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ANALYSIS OF SEAT POSITIONING MECHANISM IN ROAD VEHICLES

Abstract:
The present paper shows how to achieve structural analysis, kinematics, respectively kinetostatic and computer-aided vertical positioning mechanism of the seat to road vehicles. The kinematic analysis of the mechanism is to verify kinematic parameters of the mechanism correspond to the values imposed by the design theme, and by kinetostatic analysis are determined the forces of mechanism elements, respectively the calculation of their strength.

Keywords:
Mechanism, kinematic chain, position, speed, acceleration

INTRODUCTION

Analysis of plane mechanisms known to one evolution over time. Thus in practices are known several methods of analysis of plane mechanisms (positional, kinematic, kinetostatic or dynamic), respectively the graphical methods, graphoanalitics and analytical each of them having advantages and disadvantages.

Graphics and graphoanalitics methods (vector equations method, projected instantaneous center of rotation, similarity, respectively polygon method forces, etc.), have the advantage that are very easily to use, requires a relative low workload, but the accuracy of results is not always the one, because the measurement error in the graphic plane.

Analytical methods (polygonal contour method) involve writing equations contour projections and their successively derivation, respectively the equations of equilibrium, resulting linear equations systems who need to be solved for as many positions of leadership element. The workload is very high, requiring solving equation systems using programs written in different programming languages, but the accuracy of results is high. This method has the disadvantage that requires knowledge of a programming language.

With the development of CAD software (Computer Aided Design) software companies have developed software packages specific field of engineering. Thus, for modeling and simulating mechanical systems are known several applications such as Mecaplan, Algor, Adams, WorkingModel, SAM, Catia, Watts & Roberts, etc. some of them doing calculations by finite element method.

Further in the following paragraphs will be present the modeling, analysis and simulation of mechanism with SAM51 program.

POSITIONING MECHANISM STRUCTURAL ANALYSIS

Overall scheme of the mechanism, 3D modeled in Autodesk Inventor Professional is shown in Figure 1.

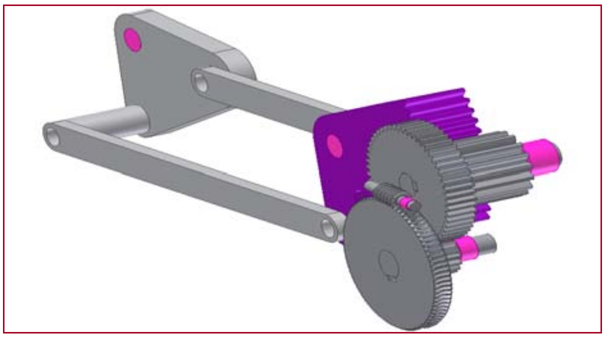

Figure 1. Overall scheme of the mechanism

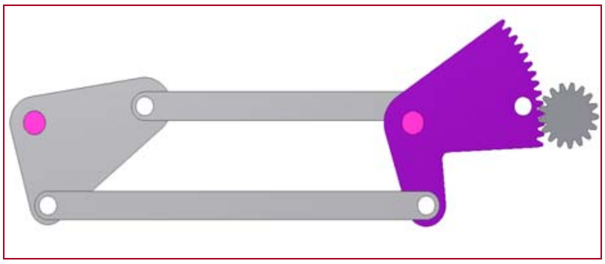

Figure 2. Articulated parallelogram mechanism

Analysis will consider only the basic mechanism, articulated parallelogram (Figure 2). Kinematic scheme of the mechanism is shown in Figure 3, and has the following technical characteristics:

Figure 3. Mechanism kinematic scheme

- *Lifting height – 38 mm*
- *While lifting chair – 3,1 s*
- *kneeling chair time – 3,1 s*
- *angle of rotation of the element manager (1+5) – 45 degrees*
- *loading mechanism – 1200 N + weight*

Geometric dimensions of component kinematic elements:

l_1 = 35 mm; l_2 = 170 mm; l_3 = 35 mm; l_4 = 50 mm; l_5 = 50 mm; distance between bearings 1 and 4 – 170 mm

Analyzing kinematic scheme of the mechanism (Figure 3) may specify the following:

