



# Design of Double Oscillating Sliding Mechanism

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**Abstract.** The major objective of this paper is to solve a synthesis problem, namely the design of a mechanism with a double oscillating slide that has the role of rotating a rocker at 180°; the relationships between the lengths of the elements that ensure its rotation without blocking are established. The geometric model of the mechanism was made in the Autodesk Inventor program and imported in the Altair Inspire program. The kinematic analysis of the mechanism was performed in Altair Inspire program and its working was validated.

**Keywords:** oscillating sliding mechanism · kinematic analysis · Autodesk Inventor · Altair Inspire

## 1 Introduction

In the literature there are various models of mechanisms that ensure the rotation of an element with an imposed angle. These types of mechanisms find their applicability in different fields (e.g.: industry, medicine, sports). Link, gear, cam, or hybrid mechanisms may result from this synthesis problem (e.g.: [4, 5]). Some of these mechanisms are based on reciprocating type of mechanisms; they are used, for example, in shaping machines and in concrete pumps, with the role of reducing the time in the return stroke in relation to the working time (e.g.: [1, 2]).

In this paper, the Autodesk Inventor program for geometric modelling was used.

Files can be imported directly from Autodesk Inventor into Altair Inspire software without the need to save them in a specific general format. Altair Inspire also has other features for kinematic analysis (e.g. intuitive graphical interface and flexibility in choosing and editing the engine); with this program, the animation and kinematic analysis for a mechanism that provide 180° rotation for one element was performed.

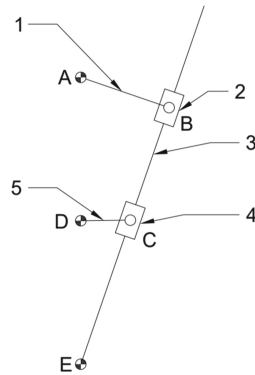
The model adopted in this paper is based on the concept of Eng. Doan Van Minh from Vietnam, Hanoi [3].

## 2 Mechanism Model

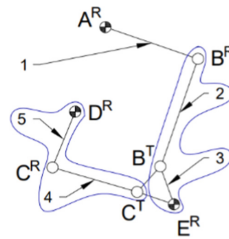
### 2.1 Structural Analysis of the Mechanism

The kinematic scheme of the mechanism is shown in Fig. 1 (1 – the crank, 2 and 4 – the sliders, 3 – the rocker, 5- the oscillating element) and the structural one in Fig. 2.

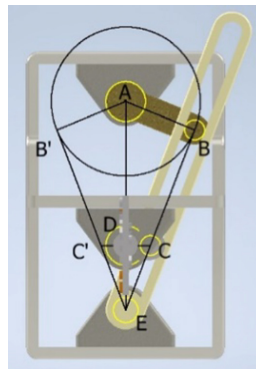
The mechanism can be decomposed according to Assur's principle into driving element 1, and two dyads: RTR and RRT.



**Fig. 1.** Kinematic scheme of the mechanism.



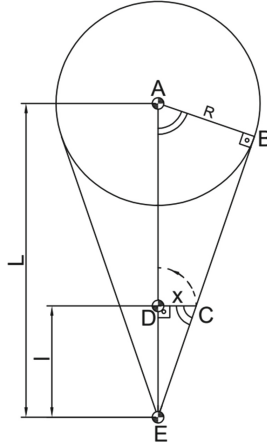
**Fig. 2.** Structural scheme.



**Fig. 3.** The mechanism in the limit positions.

## 2.2 The Geometry of the Mechanism

The desired extreme positions of the oscillating element are imposed, in order to result in its  $180^\circ$  rotation (CD, DC' are collinear). The oscillating element changes its direction of rotation in the extreme positions of the rocker link. The limit positions of the rocker element are tangent to the trajectory of the point B (Fig. 3).



**Fig. 4.** Scheme for determining the avoidance of hitting elements.

From the similar triangles ABE and CDE results the relation 1 of proportionality between the sides (Fig. 4).

$$\frac{l}{\sqrt{L^2 - R^2}} = \frac{x}{R} \quad (1)$$

We adopt the parameters L and R. In Eq. 1 we adopt l and determine x (2) or we adopt x and determine l (3).

$$x = \frac{R \cdot l}{\sqrt{L^2 - R^2}} \quad (2)$$

$$l = \frac{x \cdot \sqrt{L^2 - R^2}}{R} \quad (3)$$

In order not to hit the elements, the inequality 4 must be checked.

$$L - l > R + x \quad (4)$$

For the version when x is adopted, the expression of l (3) is replaced in inequality (4) and the inequality (5) results.

$$L - \frac{x \sqrt{L^2 - R^2}}{R} > R + x \quad (5)$$

After intermediate calculations, the Eq. 6 is obtained, indicating the admissible range for the variable x, so as to avoid hitting the elements.

$$x < \frac{L - R}{1 + \frac{\sqrt{L^2 - R^2}}{R}} \quad (6)$$

In conclusion, if R and L are known, x is adopted so that it respects (6), and l is calculated with Eq. (3), according to x adopted, and vice versa.

