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STUDY OF INNOVATIVE SHEATHING CONSTRUCTION OF WAGON DOORS USING STRAIN GAUGE METHOD AND FINITE ELEMENTS METHOD

Abstract: The purpose of this paper is to present the results of studies on the application of innovative sheathing construction of wagons doors. Measurements were made using strain gauge method. Verification of the results was carried out in a computer program using finite elements method. The strain gauge studies was conducted on model built in a scale 1:4. In the next step it is planned to perform the entire wagon doors from composite.

1. Introduction

Due to technological and computer progress, application of computer techniques, which help in engineering calculations and simulations is growing. Less frequently are used traditional measurement techniques. In this paper two methods were summarized: the method which uses the phenomenon of the resistance change that is caused by the change of geometric characteristics of the cable, and one of the computer simulation methods – the finite elements method. Object of the study are wagon doors made in scale 1:4. The initial load is transmitted by a hydraulic cylinder driven by a hand pump.

2. Finite Element Method

The basic principle of the finite element method analysis is a discretization of the geometry of the object under examination on the millions of small elements called the net. The first stage of FEM analysis is a division of the element geometry on the finite parts. The next step is to define a material from which the element is made. Then the forces which are aggravating the tested model were applied and the fixing were imposed.

FEM analysis was carried out in an advanced program UGS NX SIEMENS. By applying the appropriate modules allows carry out of FEM analysis, analysis and simulation of movement and 2D documentation generation.

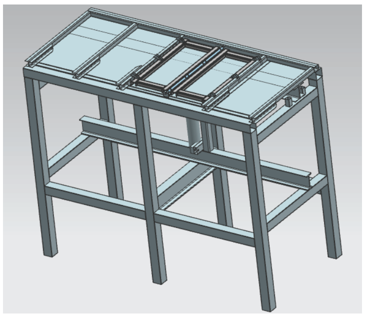

Fig. 2.1 CAD model of measurement stand

In figure 2.1 computer model of stand with mounted wagon wall with the doors was shown.

3. Strain gauge method

The basic principle of strain gauge method is a change of resistive properties of metal wire by changing its length. Strain gauge examined a deformation (elongation or shortening), changes its resistance is proportional to the elongation. This properties is used to deformation measure of different kinds of elements. Between the resistance R, the resistance change ΔR and a deformation there is a dependence written by the formula:

$$\frac{\frac{\Delta R}{R}}{\varepsilon} = k \tag{1}$$

The k value is the deformation sensitivity coefficient of strain gauge, commonly known as a strain gauge constant. Resistance strain gauges are used to measure of stress within the range of elasticity of the tested material. This is done in a such way that on the basis of known value k constant of strain gauge and measured unit increase of resistance ΔR/R, from the equation 1 defines the quantity of unknown unit deformation ε, from which it is calculated stress σ. During measurements modern measurement devices were used, which includes: modular connection box CANHED, measuring amplifier MGCplus and computer with installed software CATMAN.

4. Composite materials

Composite materials are increasingly used in various engineering constructions. The basic idea of materials engineering is to obtain a material with a specific, desired properties. According to the definition construction composite is called a material distinguished by particularly selected properties, among which the crucial is an ability to transfer a mechanical loads. Since the structures of composite materials allow for significant reduction of object weight, and moreover in some cases reduction of production cost. Therefore it was decided to replace the steel side wall of wagon doors for composite material. The composite used for this purpose is a glass mat with a weight of 100g and epoxy resin matrix.

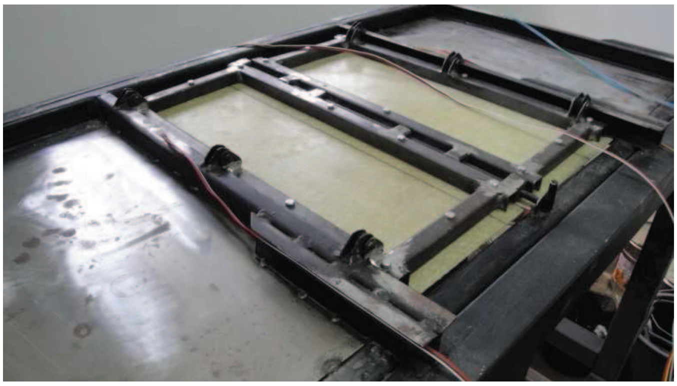

Fig. 4.1 The real measurement stand with doors with a composite side

5. Researches

Tests were conducted on two models. The first is the real model built in scale 1:4, on which the stress tests of wagon wall were conducted with loads: 20, 40 and 60 bar, and the results were obtained from the strain gauge method. The second model was the CAD model made in NX 7.5. program in which the FEA analysis was performed. The results were read from the resulting stress maps. This analysis was optimized by the boundary conditions, a density and a type of grid.

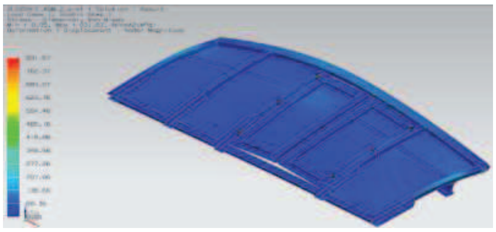

Fig. 5.1 FEA analysis stress map

In a table 5.1 the comparision of the results of both methods was shown.

Table 51. Comparision of stress values obtained at a pressure of 20 and 60 bar

Stress value obtained at a pressure of 20 bar								
Number of measuring point	1	2	3	4	5	6	7	8
Results from strain gauge method [MPa]	**4**	**35**	**9**	**12**	**20**	**24**	**28**	**1**
Results from Finite Element Method [MPa]	**3,2**	**35**	**28**	**25**	**23**	**25**	**29**	**0,7**
Error [%]	20	0	47	108	15	4	3	30
Stress value obtained at a pressure of 60 bar								
Number of measuring point	1	2	3	4	5	6	7	8
Results from strain gauge method [MPa]	**12**	**177**	**79**	**49**	**81**	**71**	**189**	**7**
Results from Finite Element Method [MPa]	**7**	**120**	**79**	**54**	**73**	**71**	**95**	**4**
Error [%]	41	32	0	10	10	0	49	42

After comparing results of strain gauge method and finite element method, the stress values, that occurred in tested wall while the side of wagon doors was made of steel sheet and of laminate, were compared. The comparison results are presented below.

Table 5.2 Comparison of the stresses arising in the steel and composite doors

Stress value obtained at a pressure of 20 bar								
Number of measuring point	1	2	3	4	5	6	7	8
Results from strain gauge method (steel) [MPa]	**4**	**35**	**9**	**12**	**20**	**24**	**28**	**1**
Results from strain gauge method (laminate) [MPa]	**4**	**35**	**9**	**11**	**31**	**30**	**19**	**1**
Difference [MPa]	0	0	0	1	11	6	9	0
Stress value obtained at a pressure of 60 bar								
Number of measuring point	1	2	3	4	5	6	7	8
Results from strain gauge method (steel) [MPa]	**12**	**177**	**79**	**49**	**81**	**71**	**189**	**7**
Results from strain gauge method (laminate) [MPa]	**11**	**182**	**79**	**48**	**87**	**84**	**178**	**6**
Difference [MPa]	1	5	0	1	6	13	11	1

6. Conclusions

Based on the conducted researches can be concluded that the results are different in both methods. The reason for this is definitely a „manual execution" of composites, and the idealization of certain elements of the CAD model. As a part of future researches will be an analysis o stresses in the railway carriage wall in a scale 1:1

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