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TRACKING SYSTEM TYPE CAM-LINKAGE MECHANISMS

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Abstract: *Concentrator collectors are generally used in order to increase the quantity of energy absorbed from the Sun. These collectors use only the direct radiation, being equipped with a single axis tracking system. This paper presents some types of tracking systems, with linkages and cam mechanisms and the kinematic analysis of a complex mechanism of this type, using multibody system method.*
Key words: *tracking systems, came - linkage mechanisms*

1. INTRODUCTION

The cams, gear boxes or linkages mechanisms are an important part for tracking systems for solar collectors or solar panels. So far, these mechanisms were individually analyzed, using specific models for each type of mechanism. In order to obtain the dynamic behaviour of the product, a unique model for all of these types is required. The Multibody system method –MBS (used by the high performance software like ADAMS) proposes a unique interpretation for all these types of mechanisms (Ciobanu&Visa, 2005).

Concentrator collectors are generally used in order to increase the amount of energy absorbed from the Sun. For a better concentration of the solar radiation, due to the change of the sun position on the sky, these collectors are equipped with tracking systems (Duffie&Beckman, 1991). Tracking systems are classified by their motions: rotation can be around a single axis (usually horizontal East-West, horizontal North-South, vertical, or parallel to the earth axis) or can be around two axes(Stein& Harrigan, 1985).

Most common tracking systems use a gear box and a belt, rope or chain transmission. Collector trackers also use actuators or systems based on the "hydro-mechanic", or gravitation principle.

The paper proposes a unitary/common kinematic method for the modelling of the linkage and cam mechanisms using MBS (Visa, 2009). The goal is to use these software's to generate the kinematic and dynamic functions and to solve them numerical. The kinematic model proposed is tested by analyzing a mechanism used as a tracking system for a solar collector.

2. TRACKING SYSTEM

A parabolic trough concentrates the incoming solar radiation into a line running along the length of the trough. A tube (receiver) carrying a transferring heat fluid is placed along this line, absorbing the concentrated solar radiation and heating the inside fluid (Ciobanu, 2009). The trough must be tracked round one axis. In figures 1 is presented the structural scheme of a complex tracking mechanism. The main parts are: 1-2-3 mechanism with disc cam and oscillating follower, 3-4-5-1 – linkage mechanism, 5-6-7-1 – ratchet system. The parabolic trough collector and ratchet gear are bounded together making one body (fig. 2).

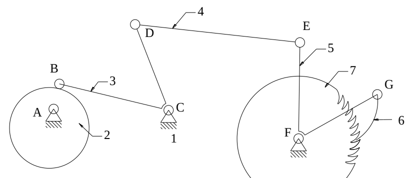


Fig. 1. Tracking system for parabolic trough collector

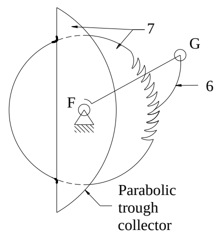
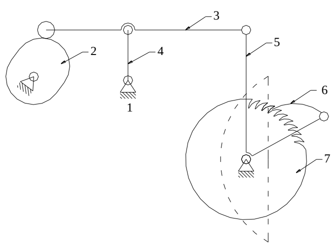
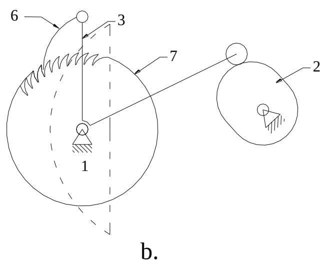


Fig. 2. Collector assembly – ratchet gear system

The tracking system is driven using a motor connected to cam 2. By means of the oscillating follower 3 and coupler 4, the rotational motion is transmitted to the element 5 which drives the ratchet gear mounted on the parabolic trough 7. In order to avoid the reverse motion (corresponding to the zone of follower approach) the ratchet gear is equipped with a one way coupling. According to this operating principle, in figure 3 are presented other types of tracking systems.



a.



b.

Fig. 3. Other types of tracking systems type cam – linkages

3. KINEMATIC ANALYSIS

In order to determine the kinematics conditions imposed to the tracking system, it is considered the case of a month, when the average time of day is 15 hours. Thus, the collector should

