4. Boundary conditions and the load of the external frame

The static analysis performed for study 1 provides a full picture of the changes that have occurred in the construction of this prototype. The results show the distribution of displacements, stresses and strains that occurred under the influence of a given load.

The study provides analysis results in any areas of the framework, including the maximum values that have been achieved and their location. During the simulation very good results of displacements, stresses according to the Huber-von Mises hypothesis and deformations were achieved. Figures 5 to 7 show graphic results from study 1.

The maximum displacement occurred on the stringers but these are very small values (1,049mm) and thus confirm the reliability of the prototype.

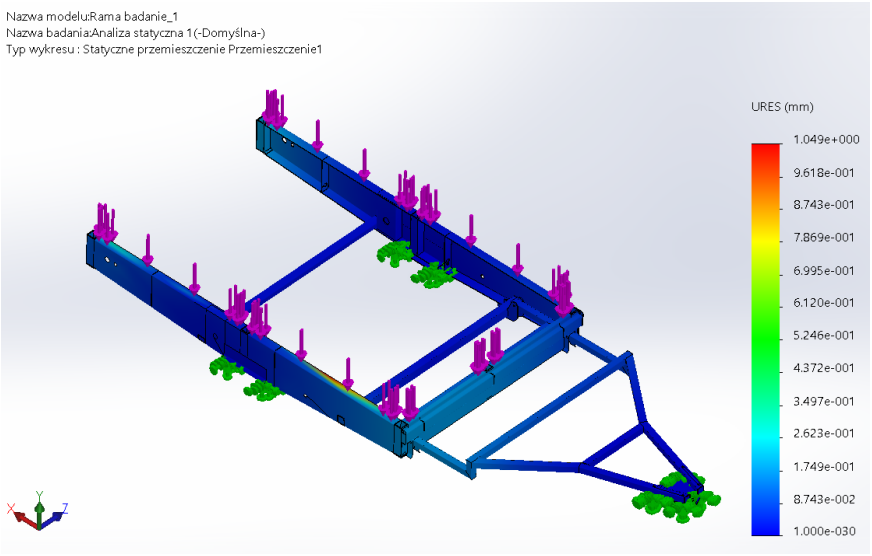

Fig. 5. Distribution of resulting displacement – first task

The highest values of the reduced stresses have been noticed on the extreme parts of the frame. This has been illustrated in Fig. 6. The results of the strain have been included in Fig. 7.

