EAN 2019
57th conference on experimental stress analysis

Mechanical structures made of high-strength sheets or composites for electric vehicles

ŠEVČÍK Ladislav[1,a] and LUFINKA Aleš[1,b]

[1]Department of machine design; Faculty of Mechanical Engineering; Technical university of Liberec; Studentská 2, 461 17 Liberec, Czech Republic

[a]ladislav.sevcik@tul.cz, [b]ales.lufinka@tul.cz

Keywords: High-strength steel, Welding, Tensile test, car protection

Abstract. The paper deals with the problem of calculations of high-strength sheet metal structures. These sheets are mainly used for parts that deform in non-standard situations. These parts protect the crew in this case of a electro truck. The success of the calculation depends mainly on the technological execution of the welds of these sheets. The temperature affecting the structure of the high-strength sheet affects its strength and flexibility. Welding technology varies considerably in companies. It is therefore very difficult to estimate the strength properties and so at least the tensile test must always be performed on these sheets.

Introduction

Nowadays designer exhibited question if key parts of an electric vehicle to propose a high-strength steel, or fiberglass or carbon fiber. Both types of materials are commonly available on the market today and companies have technologies to process them the battery. Meanwhile, it is not possible to accumulate electricity so mass and the density was comparable to other types of fuels such as diesel, petrol, gas. Due to this current state of knowledge, it is necessary to reduce the weight as much can be from many point of view and to increase the strength of the supporting parts of the electric vehicle as much as possible.

The paper deals with the problem of connecting individual parts of the electric car frame. In the case of composites, an insert is used to attach parts to the frame, and in the case of high-strength steels, mostly different type of welds. Welding technology for high-strength sheets is the manufacturing secrets of the company. The aim is to minimize recrystallization of the structure of high-strength sheets by heat. Since the calculations affect the elastoplastic area, it is necessary to measure the characteristics of the welded high strength parts.

Measurement devices

The standard tensile testing device FU250 was used to measure the properties of welded parts. The test device is equipped with hydraulically operated jaws for specimens anchoring. The result of the tensile test is the dependence of normal tension σ on the relative elongation ε. So, two quantities - loading force and specimen elongation - need to be measured during the test. The force sensor is a standard equipment of the test device but the external extensometer needs to be used for the elongation measurement. An extensometer based on the incremental length sensor Renishaw was used for this measurement. This sensor measuring accuracy is 0.001 mm. A wide choice of initial length L_0 and the sensor destruction resistance during the specimen breaking are the two biggest advantages of this solution. The extensometer digital output cannot be connected to the test device FU250 control system, so the DEWE5000 universal measurement device was used for data record. The extensometer and the force signal from the FU250 control system were connected to this device. The extensometer principal and block scheme is shown in Fig. 1.

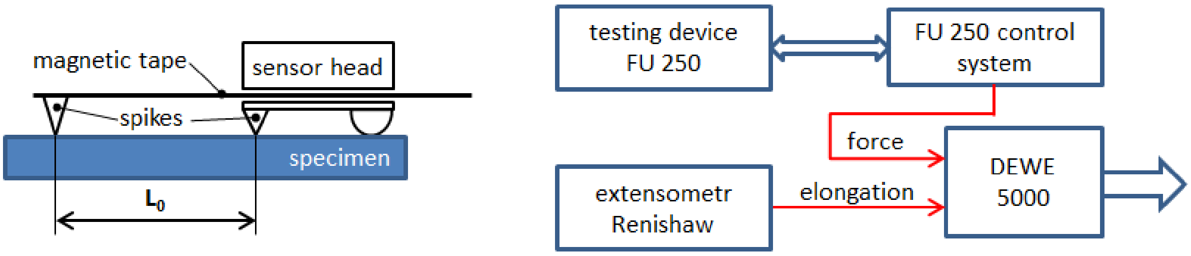

Fig. 1: The extensometer Renishaw principle (left) and measurement block scheme (right)

Solution procedure

Two 10 mm thick Simaxx 690QL sheets were welded together and cut into square bars samples approximately 10x10mm [2]. Broken samples are in Fig.2. Shredder was equipped with extensometer of own production. It was attached to the rod by elastic elements. Its advantages are in the possibility of attachment to the given square sample and resistance to mechanical damage. See Fig. 3.

