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VERIFICATION OF MECHANISM´S FUNCTIONALITY FOR POSTIIONING THE CAR SEAT USING MSC.ADAMS

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Abstract: *This paper presents dynamic of a virtual prototype (VP) of a lock mechanism, which would lead to verify its functionality in terms of kinematic and dynamic parameters. The proposed modifications of input parameters of the technical equipment addressed were verified using the software environment of MSC.ADAMS.*

Keywords: Simulation, Sensitivity analysis, Dynamic, Kinematic, Virtual prototype, MSC.ADAMS.

1. Introduction

The possibilities of new products design process implementation are changing with the rapid development of computer technology. It is the process of software environment simulation of the equipment being developed that has become an essential and very powerful tool needed to handle even the most complex problems of engineering practice. The initial proposal and more accurate design of new equipment made in the simulation process bring savings of time as well as financial gain. Savings are also shown in the performance of the experiment itself, because the very experiment can be prepared with minimum weaknesses thanks to the simulation. A structure created using the synthesis method enjoys a great advantage in the opportunity to assess the shape, form, appropriateness and functionality of the technical equipment design. In this paper, we present a simulation of a new design of technical equipment, which would lead to verify its functionality in terms of kinematic and dynamic.

2. Dynamic analysis of a locking mechanism virtual prototype

A car seat positions, supports and protects the passenger. In order for the ride to be comfortable, ergonomic and safe at the same time, the car interior elements must be modified or adjusted so to suit the widest possible range of passengers. One of the most important modifications of the car interior is the distance of the seat from the steering wheel. Based on these facts it is necessary to adapt the seat individually and enable its adjustment according to the size and needs of the passenger. Quick and safe securing of the distance of the seat from the steering wheel is provided by a locking mechanism that attaches the seat to the car floor. Ideally, the car seat position adjustment can be changed within the shortest time possible. At the same time, this process should take place as smoothly as possible, and with maximum safety for the passenger. The locking mechanism portfolio comprises a number of design types, for example, vertical or horizontal ratchet or permanent engaged locking. This paper presents analysis of a virtual prototype (VP) mechanism of a modular lock that is used to lock, or prevent the movement of, the car seat sliding rails in the direction of the vehicle travel (Arnold, 2008).

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3. Mobility of the lock mechanical system

Fig. 1 displays a kinematic diagram of the locking mechanism. This scheme includes only those structural elements which have a decisive influence on the results of dynamic analysis. The elements are: frame (1), housing that includes the upper rail (UR) (2), locking element (LP1/LP2) (3). Scheme A shows the state when turning the locking rod unlocks the seat and the locking elements lean upon the side if the lower (blue) rail. The seat travels along the lower rail at the velocity v_z from position A to the position where there is an opening. Subsequently, a pre-stressed leaf spring enables insertion of the locking element into the opening at the velocity v_x (Dekýš, 2015).

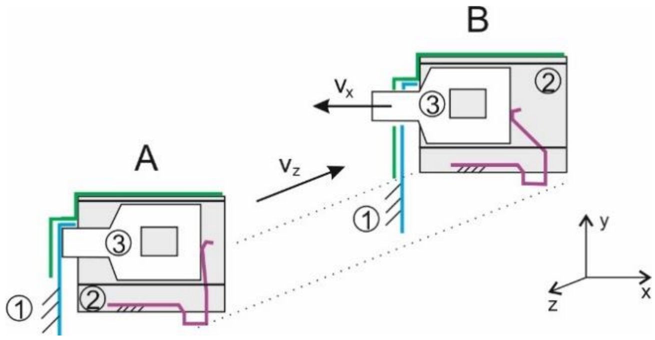


Fig. 1: Kinematic scheme of the mechanism: A – initial position, B – final position.

This kinematic has two degrees of freedom n. The upper rail moving on the lower rail defines the first degree of freedom, and the second degree of freedom is the movement of the locking element to be inserted into the opening using the pre-stressed spring. During the dynamic analysis in the MSC.ADAMS environment we consider two moving bodies in a three dimensional space. Then, the equation for calculating the constrained mechanical system degrees takes the following form:

u – the total number of members in the constrained mechanical system, including the frame,

$n_v(u-1)$ – mobility of a group of free bodies,

$\sum_{t=1}^{n_v-1} ts_t$ – removed degrees of freedom due to constraints between pairs of members of the constrained mechanical system.