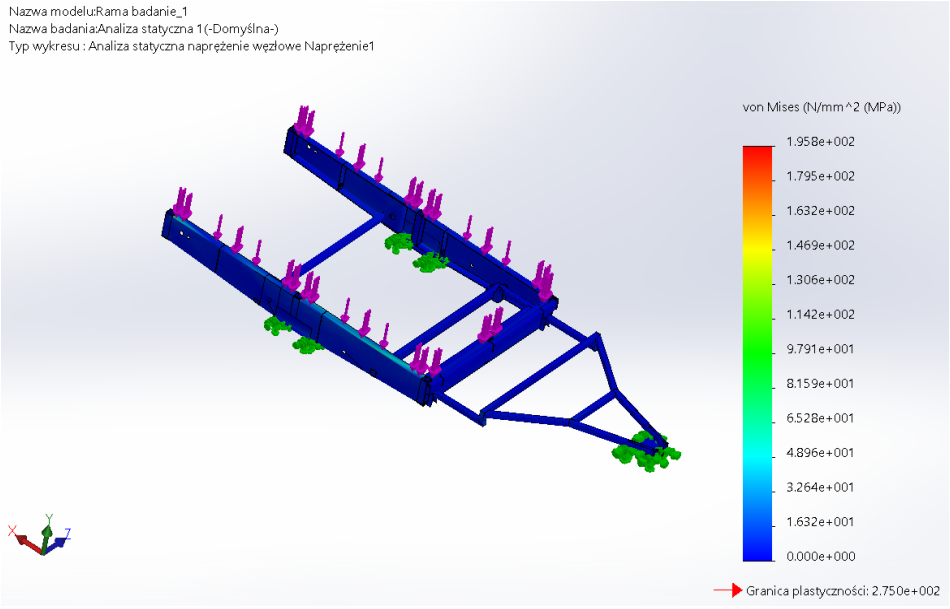

Fig. 6. Distribution of reduced stresses – first task

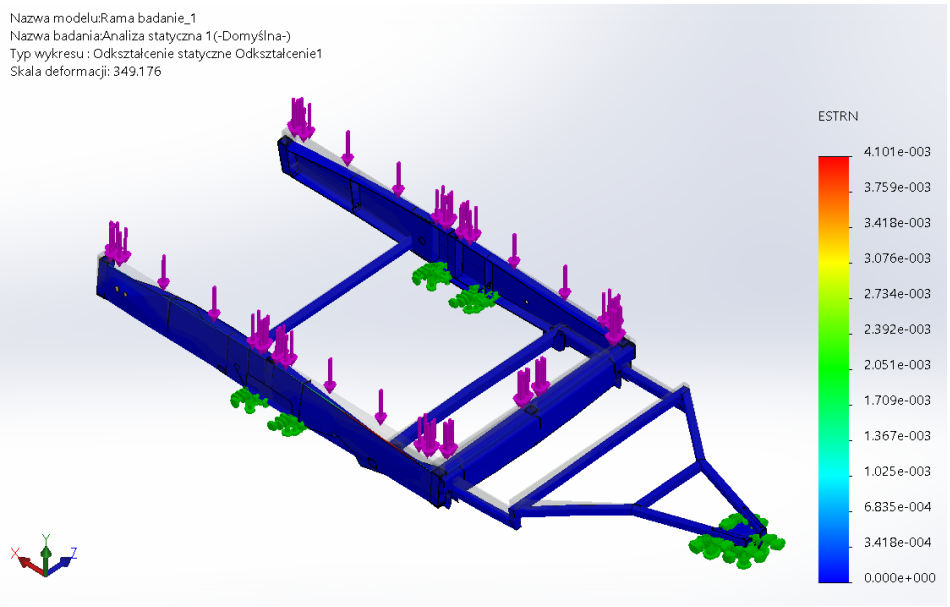

Fig. 7. Distribution of strains – first task

2.2 Task no. 2 – internal frame

The internal frame has been subjected to the load distributed in all surface of the floor. The value of the increased admissible load is equal 15000 N. The illustration of this is included in Fig. 8.

