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Measurement and Numerical Analysis of Lifting Platform Construction for Car Relocation

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Abstract. Measurement and model analysis through numerical simulations led to the assessment of stress of structural nodes of scissor lifting platform, which is used for relocation of cars from a production line. It also led to optimization of producing process. Immediate load of scissor lifting platform by a car on stand causes additional bending moment that must be captured in a scissor mechanism. At the beginning the experimental measurements on the real lifting platform were made for obtaining of dependence of displacement, velocity and acceleration on time which was almost 1.5±0.1 g. Then dynamical analysis using a numerical method Runge Kutta 4th order of lifting platform were created. Model analysis showed that the initial immediate acceleration of lifting platform at start and immediate deceleration at stop lead to dynamic shocks. These dynamic shocks are due to long term operation dangerous because they permanently load not only pivots but also other parts – bearings and joining parts. A resonance may occur as well. In particular, dynamic shocks caused damage of structural nodes. Immediate load of scissor lifting platform by a car on stand causes additional bending moment. It is not appropriate in terms of long-term operation. Recommended load lifting platform should be symmetrical.

Introduction

Currently, lifting platforms in large production lines are used especially in the automotive industry, and they provide the desired logistics and layout of the production process. This paper deals with a platform lift, which is used for moving the car with the base from the upper level to the lower level of the production hall. The platform (see Fig.1) consists of a frame profile stand firmly anchored to the floor, on which is placed a scissor mechanism with traversing members (wheels are mounted on the frames). This platform moves from the top position to bottom position for 10 seconds approximately. The aim is to assess the components, which are most loaded by dynamic loading which is caused by the movement of the platform. For complicated construction, like this, would be very complicated to use analytical calculations, so it is appropriate to establish a model that uses numerical methods for the study of movements and loads. That is why the numerical analysis are very suitable tool for the study and optimization of various structures [1, 2, 3]. Also, it can be very suitable, when it can not be used analytical relationships, or for their refinement.

Description of the Solution

Experimental Analysis of the Real Production Line

The platform moves on the given trajectory and time by the certain velocity. On a start 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 line directly in factory. The principle of measurement and a placement of the sensors are shown schematically in Fig.1 (down). Starting position for measurement was always of the highest and lowest position of the platform. In between these positions acceleration and position were measured. When moving down the platform was loaded by the stand with the car (4500 kg), when moving up without load, which corresponds to 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. Therefore results of acceleration measuring shown as immediate acceleration of the platform without gravity. Displacement was measured cable reverse sensor Micro Epsilon-WDS-4000-P115-CA-P and recorded in the data logger Dewetron DEWE 5000 with software Dewesoft 7.03. The resulting data was processed in the software Datel 08.01.