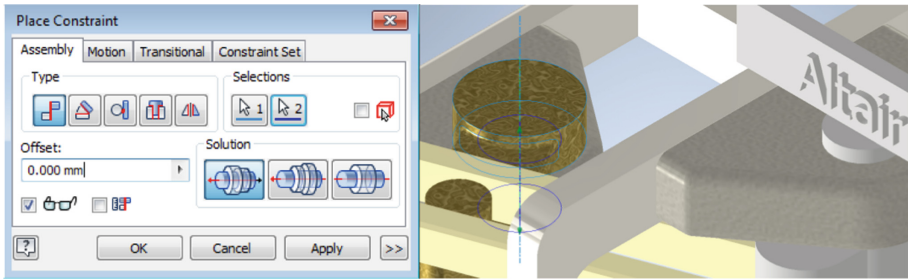


Fig. 5. The constraint of cylindrical parts.

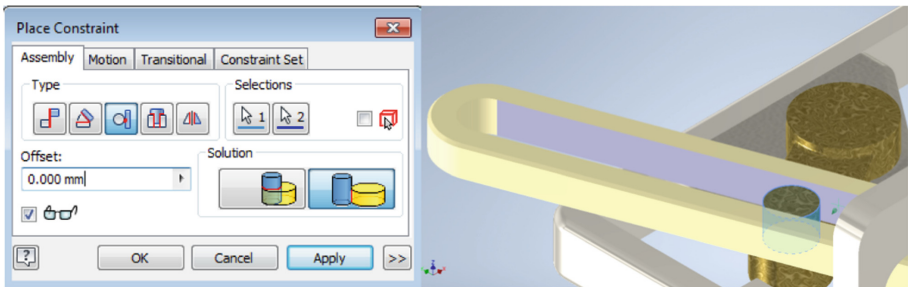


Fig. 6. Cylinder-plane constraint.

### 2.3 Geometric Modeling with Autodesk Inventor

With the Autodesk Inventor program, the geometric model of the mechanism was created, respecting the imposed relationships between its geometric parameters in making the parts sketches ( $R = 30$  mm,  $L = 84$  mm,  $l = 26$  mm,  $x = 8,74$  mm). The geometric model for each kinematic element was made. After modeling, the parts were introduced in the assembly plan and were constrained to obtain the degrees of freedom specific to the kinematic joints (Fig. 5, Fig. 6).

The final mechanism is presented in Fig. 7 and Fig. 8. The file was exported in \*.stp format to Altair Inspire program, for kinematic analysis.

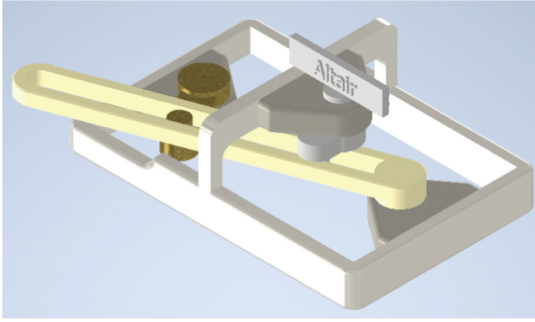
### 2.4 Kinematic Analysis

After opening the file in Altair Inspire, indicate the direction of gravity.

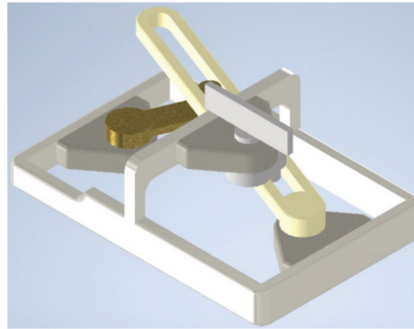
With the *Rigid Element* instruction, the component parts of the base were stiffened and fixed with *Ground* instruction.

To indicate the kinematic joints, access the *Joints* command, which has the facility to automatically recognize the possible joints made by the surfaces in contact. Of these, the following joints have been activated:

- crank and base
- rocker and base



**Fig. 7.** The mechanism in the left limit position.



**Fig. 8.** The mechanism in the right limit position.

– oscillating element and base.

The two upper 4th class joints between the crank final bolts and rocker have been defined as contacts.