That between pairs of members of the constrained mechanical system is provided by the equation:

$$s_t = \sum_{v=2}^{v_m} s_{tv}(v-1), \tag{1}$$

s_t – the number of links of class t of all pairs of constrained bodies in the constrained mechanical system,

s_{tv} – the number of links of class t linking the number v of members,

v – the number of bodies in the link s_t of bodies,

v_m – the maximum number of bodies links of class t in constrained mechanical system.

Two situations may occur during locking: a partial lockdown, i.e. the locking element passes through only one opening in the upper rail, and a complete lockdown of the mechanism when the locking element passes through both openings in the upper rail (Fig. 1) (Vavro, 2015).

4. Input parameters

It should be noted that if the modular lock is unlocked even during a ride a sudden deceleration / acceleration occurs, then the locking elements might not bog down into either of the openings in the lower rail (LR). This would prevent locking the car seat and it would move all the way to the improper extreme position, i.e. to the dash board. The task of dynamic analysis in MSC.ADAMS software is to verify whether the modular lock is able to provide and ensure sufficiently safe locking of the moving car seat even at maximum deceleration / acceleration values. The acceleration parameter was obtained from the data measured in a crash test. A 3D model of the locking lock mechanism was created in Catia software. Individual VP files were imported in .stl format to the MSC.ADAMS/View environment. The bodies were considered as rigid (Rigid Bodies) (Fig. 2). The VP model used shifting geometric constraints and contact function. The total VP mechanism weight was calculated as the sum of the child dummy weight (22 kg), child safety seat weight (8 kg) and the car seat itself (20 kg). Since the car seat is screwed to the two rails and each rail has its own modular lock, the calculated total weight was divided equally between the two rails. To carry out VP simulation, we recommended acceleration 25.25 g [m.s^{-2}]. This parameter was obtained during a real crash test (Močilan, 2016).

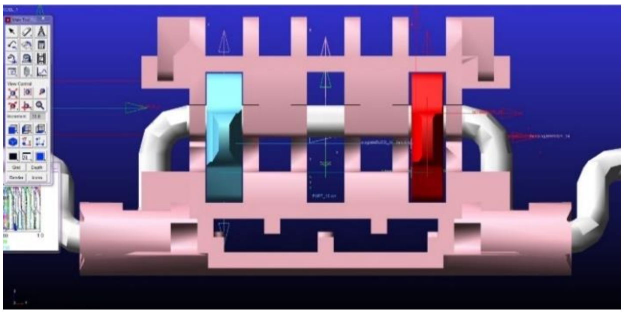


Fig. 2: Virtual prototype of locking mechanism.

A real spring is represented in the VP by a geometric constraint (SPRING). The spring is connected to the housing in the marker located at the height of the centre of gravity LP1/LP2, and to the marker of the locking element's centre of gravity LP1/LP2. Monitoring the current position of LP1 and LP2 in the rail opening uses meter for detection of distance markers. One meter is on the LP1 and LP2 edge and the other, reference meter, is situated on the edge of the upper rail outer opening (Fig. 3). In geometric constraints, we considered passive resistances in order to achieve simulations displaying more accurately the real mechanism behaviour (Jakubovičová, 2015).

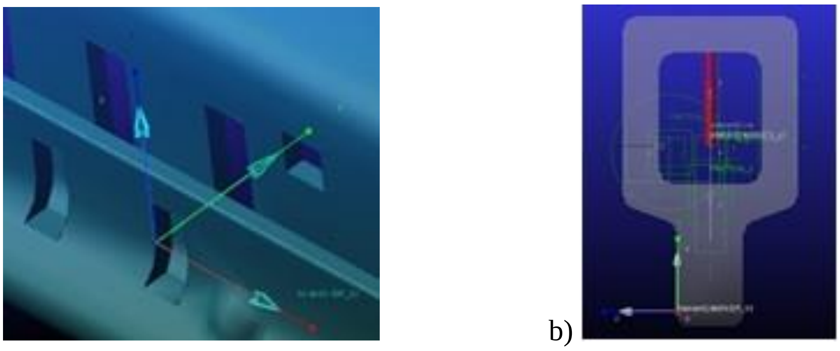
a)  b)

Fig. 3: Position of markers: a) on upper rail; b) on LP.

