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Original Research Paper

Presentation of the Mechanism in the Cross

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Abstract: The cross-machine has frequent uses in mechanical assemblies, automation, robotics and mechanisms with various uses. In the present paper we want to present this type of mechanism with its main, geometric, cinematic, strengths and propose its study in its possible use as an internal combustion engine. In this novelty, the mechanism will have two types of operation, one when operated from the crank (a compressor operation) and another when actuated from the piston (a motor operation). The forces will be presented along with their distribution (how the forces are distributed from one element to the other) in both modes of operation, compressor and engine.

Keywords: Cross-Machine, Robots, Manipulators, Automation, Engines, Mechanical Transmissions, Kinematics, Forces, Dynamics, Dynamic Kinematics, Dynamic Forces

Introduction

The cross-machine mechanism to be studied in the present paper is presented in a schematic diagram in Fig. 1. It is made up of a crank 1 and a dyad RTT (an assuric structural group).

Such a mechanism has some clear advantages compared to other types of mechanisms, it has a more rigid structure compared to other mechanisms and at the same time a better-balanced structure in operation.

In order for the mechanism to work normally even at high speeds, it must be properly constructed, with ball bearings with limited, well-dimensioned games, according to the model in Fig. 2 (Frăţilă *et al*., 2011; Pelecudi, 1967; Amoresano *et al*., 2013; Antonescu, 2000; Comănescu *et al*., 2010; Aversa *et al*., 2016a; 2016b; 2016c; 2016d; 2017a; 2017b; 2017c; 2017d; 2017e; Mirsayar *et al*., 2017; Cao *et al*., 2013; Dong *et al*., 2013; De Melo *et al*., 2012; Garcia *et al*., 2007; Garcia-Murillo *et al*., 2013; He *et al*., 2013; Lee, 2013; Lin *et al*., 2013; Liu *et al*., 2013; Padula and Perdereau, 2013; Perumaal and Jawahar, 2013; Petrescu and Petrescu, 1995a; 1995b; 1997a; 1997b; 1997c; 2000a; 2000b; 2002a; 2002b; 2003; 2005a; 2005b; 2005c; 2005d; 2005e, 2016a; 2016b; 2016c; 2016d; 2016e; 2013; 2012a; 2012b; 2011; Petrescu *et al*., 2009; 2016a; 2016b; 2016c; 2016d; 2016e; 2017a; 2017b; 2017c; 2017d; 2017e; 2017f; 2017g; 2017h; 2017i; 2017j; 2017k; 2017l; 2017m; 2017n; 2017o; 2017p; 2017q; 2017r; 2017s; 2017t; 2017u; 2017v; 2017w; 2017x; 2017y; 2017z; 2017aa; 2017ab; 2017ac; 2017ad; 2017ae; Petrescu and Calautit, 2016a; 2016b; Reddy *et al*., 2012; Tabaković *et al*., 2013; Tang *et al*., 2013; Tong *et al*., 2013; Wang *et al*., 2013; Wen *et al*., 2012; Antonescu and Petrescu, 1985; 1989; Antonescu *et al*., 1985a; 1985b; 1986; 1987; 1988; 1994; 1997; 2000a; 2000b; 2001; List the first flights, From Wikipedia; Chen and Patton, 1999; Fernandez *et al*., 2005; Fonod *et al*., 2015; Lu *et al*., 2015; 2016; Murray *et al*., 2010; Palumbo *et al*., 2012; Patre and Joshi, 2011; Sevil and Dogan, 2015; Sun and Joshi, 2009; Crickmore, 1997; Goodall, 2003; Graham, 2002; Jenkins, 2001; Landis and Dennis, 2005; Clément, Wikipedia; Cayley, Wikipedia; Coandă-1910, Wikipedia; Gunston, 2010; Laming, 2000; Norris, 2010; Goddard, 1916; Kaufman, 1959; Oberth, 1955; Cataldo, 2006; Gruener, 2006; Sherson *et al*., 2006; Williams, 1995; Venkataraman, 1992; Oppenheimer and Volkoff, 1939; Michell, 1784; Droste, 1915; Finkelstein, 1958; Gorder, 2015; Hewish, 1970).