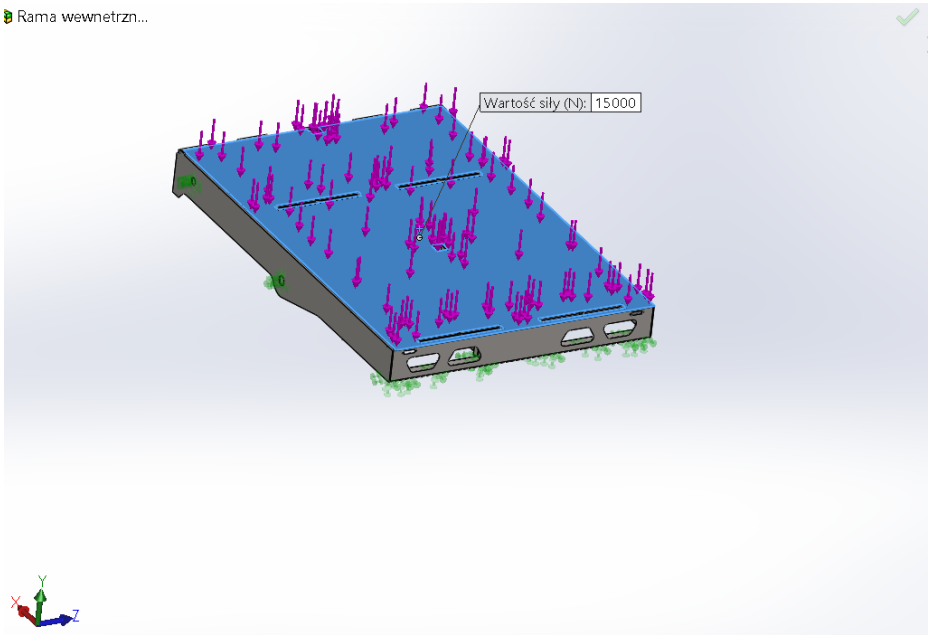

Fig. 8. Boundary conditions and the load of the internal frame

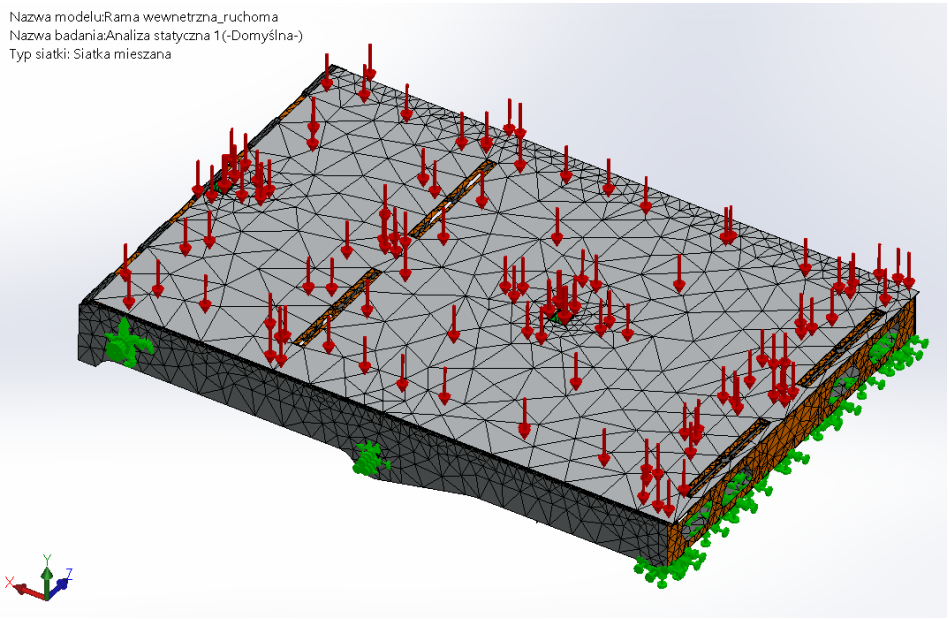

Fig. 9. Model of the analysis with mesh of the internal frame

Also for study 2 very good results were obtained, which are shown graphically in Figures 10-12. The obtained results confirm a solid construction (theoretical assumptions) which for displacements amounted to only 0.392 mm at small stresses 47.53 [MPa].