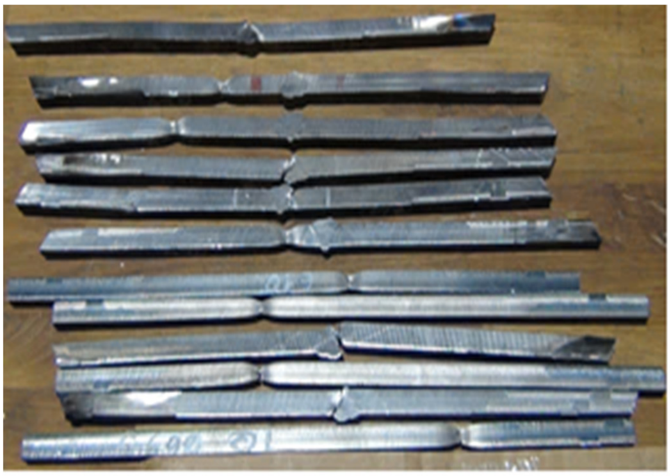

Fig. 2: Samples of welded cut sheets to the measured after the test

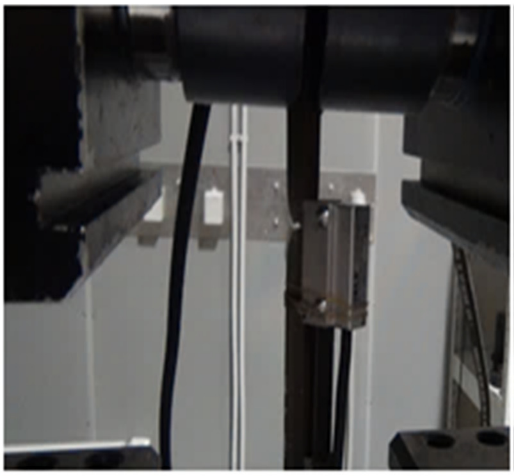

Fig. 3: Fitting of the extensometer on the specimen

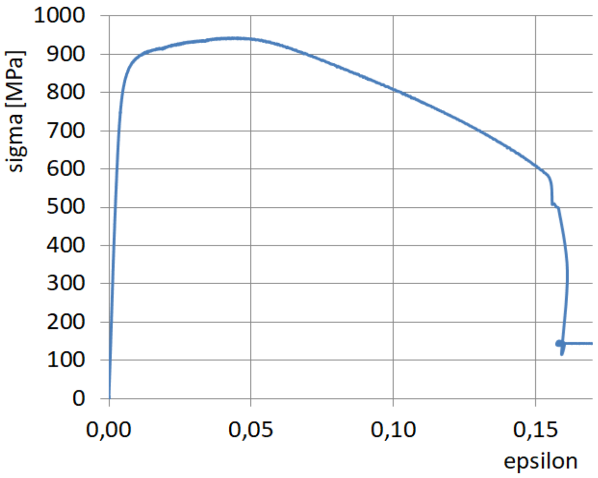

Fig. 4: Material 690, welded, broken outside the weld - weld made OK

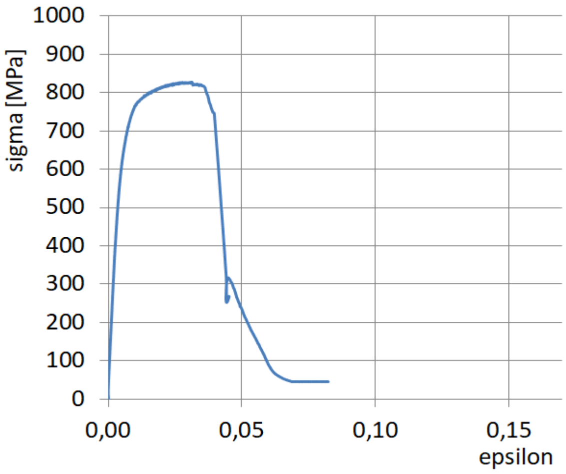

Fig. 5: Material 690 welded, broken in weld

The FEM calculation was based on the tensile test data of the material, Fig. 3, 4 by [1]. The device is tested by loading forces in two directions. Forces operate gradually over time. Load first in the direction of travel. The device deforms plastically. It is then unloaded but partially deformed. It is then loaded with a horizontal force see Fig.5. This again causes plastic deformations. As a result of the positive evaluation, the permanent deformation of the device does not reach a certain space.