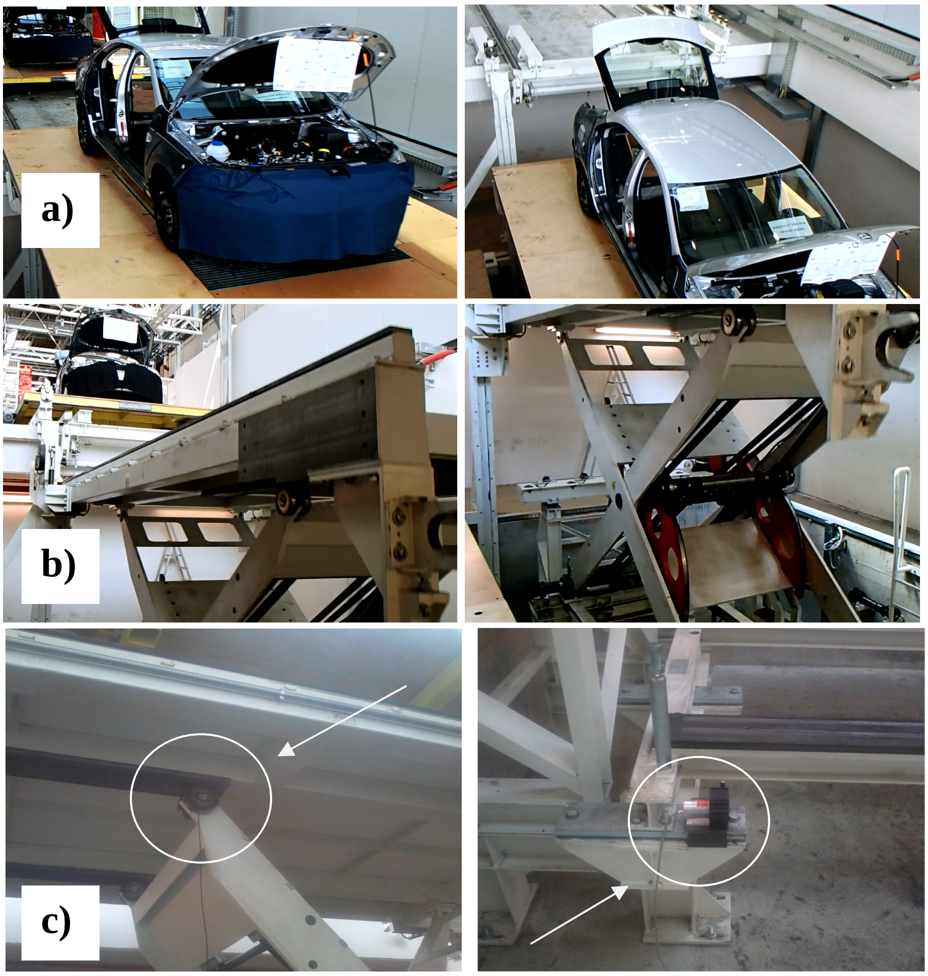

Fig. 1. a) Lifting Platform Construction For Car Relocation, b) Scissor lifting platform, c) placement of acceleration sensor (left) and a placement of trajectory sensor (right).

Numerical Analysis

Numerical analysis of dynamic load of technical assessment of the construction nodes of the platform was based on CAD data. For model dynamic analysis of platform were used only data of parts and components that contribute to transformation of dynamic loads, such as construction platforms, storage, cogs, wheels. Other parts such as the drive coupling parts (screws, washers, bearings...) were removed from the model. Dynamic analyzes were performed to assess the loading course of platform and its scissor mechanism on which the upper part of platform, stand and car acts. This geometry was imported into ANSYS pre-processor for kinematic and dynamic analysis of the forces. Then kinematic model of the links among different parts (obr.2b), forces (defining of the material model, the weight of individual components, platform load) and initial and boundary conditions were defined (Fig. 4). Dynamic analysis was performed using the numerical solver using the 4th order Runge-Kutta method (1).

$$y_{n+1} = y_n + \sum_{i=1}^{p} \vartheta_i \chi_i, \quad \chi_i = f\left(t + \alpha_i h, y_n + h\sum_{j=1}^{i-1} \beta_{ij} k_j\right), \qquad (1)$$

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

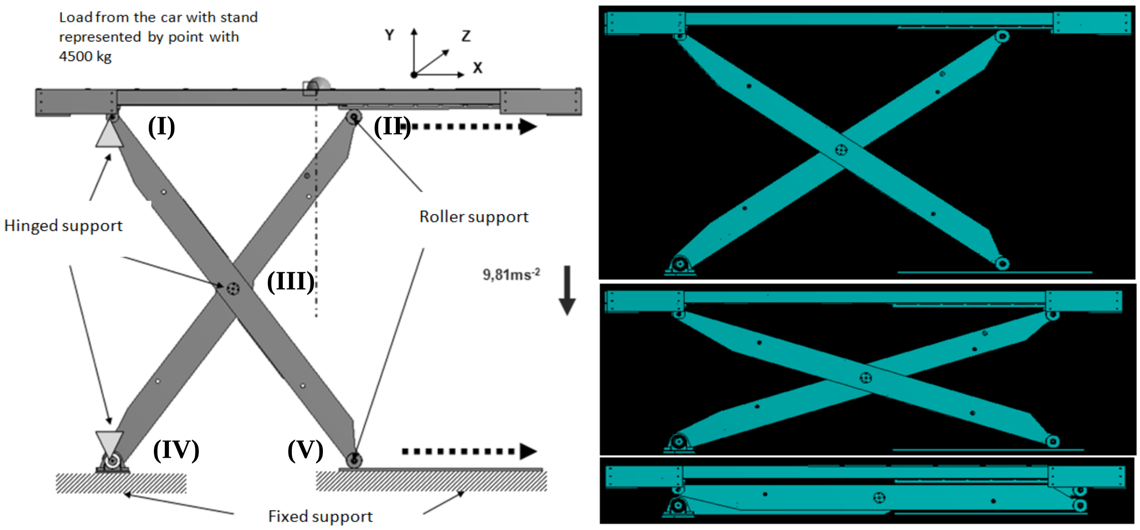

Fig. 2. Numerical model: a) Scheme of links applied in the model, b) time response.

