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Procedia Engineering 177 (2017) 510 – 515

Procedia Engineering

www.elsevier.com/locate/procedia

XXI International Polish-Slovak Conference "Machine Modeling and Simulations 2016"

Numerical analysis of the structure girder for vehicle axle scale calibration

Miroslav Blatnický[a]*, Mária Štauderová[b], Ján Dižo[a]

[a]*University of Žilina, Faculty of Mechanical Engineering, Department of Transport and Handling Machines, Univerzitná 8215/1, 010 26, Žilina, Slovak Republic*
[b]*University of Žilina, Faculty of Mechanical Engineering, Department of Applied Mechanics, Univerzitná 8215/1, 010 26, Žilina, Slovak Republic*

Abstract

This paper deals with strength analysis of a part of a welded steel structure that will be used to calibrate vehicle axle scales with a loading capacity up to ten tons. The structure strength analysis is carried out in ADINA software, and this analysis results will be used to check the safety of the design and structure. In the case of exceeding the permissible stress, deformation (strain), displacement, etc., this analysis results will form a benchmark material for optimisation of the structure.

Peer-review under responsibility of the organizing committee of MMS 2016
Keywords: strength analysis; ADINA; vehicle; testing device;

1. Introduction

Weight measurement is one of the most widely used laboratory and technical activities. Scales, weights and weighting utilise numerous subjects – either for the direct weight measurement, or as one of the inputs in the measurement of derived physical quantities. New types of scale designs have been developed and widely used in practice, increasing the accuracy and speed of measurement. In order to ensure measurement accuracy over the entire technical life of the scales, these require regular calibration with precisely defined recalibration intervals whose time step is defined in standards. We have designed a testing device in order to enable carrying out

* Corresponding author. Tel.: +421415132659.
E-mail address: miroslav.blatnicky@fstroj.uniza.sk

Peer-review under responsibility of the organizing committee of MMS 2016
doi:10.1016/j.proeng.2017.02.253

experimental measurements [1-3] to determine suitability of a scale for vehicle axles with a loading capacity up ten tons. Since, currently, great emphasis is placed on efficiency, cost reduction and economically advantageous performance, this structure will be subjected, prior to a prototype manufacture, to strength analysis with software support [4, 5] in order to determine whether the structure is able to withstand the given load with a certain degree of safety. The importance of strength analysis lies in the investigation of the existing structure prototype, created in a virtual environment using a CAD system [6], in terms of its strength at the given load in the software environment, without a necessary preceding costly manufacture of the product. Based on the above-mentioned analysis we are able to say in advance whether a given structural design is satisfactory or, conversely, it needs further optimisation in order to prevent potential loss of life or property.

2. Analysed body

The main part of the structure consists of two parallel angle girders – side plates, to which suspension means of thick metal sheet are welded. Here will be fitted suspension tubes of the boxes in which the load (weight) is situated. On this support structure, a hydraulic cylinder is placed that will lift the whole structure and transmit the compressive force derived from the burdens onto a scale placed on a platform, through the girder, in order to calibrate the scale. Strength calculation of this girder is the focus of this analysis. The main loading forces are the gravitational forces derived from the weights of individual boxes with weights and of the frame. The dominant stresses will include bending, pressure and shear, and we will examine their effect on the structure (Fig. 1) by numerical strength analysis.

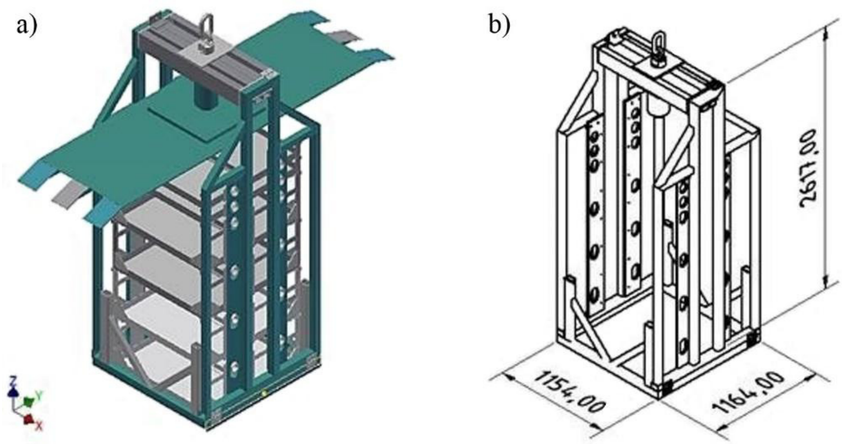

Fig. 1. Steel structure for vehicle axle scale calibration (a) and its basic dimensions (b).

The analysis will result in comparison of the observed values of stress, displacement and strain (deformation) of the structure's upper girder with the permissible values that depend on the type of material used (strength, stiffness, etc.). Since we are dealing with a welded structure consisting of thin-walled sections, it will be modelled as a shell body using central line planes, with a subsequent thickness assignment. This steel structure will be gradually loaded with a burden weighting from 2 tons up to 10 tons, including its own weight, so as the structure will gradually lift the boxes containing weights, located inside the structure.

The burden consists of 16 weights – 500 kg each, own weight, and additional lighter weights so that the total weight be 10 tons. The boxes with weights are stockpiled, and each box contains four weights. The structure is made of STN 11 523 steel that has the yield strength $R_e = 320 \div 360$ MPa, and the ultimate strength $R_m = 520 \div 640$ MPa [7]. The safety coefficient is $k = 2$ (-). At the weld sites we must take into account a reduced permissible stress by the recommended 30 %, through introducing the welding effect coefficient $c = 0.7$ (-). Then, the permissible stress for the material chosen, with consideration of the relevant coefficients, will be as follows (1):