Furthermore, the loading procedure (tests) according to the standard for the calculation of operator protection during overturning and the size of welds, in particular at welding points, was entered. The plastic and elastic deformations and stresses were calculated in gradual loading by individual tests in Ansys Workbench 17.2, module transient structure. The project scheme is shown in Fig. 6. In linear static structure were counted deformation and stress separately for each load. In transient structural the loading was linked to the previous one.

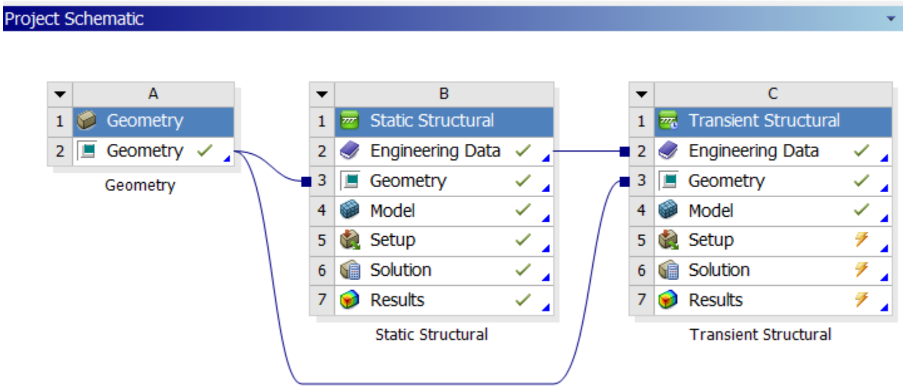

Fig. 6: Project scheme

In transient structural the loading was linked to the previous one. In the graph, Fig.7 the load intervals are plotted on the horizontal axis, and load values in [N] are plotted on the vertical axis.

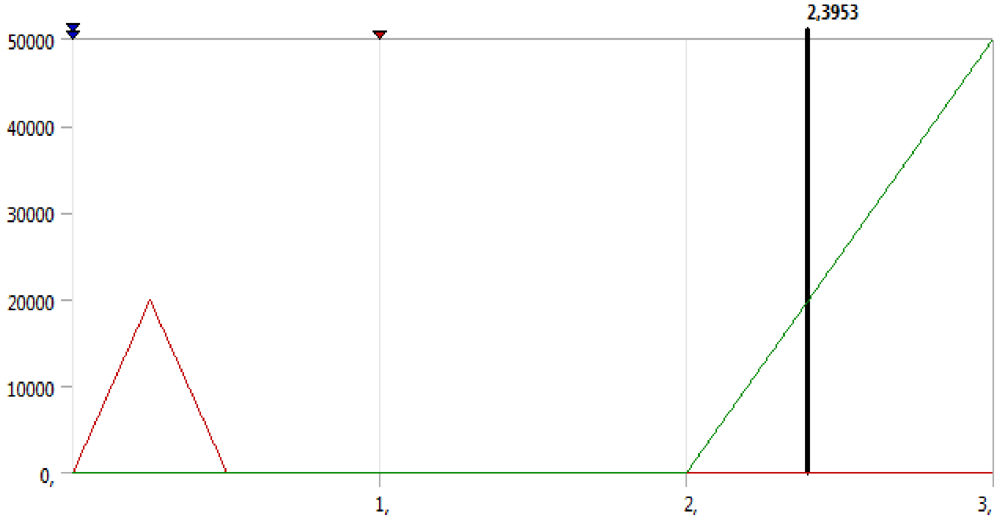

Fig. 7: Loading process

Results

Taking into account the post-test deformation and stress of transient loading, see Fig. 8, 9.
Result of equivalent plastic deformation and elastoplastic deformation are in Fig. 10, 11.