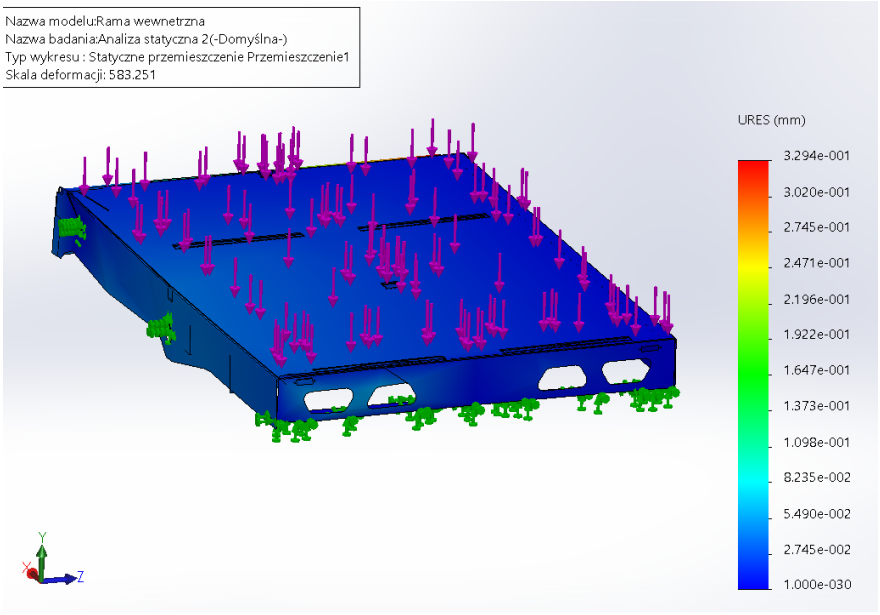

Fig. 10. Distribution of resulting displacement – second task

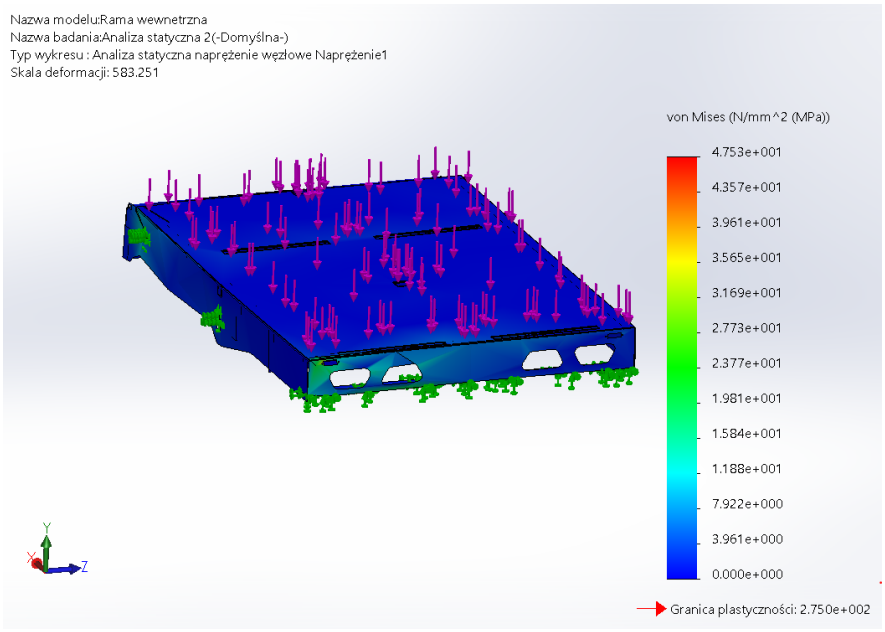

Fig. 11. Distribution of reduced stresses – second task

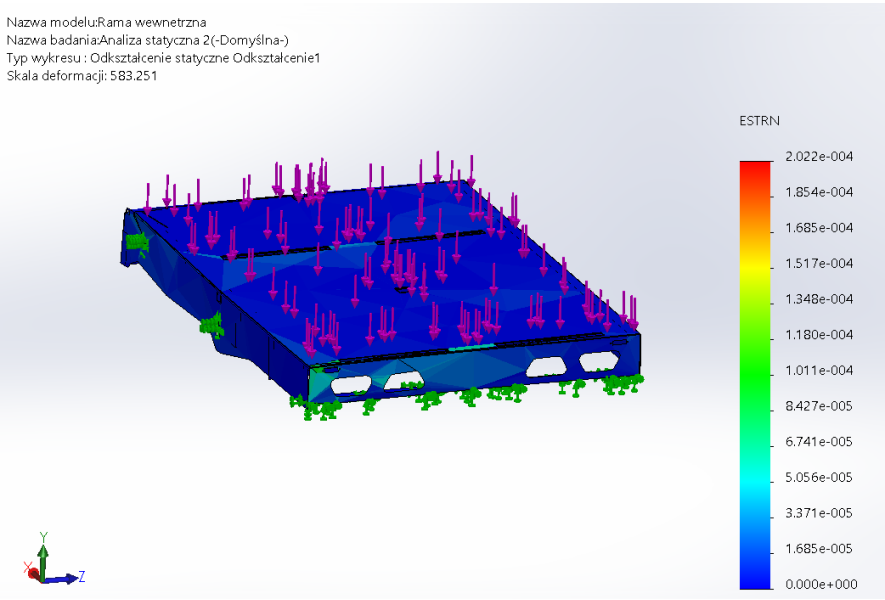

Fig. 12. Distribution of strains – second task

Conclusions

The studies of the prototype of the multi-tasking car trailer, which maintained the standards of the usual trailer and combine within construction the functionality of few specialized one-tasking trailers into a one multi-tasking trailer, have been performed. The proposed

prototype of the system is useful in many specialized tasks, which have been mentioned in the introduction. The most satisfying of the innovative solutions are:

- the way of spreading the back side, which, after unfolding, prolongs the loading space of the trailer,
- multifunctional folding frame, which, after proper setting and fixing, creates the various configurations necessary to transport of the specified loading,
- a special backlight of the sliding back panel, in which the innovative solution is a way of its sliding without a need of unscrewing bolts or removing pins, which is dedicated to carrying long loads such as kayaks.

In this work the analysis of the strength analysis, in reference to specified construction nodes, have been performed and included. The analysis has been made on the SolidWorks 2015 environment, by using the finite element method. The external and internal frames have been examined in the analysis in order to ensure the constructional solution in the using the trailer i.e. during entry of quad type cargo. The construction of the trailer has been designed according to the constructional assumptions and satisfies the strength requirements.

The maximum analyzed values and areas where they occurred can be seen in the drawings placed under a particular study. All values obtained during the tests are consistent with the assumptions for the project and guarantee a solid construction and long-term use.

References

1. K. Bentkowska-Senator, Z. Kordel, J. Waśkiewicz, *Transport samochodowy ładunków*. (Wyd. ITS, 2009)
2. P. Ladra, B. Posiadała, *Modeling and Strength Analysis of the Specialized Car Trailer*. Rusiński E., Pietrusiak D.: Proceedings of the 13th International Scientific Conference, RESRB 2016, Lecture Notes in Mechanical Engineering, Springer, Cham, (2016)
3. P. Ladra, *Projekt komputerowy przyczepki samochodowej specjalizowanej*. (Praca magisterska Politechniki Częstochowskiej, Częstochowa, 2015)
4. J. Domański, *SolidWorks 2014 Projektowanie maszyn i konstrukcji. Praktyczne przykłady*. (Wydawnictwo Helion, 2014)
5. P. Kęska, *SolidWorks 2013. Konstrukcje spawane. Arkusze blach. Projektowanie w kontekście złożenia*. (Wydawnictwo CADvantage, 2013)
6. B. Posiadała, *Modelowanie i analiza zjawisk dynamicznych maszyn roboczych i ich elementów jako dyskretno-ciągłych układów mechanicznych*. (Wydawnictwo Politechniki Częstochowskiej, Częstochowa, 1999)
7. *Problematyka transportu drogowego*. Praca zbiorowa pod red. G. Nowackiego (Wyd. ITS, 2008)