- *The mechanism consists of three moving kinematic elements, 1+5, 2, 3+4 (items 3 and 4 respectively 1 and 5 are hardened one each other, relative angle between them keeping constant).*
- *The mechanism consists of four kinematic Class V joints (C5), 1,2,3,4, joint 5 and 6 don't have kinematic role (assurance the link with rod port - chair).*
- *The mechanism can be considered plane, so the family will be equal three.*

$$So: f = 3;\ n = 3;\ C_5 = 4 \qquad (1)$$

Mechanism mobility degrees number:

$$M = 3n - 2C_5 = 3\cdot 3 - 2\cdot 4 = 1 \qquad (2)$$

Mobility degrees number is equal to 1, the positioning mechanism is well defined, so for each leadership element position (1) correspond well-defined positions of other cinematic elements.

POSITIONING MECHANISM KINEMATIC ANALYSIS

Positioning mechanism kinematic analysis was performed using program SAM51 for seat lifting kinematic cycle, considered more damaging than the descent cycle and involves the following steps:

*- **Mechanism modeling**: mechanism will be modeled in the lower extreme position (Figure 4), based on kinematic joints coordinates resulting from geometric synthesis:*

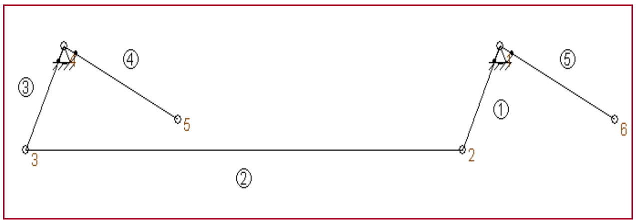

Figure 4. Lower Extreme Position
Joint 1 - (125.37,22.55); Joint 2 - (110.58,-9,17);
Joint 3 - (-59,42,-9,17); Joint 4 - (-44,63,22.55);
Joint 5 - (0,0); Joint 6 - (170,0)

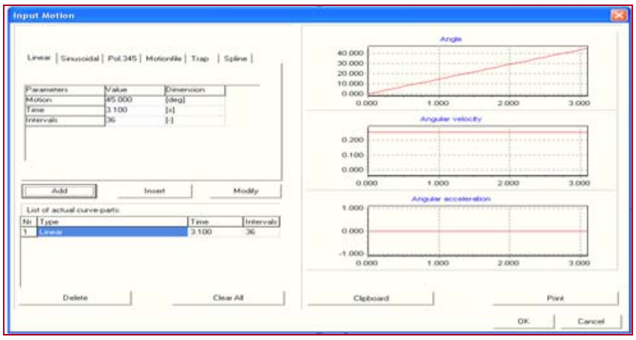

Figure 5. Input motion of the mecanism

*- **Specify the input motion of mechanism**. The input motion of the mechanism would be a uniform rotational in kinematic joint 1 (angular acceleration ε_1= 0) as shown in Figure 5 (for lifting - rotation angle 45 degrees, kinematic cycle time 3,1 s).*

*- **Kinematic analysis**. It seeks changes in graphic form the kinematic quantities variations of kinematic components items within the time in which the complete lifting of the seat race. For example is presenting kinematic joints D - E, which are part of the port rod - chair (not represented in the kinematic scheme, being parallel to the main rod 2).*