Summary

The resulting courses of track, velocity and acceleration measurements obtained on a real platform are shown in Fig. 2. The course of the trajectory, in other words the displacement of the platform is constant in the whole range (time 0 ~ 14 sec.) The velocity course the platform is characterized by a steep increase at time 0-1s, constant course at time 2-9 s, and when braking steep deceleration at the time of 9-10s occurs. The acceleration of platform in the range of about 1-9 s is approximately constant with a value of 1 g = 9.81 ms^{-2}.The results show that when the move of platform starting (t = 0-1 s) the acceleration is 1 g + 0.5 g (~ 15 ms^{-2}) and when platform stops (t = 9-10 s) the deceleration is 1 g + 0.4g, thus resulting acceleration is -1.4 g (~ -14 ms^{-2}). The course is characterized by a start and end thrust, which apparently causes the initial oscillations (Fig. 4). The maximum load values in the most exposed places I-V are listed in Table 1.

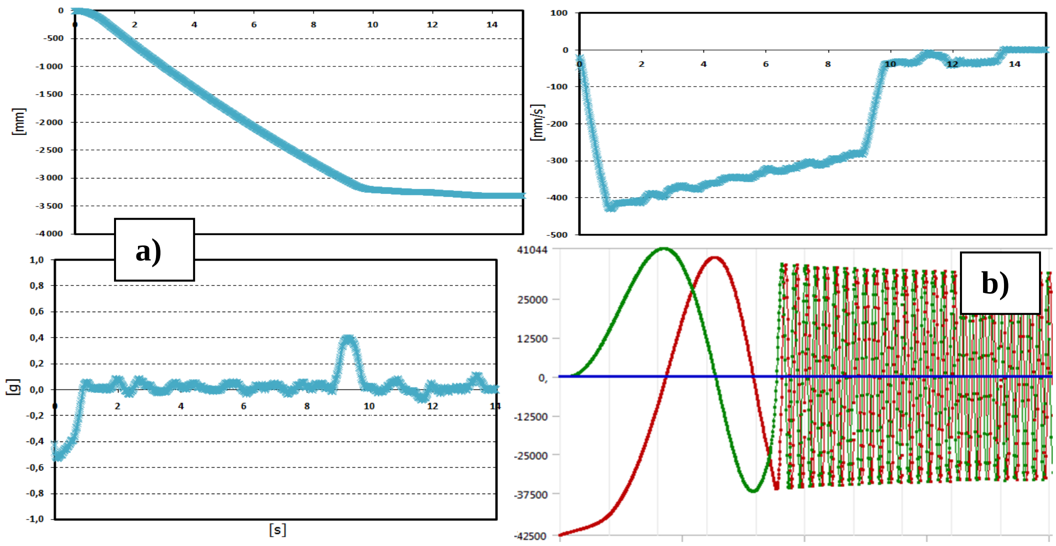

Fig. 3. a) results of experimental analysis: displacement, velocity and acceleration; b) course of initial oscillation.

Table 1. Results of numerical analysis of loaded construction nodes of the platform.

Construction node (see Fig.2)	(I)	(II)	(III)	(IV)	(V)
Force [N]	52951	47325	102590	48440	60879
Indentation stress [MPa]	38,9	52,5	56,9	18,1	67,75
Bending stress [MPa]	124,3	374,9	193,5	31,4	483,1
Shear stress [MPa]	42,1	66,9	36,3	7,6	86,2

Conclusions

Immediate load of scissor lifting platform by a car on stand causes additional bending moment. It is not appropriate in terms of long-term operation. Recommended load lifting platform should be symmetrical (equal distribution of forces on each side of the construction).

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