Science Publications

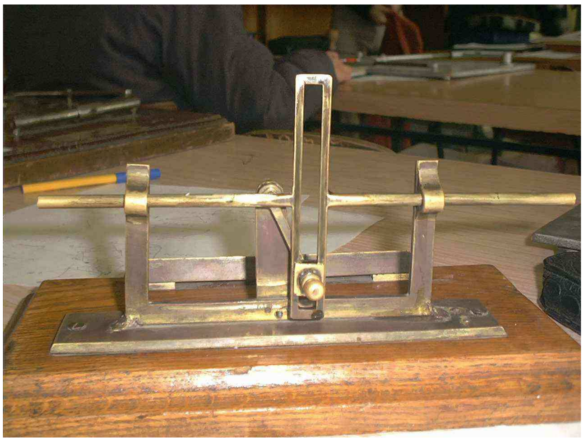

Fig. 1: The cross-machine mechanism

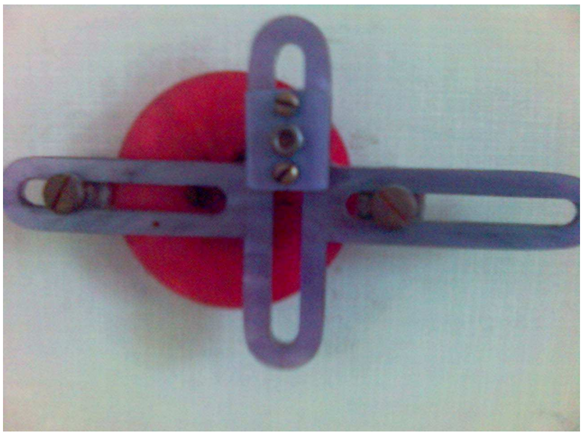

Fig. 2: The cross-machine mechanism

Materials and Methods

Dyads by the appearance of five (RTT), are generally used in cross-mechanisms. The kinematic scheme of a type 5 dyad can be seen in Fig. 3.

The dyad of the five RTT (Fig. 3) of the elements 2 and 3 has only one rotation input coupler *B* and two translational couplers, an inner one *B** and another external input *C*, which even if materialized by two symmetrical constructive couplings (which have the role of supporting and printing a correct dynamo of the dialect RTT) is only one kinematic because it links only between elements 0 and 3.

The cross (element 3) moves to the right or left on the holders of the coupling *C*, being practically driven by the piston 2 which slides in its turn on the vertical axis of the cross, receiving the movement from a motor element through of the rotating coupler *B*.

On the diadem, all the kinematic parameters of the input couplers *B* and *C* are known and the positional parameters s_2 and s_3 with their derivatives must be determined according to the relations given by the system (1).

