Experimental and numerical analysis for study a stress of new type lifting platform construction for car relocation

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Abstract: This article studies the mechanical loading of a new type of lift platforms and it is connectedto study of other types of lifting platforms, which has been published previously. For a stress assessment which acts in individual parts of a platform lift for moving of cars dynamic analysis and experimental studies were performed. The analysis of loads shows that immediate loading ofthe platform by bending momentumcauses that a construction of platform has to be suitably fixed. First experimental measurements were carried out on the real platform for obtaining of trajectory, velocity and acceleration during movement. Subsequently, the model analysis of the lifting platform using a four point Runge-Kutta method was assembled. Depending on the dynamic motion the stress distribution in the critical parts of platformwas investigated.The model analyses was shown that a step loading during acceleration and deceleration of the platforms leads to a dynamic impacts that areunsafefrom point of view of long term usage. The consequence of said consist in repeated overloading of pivots, bearings, rollers and other parts. Also the dynamic stress may be accompanied by the resonances. Therefore the design of lift platform has to beoptimized to ensure adequate safety.

Keywords: Lift platform; stress,experiment; numerical analysis

1 Introduction

Currently, lifting platforms in large production lines are used especially in the automotive industry. They provide the desired logistics and layout of the production process. This paper deals with a new type of platform lift, which is used for moving the car from the upper level to the lower level of the production hall. This platform moves from the top position to bottom position for 10 seconds approximately. For study stress from dynamic moving were made experimental and numerical analysis.Numerical analysis of dynamic load of the construction nodes of the platform was based on CAD data. For model dynamic analysis of platform were used all important parts and components that contribute to a creation of dynamic loading, such as base of platform, stubs, rollers, etc. similarly to the previous papers [1,2].

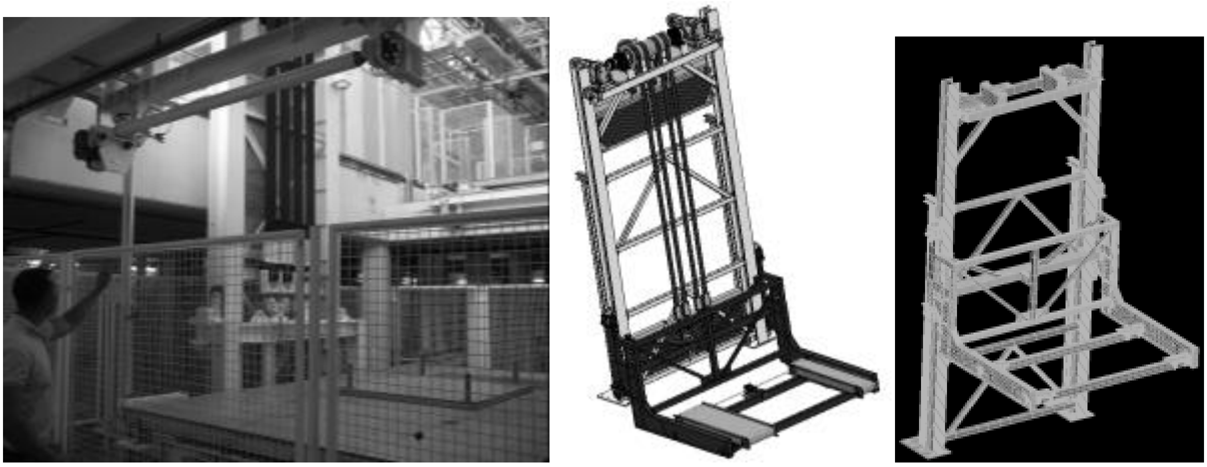

Fig. 1: Real testing of lifting platform (left), CAD model (center)numerical model (right).

2 Description of the solution

The platform moves on the given trajectory by the certain velocity. On a beginning and the end of the moving a step change of velocity appears (it is connected with extreme acceleration). It was therefore necessary for an evaluation of the trajectory to measure the velocity and acceleration of the real platform during operation of platform directly in the factory. Starting position for measurement was always in the highest and lowest position of the lifting platform (Fig.2). In between of these positions the acceleration and position were measured. The platform was loaded by the car during downward movement, and during upward movement it was without load that is corresponding with real use. Used biaxial accelerometer Analog Devices ADXL 203EB measured acceleration and static acceleration (gravity). At the beginning of each measurement the static acceleration (gravity = 9.81 ms^{-2}) was reset to zero, therefore in the vertical direction the acceleration was equal to 0. Thus results of acceleration measuring show immediate acceleration of the platform without gravity acceleration. Displacement was measured with the cable reverse sensor Micro Epsilon-WDS-4000-P115-CA-P and recorded with the data logger Dewetron DEWE 5000 with software Dewesoft 7.03.