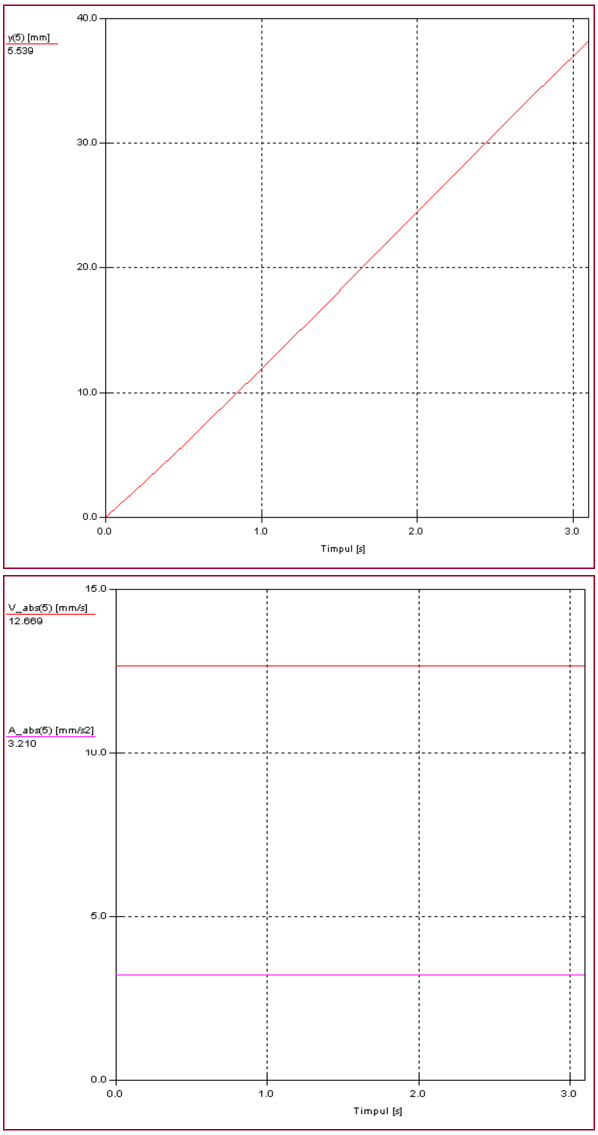

Figure 6. Kinematic of joints D – E

Their movement is identical with the movement of any point on the rod port - seat. According to the graphs in Figure 6, follows the following sizes:

- *Vertical movement: y(5) 0 ÷ 38 mm, complies with the design theme – vertical movement of the seat being – 38 mm*
- *Absolute speed: v_abs(5) = 12,669 mm/s = const*
- *Absolute acceleration: a_abs(5) = 3,210 mm/s²*

THE POSITIONING MECHANISM KINETOSTATIC ANALYSIS

Kinetostatic analysis of the positioning mechanism involves the following steps:

*- **External loading mechanism establish** (Figure 7) - is considered the loading mechanism force, F = 1200 N, distributed on port rod seat - with their two marginal joints: in joint D: F = 600 N; in joint E: F = 600 N*

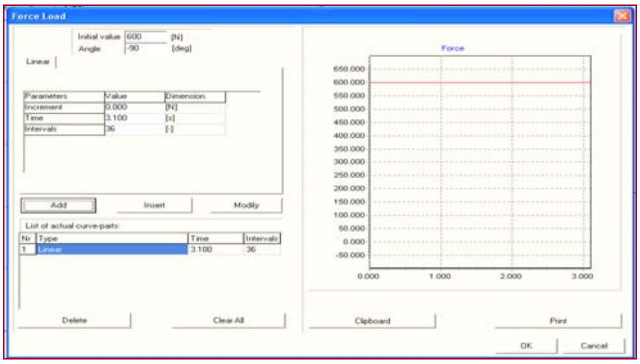

Figure 7. Force load

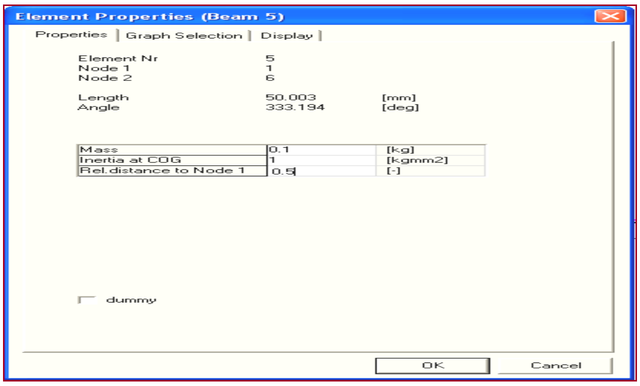

Figure 8. Element properties

*- **Defining the masses, moments of inertia and center of gravity position** for each kinematic element – will be done individually for each individual item as shown in Figure 8. Although the kinematic elements don't have considerable masses, in calculations will also consider the weight forces. To simplify the centers of gravity should be at mid-length features, and moment of inertia around an axis through the center of gravity will be considered equal to 1.*

Scheme loading mechanism for positioning the seat at minimum position obtained by the above is shown in Figure 9.