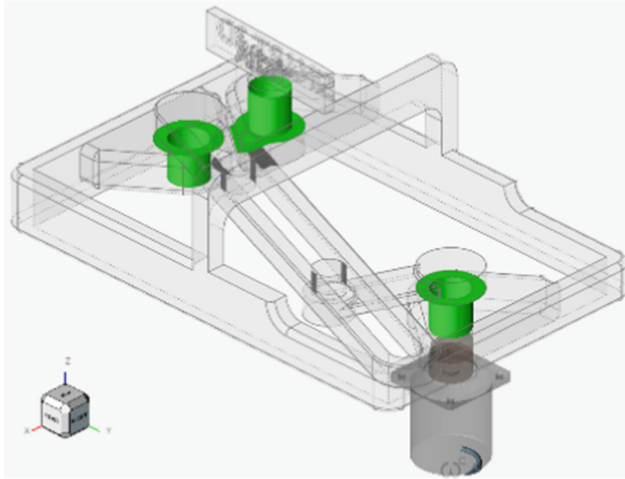
In the kinematic joint between the crank and the base was placed the engine having the linear law defined by the following parameters: *Speed* of 60 rpm, *End time* 10 s, *Output Rate* 30 Hz (Fig. 11).

The next step is to access the *Motion Analysis* command to perform the kinematic analysis.

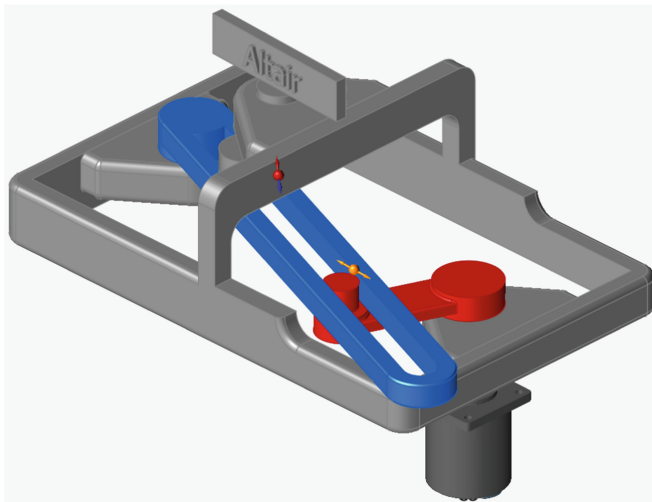
After animate the mechanism, access the diagrams with the results through the *Plot Manager* command.

The displacement, velocity and angular acceleration of the oscillating element with  $180^\circ$  rotation are shown in the Figs. 12, 13 and 14 respectively.

From Fig. 12 results the total angular displacement of the oscillating element of  $180^\circ$ , which respects the condition imposed in the synthesis problem of the function generating mechanism. The time of 0.4 s also resulted for one direction of rotation of the oscillating element and for the opposite direction a shorter time, 0.6 s.



**Fig. 9.** The recognition of the joints from the mechanism.



**Fig. 10.** Defining contacts from the mechanism.

Were obtained the maximum angular velocities of the oscillator element to a forward stroke and return of 121.2 rpm and -57.41 rpm respectively (Fig. 13); also, the maximum values of the angular acceleration were  $185.88 \text{ rad/s}^2$  and  $-159.62 \text{ rad/s}^2$ , respectively, for the two strokes (Fig. 14).

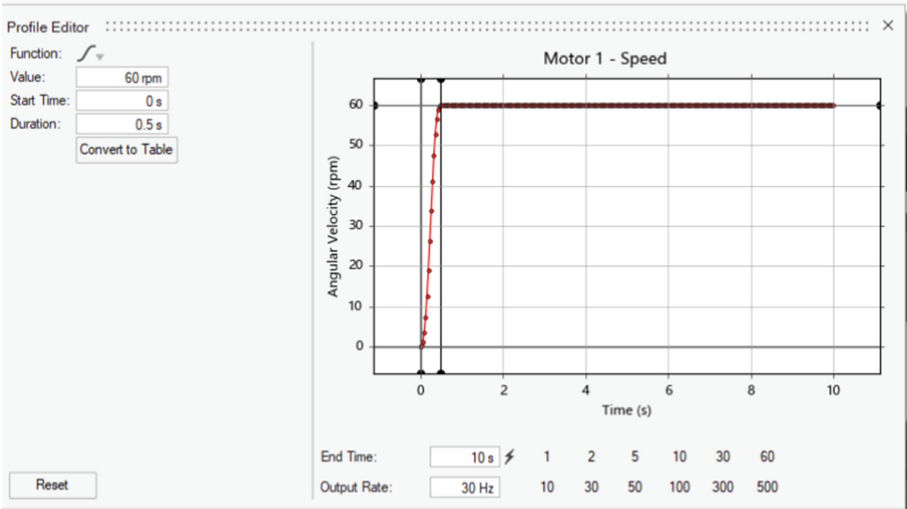


Fig. 11. The parameters of the motor.