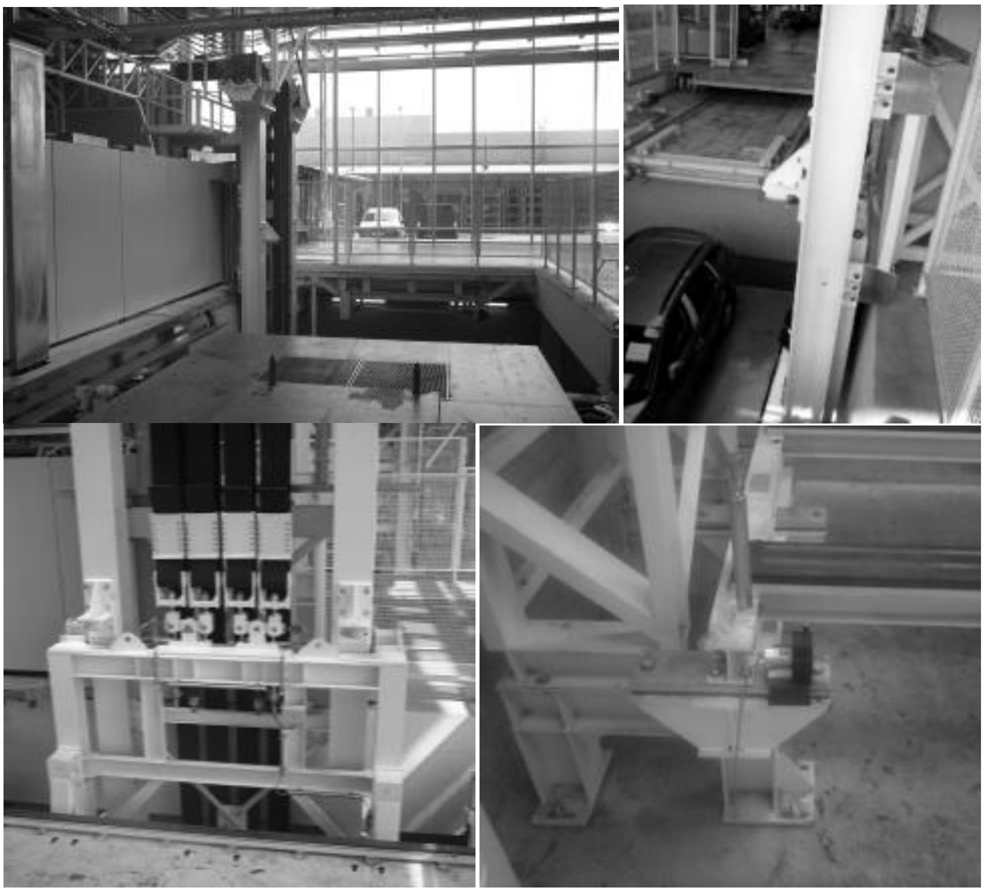

Fig. 2:Real testing of the lifting platform in Skoda Auto.

For study a dynamical stress of new type lifting platform was made FEM simulation. Dynamic analysis was performed using the numerical solver using 4th order Runge-Kutta method (1).

$$x_{n+1} = x_n + \sum_{i=1}^{p} \psi_i k_i, \quad k_i = f(t + \alpha_i h, y_n + h\sum_{j=1}^{i-1} \beta_{ij} k_j \qquad (1)$$

Where the individual coefficients are calculated so that the method order p correspond to Taylor polynomial function x (t) for 4 orders.

Assembling of numerical model for dynamic analysis was performed in the following steps:In the pre-processor was introduced and defined local coordinate systems X, Y, Z belonging to individual parts of the platform, which are not identical with the global coordinate systems of whole construction. In the next step akinematics of the individual parts, gravitational acceleration 9,81$m.s^{-2}$ anda load of the platform that is done by a car mass(1600 kg) were defined. The load is located in centre point of the platform. A fixation of the platform and defining of the load is shown schematically in Fig. 3.Bonds are defined for individual coordinate systems. If the global coordinate system will be used, the dynamic analysis cannot be executed. Among surfaces are set certain clearance.The defining of joints, bonds and force load from the weight of the car and the counterweight from the driving belts in the model is shown in Figure 4.In the last step material parameters for dynamic analysis were defined. Design of a new lifting platform consists of steel materials (isotropic properties, material density 7850 $kg.m^{-3}$, E = 210000 MPa, μ = 0.3). For dynamic analysis it is necessary defining not only the density of the material but also a volume, mass and moments of inertia with respect to the individual axes of coordinate system.These parameters are based on the real geometry of the components. It ensures required accuracy of the results. Dynamical analyses were done for different movements.