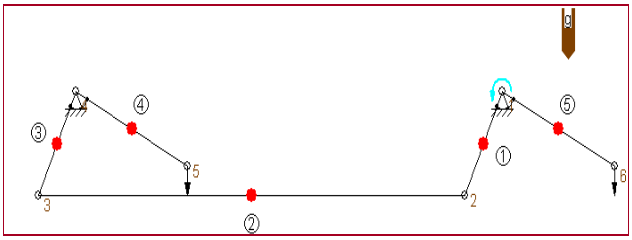

Figure 9. Mechanism charging scheme

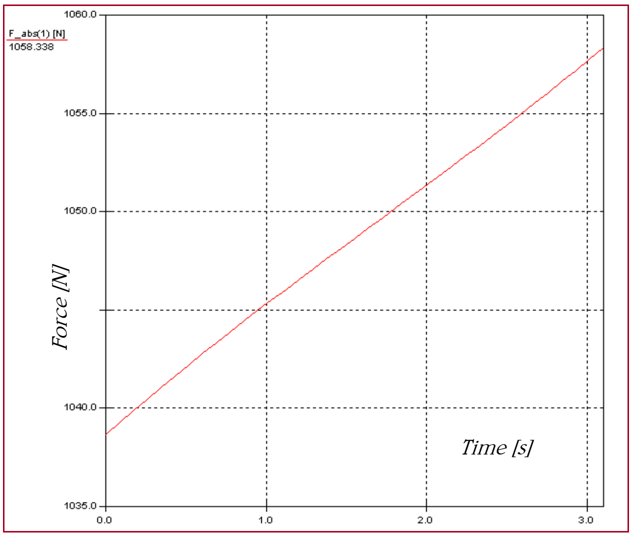

Figure 10. Joint 1 reaction force variation

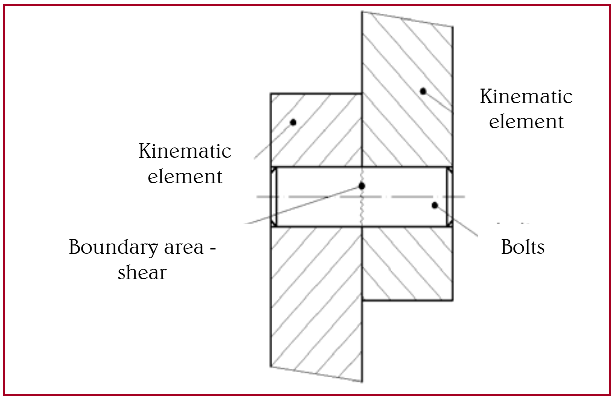

Figura 11. Bolts stress scheme

- ***Obtaining variations in graphic form, the reactions*** *of the kinematic joints on the kinematic cycle corresponding with lifting mechanism from down to up position (3,1sec). For example Figure 10 presents graphical variation of joint reaction 1.*

Maximum values of the reactions in joints are:

Joint reaction in1: RAo = 1058,338 N; Joint reaction in2): RA = 1962 N

Joint reaction in3: RB = 1962 N; Joint reaction in4: RBo = 1057,778 N

Joint reaction in5): RD = 600,763 N; Joint reaction in6: RE = 601,226 N

With the maximum values of the reaction forces war made the sizing calculations of the bolts that materialize kinematic joints. Stress scheme of the bolts is shown in Figure 11, the basic stress being shear stress in the contact area between the two kinematic elements forming that joint.

Necessary diameter of the bolts results from the shear resistance condition.

$$\tau_f = \frac{R}{A} \Rightarrow A_{nec} = \frac{\pi d_{nec}^2}{4} = \frac{R}{\tau_{af}} \Rightarrow d_{nec} = \sqrt{\frac{4R}{\pi \cdot \tau_{af}}} \qquad (3)$$

where: R – maximum value of the kinematic joint reaction

τ_{af} – shear permissible strain for bolts material

Bolts material: OL50, τ_{af} = 112 MPA (N/mm^2)

After each kinematic joint calculation, the following values for bolts diameters will results:

d_1 = 10 mm; d_2 = 8 mm; d_3 = 8 mm; d_4 = 10 mm; d_5 = 8 mm; d_6 = 8 mm

CONCLUSION

Road vehicles seat positioning mechanism analysis, made by the SAM 51 program, is a fast and efficient way to determining kinematic parameters in each stage of operation mechanism, respectively forces from elements and kinematic joints necessary for there dimensioning on stress that are submitted.

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