5. Simulation considering the system´s concurrent motions

When solving the proper functioning of the locking mechanism in the MSC.ADAMS software environment we carried out several sensitivity analyses, the outcome of which were specification of the force effect range in the mechanism´s spring, structural modification of LP1/LP2, and passive resistances in geometric constraints. Then we followed with considering only those parameters that have the greatest influence on the equipment proper functioning, and carried out simulation with consideration of the system´s concurrent motions. In the following, we will present simulation in which the lower rail carries the upper rail at a constant velocity. The lower rail then abruptly stops and upper rail moves further due to inertial effects. During this event, it is necessary that LP1 and LP2 fit into the lower rail openings, which would confirm proper functioning of the locking mechanism.

$$t = \frac{v}{a} = \frac{11.19}{25.25g} = 0.0451s \tag{2}$$

Thus, the rails moved relative to each other by, more than 6 mm, hence these two events could occur insertion of LP1/LP2 into the rail openings, and the subsequent locking of mechanism. Simulation in MSC.ADAMS was controlled by STEP function: STEP (time, 0, 0, 30, 11 190) + STEP (time, 31, 0, 31.0451, -11 190). We carried out a significant number of simulations with varying loads applied by the springs onto LP1/LP2. The best results in terms of the equipment functionality were achieved with the load from the spring forces 20 N and 25 N.

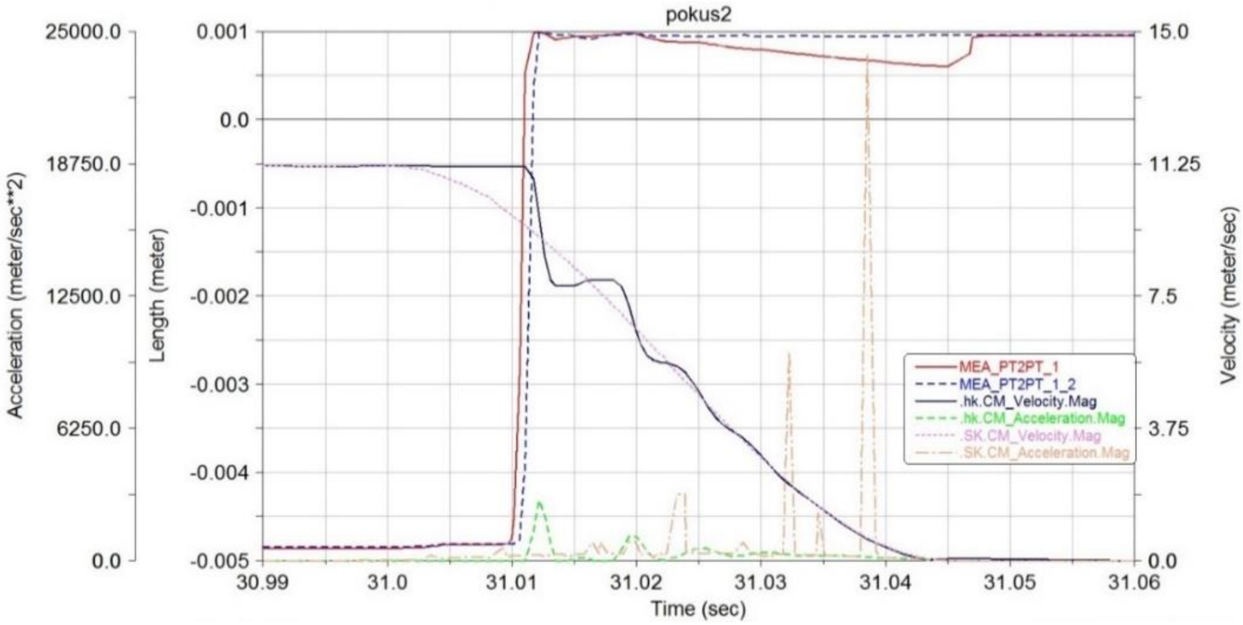


Fig. 4:Upper rail acceleration and velocity relative to the lower rail (25 N-mod. geom.).

The curve (blue and red) in (Fig. 4) shows the relative position of the locking elements marker and the reference marker on the rail at the spring force of 25 N. The (Fig. 4) clearly displays that the two locking elements engaged in full lockdown, where LP2 remained in the full lockdown and LP1 slid by 0.5 mm, while it remained in the fully locked position. This phenomenon is caused by an abrupt impact of the lower rail onto LP1. The (Fig. 4) shows further velocities and accelerations of the upper and lower rails according to time. Here it should be noted that the peaks seen in acceleration in all scenarios are caused by impact forces in contacts after LP clicking, and their value is affected by the fact it is a contact of rigid bodies.

6. Conclusion

Dynamic simulations in MSC.ADAMS confirmed that the locking mechanism fulfils its function in terms of full lockdown, when a boundary condition of acceleration is defined. It is necessary to consider the load from leaf spring force value of 10 N as proposed by the manufacturer is insufficient for safe lockdown of the mechanism. This topic represents, that the construction of mechanism complies with the dynamic load.

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