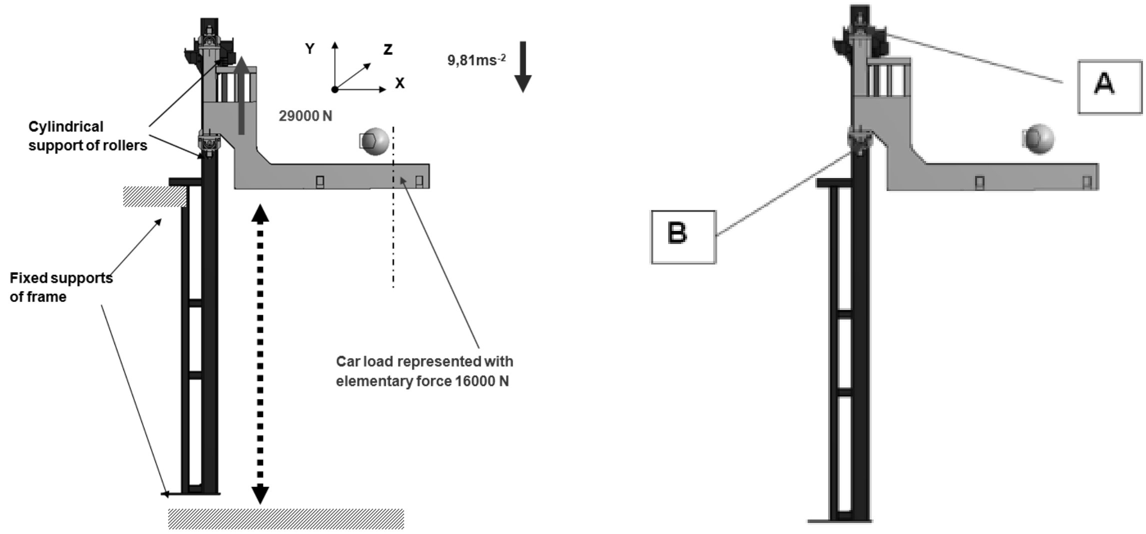

Fig. 3:Joints and boundary conditions for dynamical analyses.

For a dynamic study of platform were introduced parameters in accordance with technical documentation and previous measurements.

<u>Study 1:</u> The lifting part of the platform moves vertically from 0 to 4300 mm with constant velocity 12 m/min (0,2$m.s^{-1}$)
<u>Study 2:</u>conditions are same as in previous case, only acceleration +0,1$m.s^{-2}$up to maximal velocity 0,2 $m.s^{-1}$ is introduced
<u>Study 3:</u>conditions are same as in previous case, applied acceleration is +0,4$m.s^{-2}$
Dynamical analyses were applied by the help of Runge-Kutta iterative methodof order 4.
The results of simulation were used for evaluation of roller force that loading stubs and bearings.For this purpose two areas of interest will be studied (A – BFig. 3)

3 Results and discussion

Dynamical loading of the lifting part of platform during acceleration +1,1g (dynamical simulation –Study 2 causes maximal step load on the roller 7 202,7 N that is distributed on stubs and bearings. The value of maximal bending stress in the stub is 72,46 MPa. It corresponds to safety factor k_2=2,82. If the acceleration will be equal to +1,4g (Study 3) the force acting on roller will be 21150 N and bending stress in the stub will be 212,17 MPa. Then safety factor will be k_3=0,96 only. The acceleration +1,4gwas measured in the case of previous platform design. All results are put in Table 1 and in the Fig.4. These loads and consequently bending stress can be reduced by modifying of the platform design. It is evident that platform has unsuitably large overhang, which increases the bending stress.The article deals with the measurement and numerical analysis of dynamically loaded construction nodes of a new type lifting platform. From the results it is evident that the main problem consists in the acceleration and deceleration of the platform. In the construction oscillation and shock load are formed in carrier parts and together with the bending moment they cause high loads accompanied by the formation of high stress in critical locations (Fig.5).