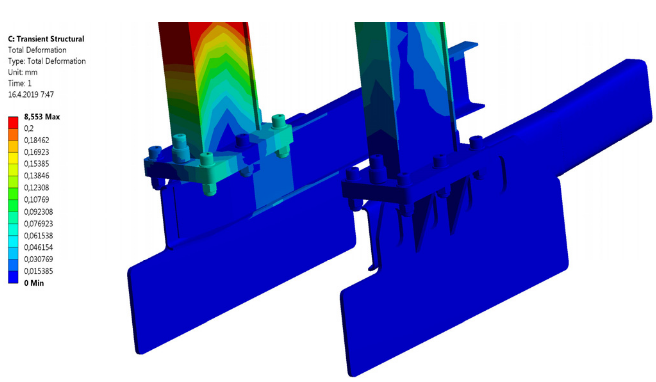

Fig. 8: Deformation after transient loading

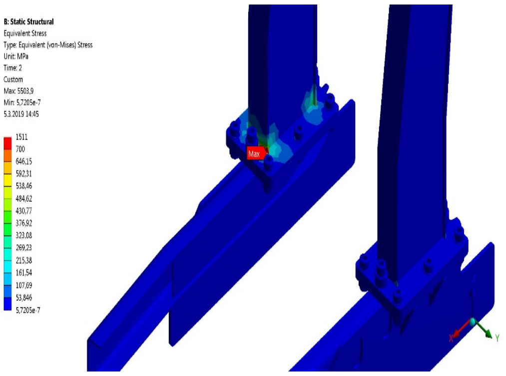

Fig. 9: Stress after transient loading

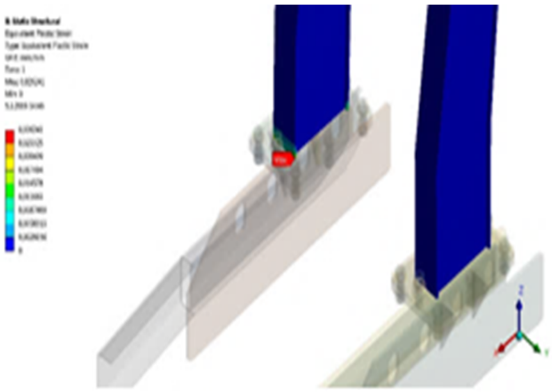

Fig. 10: Equivalent plastic deformation is 2%

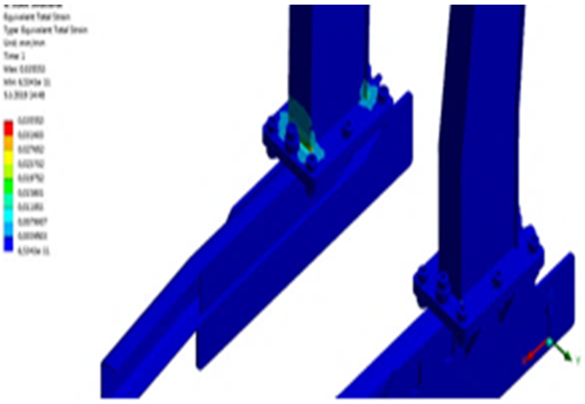

Fig. 11: Elastic and plastic deformation is 3%

Conclusions

As predicted, the resulting load capacity of the electric car frame made of welded high strength plates will depend on the technology of the welds. All measured samples reached the reported strength even in welds. Particularly the different was in the percentage of elastoplastic deformation. Poorly made welds are brittle and elongation is less to 2%. In executed welds, the elongation was more than 10%. In the FEM calculations was used the variant of the incorrectly brittle weld.

Acknowledgment

The result was obtained through the financial support of the Ministry of Education, Youth and Sports of the Czech Republic and the European Union (European Structural and Investment Funds - Operational Programme Research, Development and Education) in the frames of the project “Modular platform for autonomous chassis of specialized electric vehicles for freight and equipment transportation”, Reg. No. CZ.02.1.01/0.0/0.0/16_025/0007293 and "Innovation of the products, equipments and processes in engineering practice" with the support of the Specific University Research Grant.

References

[1] Xiaolin Chen and Yijun Liu, Finite Element Modeling and Simulation with ANSYS Workbench, CRC Press 2019, ISBN-13: 978-1138486294

[2] Parrish A. Mechanical Engineer’s Reference Book, 11th Edition, Elsevier, 19. 5. 2014 – pages 1612