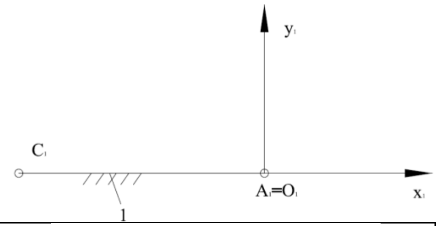
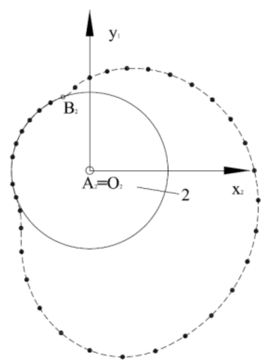
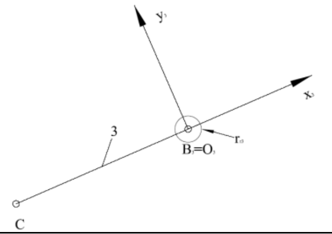
rotate 180^0 in 15 hours, which means 12^0/hour. The mechanism presented in figure 3,b is analyzed below, using the multibody system method.
Number of bodies n_c=3, where:
1-fixed body; 2-input body; 3- output body.
The degree of freedom is

$$M=3(n_c-1)-\Sigma r_g= 3(3-1)-5=1$$

Body	Geometrical constraints	Place	r_g
1-2	R	A	2
1-3	R	C	2
2-3	CC	B	1

Tab. 1. Geometrical constraints for mechanism

In order to determine the 6 unknowns (generalized coordinates – x_{O2}, y_{O2}, φ_2, x_{O3}, y_{O3}, φ_3), the geometrical model of the bodies is required (see tab. 2) (Ciobanu&Visa 2010).

	Body 1 $x_{A1}=0$; $y_{A1}=0$; $x_{C1}=-120$; $y_{C1}=0$;
	Body 2 $x_{A2}^{(2)}=0$; $y_{A2}^{(2)}=0$; Real profile of the cam, given by points (Ciobanu 2010) $B_2(x_{B2}^{(2)},y_{B2}^{(2)})$
	Body 3 $x_{C3}^{(3)}=-130$; $y_{C3}^{(3)}=0$; $x_{B3}^{(3)}=0$; $y_{B3}^{(3)}=0$

Tab. 2. Geometrical model for mechanism

The system of displacement functions is composed of 6 equations where (1) and (2) are geometrical constraints of type R for point A, (3) and (4) constraints of type R for point C, (5) constraint of type CC for point B and (6) is the driving constraint (Ciobanu, 2009).

$$x_{A1}=x_{O2}+x_{A2}^{(2)}*\cos(\varphi_2)-y_{A2}^{(2)}*\sin(\varphi_2) \tag{1}$$

$$y_{A1}=y_{O2}+x_{A2}^{(2)}*\sin(\varphi_2)+y_{A2}^{(2)}*\cos(\varphi_2) \tag{2}$$

$$x_{C1}=x_{O3}+x_{C3}^{(3)}*\cos(\varphi_3)-y_{C3}^{(3)}*\sin(\varphi_3) \tag{3}$$

$$y_{C1}=y_{O3}+x_{C3}^{(3)}*\sin s(\varphi_3)+y_{C3}^{(3)}*\cos(\varphi_3) \tag{4}$$

$$\left[x_{O2}+x_{B2}^{(2)}*\cos(\varphi_2)-y_{B2}^{(2)}*\sin(\varphi_2)-x_{O3}\right]^2+ \left[y_{O2}+x_{B2}^{(2)}*\sin(\varphi_2)+y_{B2}^{(2)}*\cos(\varphi_2)-y_{O3}\right]^2-r_{r3}^2=0 \tag{5}$$

$$\varphi_2=\omega*t \tag{6}$$

Using the software Maple 5 for numerical solving of the equation systems (1)…(6), the following displacement function is obtained (fig.4):

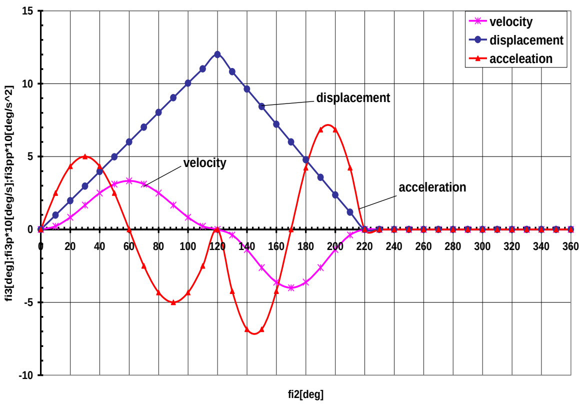


Fig. 4. Displacement function for the output body

4. CONCLUSION

For the considered numerical data, the system of equation (1...6) allows the establishment of the generalized coordinates variations, and, also, of their differentials.

Numerical study allows a comparative analysis of different types of complex mechanisms and the choice of adequate solutions for a task.

Using this method the whole range of cam-linkage mechanisms is described by six types of geometrical restrictions (R, T, RR, TT, RT, CC), that can be unitary approached in a single analytical model.

Starting from this kinematic analysis (fig.4), the dynamic behavior model of the system can be performed.

5. ACKNOWLEDGEMENTS

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