Tab.1:Results of numerical analysis of loaded construction nodes of the platform

Study	Force on roller A [N]	Force on roller B [N]
1	5269	5157
2	7142,5	7202,7
3	19835	21150

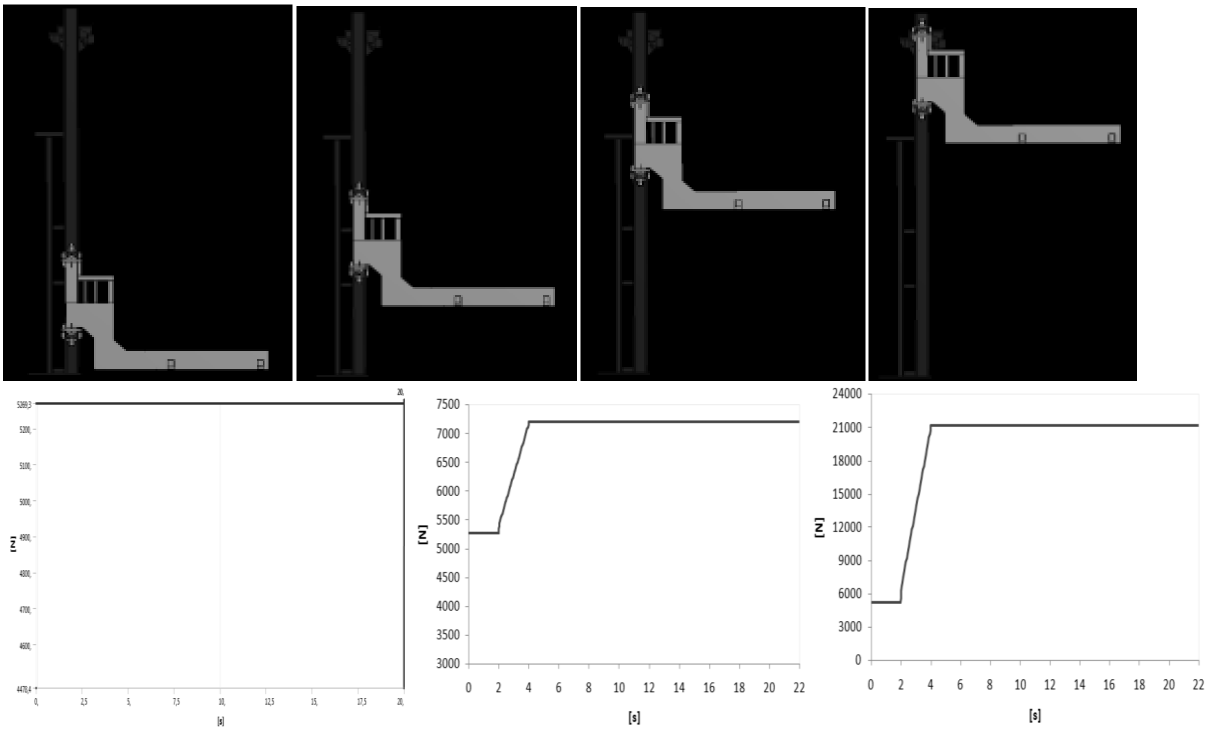

Fig .4:Results FEM: Time response of lifting platform Regal Scout (above), Force for study 1-3 (below)

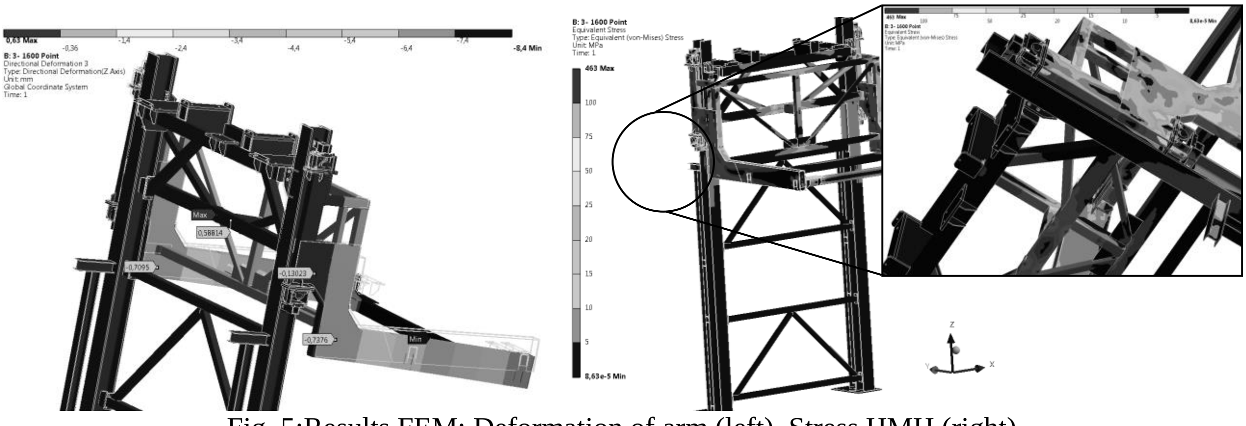

Fig .5:Results FEM: Deformation of arm (left), Stress HMH (right)

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References

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