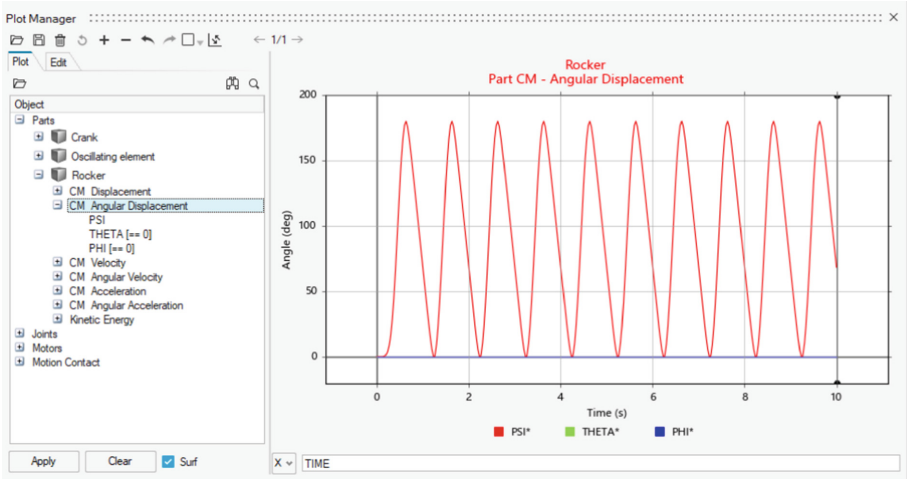
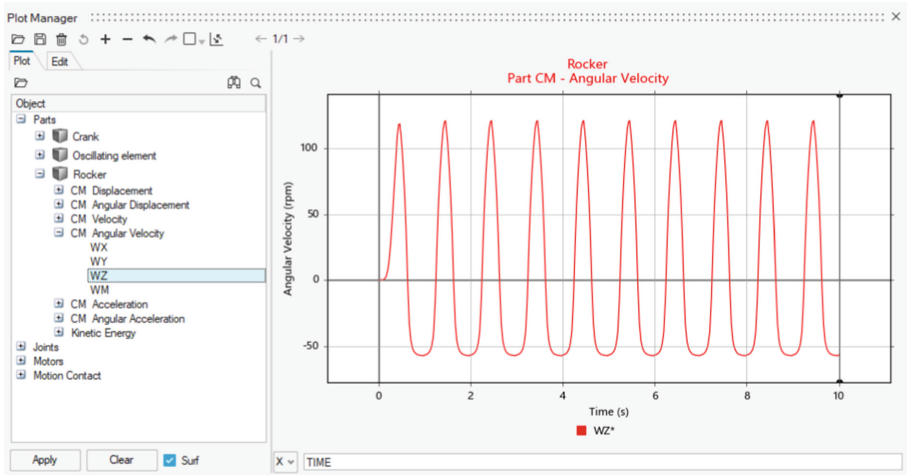
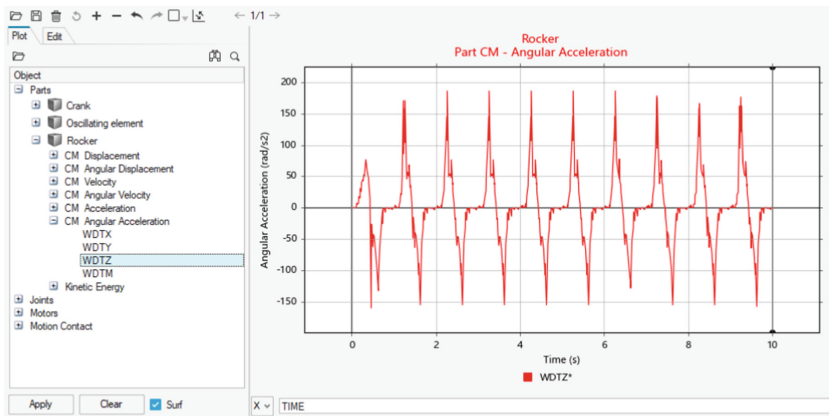


Fig. 12. Angular displacement diagram for the oscillating element.



**Fig. 13.** Angular velocity diagram for the oscillating element.



**Fig. 14.** Angular acceleration diagram for the oscillating element.

### 3 Conclusions

The analyzed mechanism falls into the alternative type mechanisms, i.e. it ensures a higher speed in one stroke than in the other. The analytical relations between the geometric parameters were determined in order to adopt the lengths of the elements so that the oscillating element to perform  $180^\circ$  without the elements hitting each other; this is a benefit of this study. Kinematic analysis of the mechanism made with the Altair Inspire software confirmed the validity of the model and gave the values of the displacement, velocity and acceleration of the rocker.



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