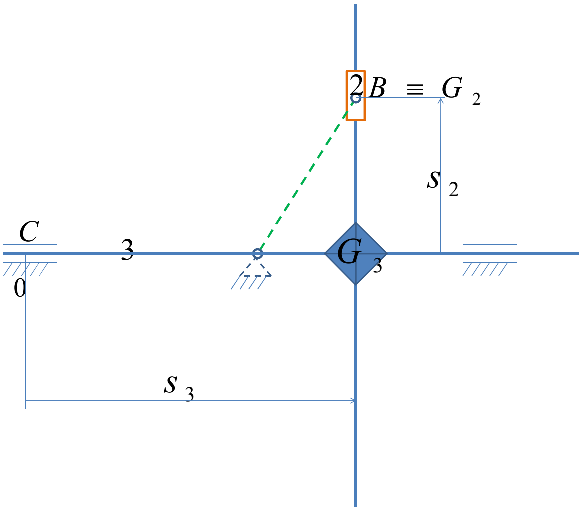

Fig. 3: The structural group, a dyad RTT

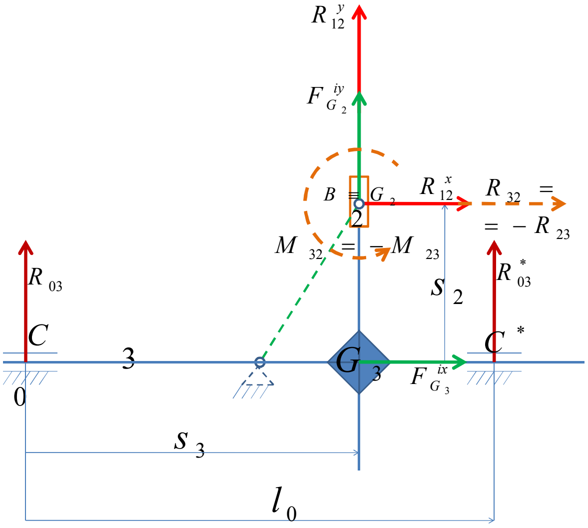

Fig. 4: The forces of a dyad RTT

For a general RTT diadem, solving is straightforward and straightforward according to the relationships (1) and in addition for the dyad RTT used in the crosshairs, the speeds and accelerations of the fixed point *C* are null, the relations simplifying much according to the system (2):

$$\begin{cases} \begin{cases} x_B = x_C + s_3 \\ y_B = y_C + s_2 \end{cases} \Rightarrow \begin{cases} s_3 = x_B - x_C \\ s_2 = y_B - y_C \end{cases} \Rightarrow \\ \begin{cases} \dot{s}_3 = \dot{x}_B - \dot{x}_C \\ \dot{s}_2 = \dot{y}_B - \dot{y}_C \end{cases} \Rightarrow \begin{cases} \ddot{s}_3 = \ddot{x}_B - \ddot{x}_C \\ \ddot{s}_2 = \ddot{y}_B - \ddot{y}_C \end{cases} \end{cases} \tag{1}$$

$$\left\{\begin{cases} s_3 = x_B - x_C \\ s_2 = y_B - y_C \end{cases} \Rightarrow \begin{cases} \dot{s}_3 = \dot{x}_B \\ \dot{s}_2 = \dot{y}_B \end{cases} \Rightarrow \begin{cases} \ddot{s}_3 = \ddot{x}_B \\ \ddot{s}_2 = \ddot{y}_B \end{cases}\right. \tag{2}$$

Dyad by the five RTT looks has the kinetostatic (forces) scheme of Fig. 4. Kinetostatic equations can be traced in the relationships given by the system (3):

$$\begin{cases} \sum M_B^{(2)} = 0 \Rightarrow M_{32} = 0 \\ \sum F_y^{(2)} = 0 \Rightarrow R_{12}^y + F_{G_2}^{iy} = 0 \Rightarrow R_{12}^y = -F_{G_2}^{iy} \\ \sum F_x^{(2,3)} = 0 \Rightarrow R_{12}^x + F_{G_3}^{ix} = 0 \Rightarrow R_{12}^x = -F_{G_3}^{ix} \\ \sum F_x^{(2)} = 0 \Rightarrow R_{32} + R_{12}^x = 0 \Rightarrow R_{32} = -R_{12}^x = F_{G_3}^{ix} \\ \\ \begin{cases} \sum F_y^{(3)} = 0 \Rightarrow R_{03} + R_{03}^* = 0 \Rightarrow R_{03}^* = -R_{03} \\ \sum M_B^{(3)} = 0 \Rightarrow -R_{03} \cdot s_3 + R_{03}^* \cdot \left(l_0 - s_3\right) + F_{G_3}^{ix} \cdot s_2 = 0 \\ \Rightarrow R_{03} = \dfrac{s_2}{l_0} \cdot F_{G_3}^{ix} \end{cases} \end{cases} \tag{3}$$

Results and Discussion

The distribution of forces to the dyad by the five RTT aspect can be seen in Fig. 5 for the compressor cycle and in Fig. 6 for the engine cycle.

Computational relations for the compressor operating mechanism are given by the system (4):

$$\begin{cases} \begin{cases} F_u = F_m \cdot \cos\varphi \\ F_b = F_m \cdot \sin\varphi \end{cases} \begin{cases} \dot{s}_2 = \dot{y}_B - \dot{y}_C = \dot{y}_B = l_1 \cdot \omega \cdot \cos\varphi = v_B \cdot \cos\varphi \\ v_m = v_B = l_1 \cdot \omega \end{cases} \\ \eta_i^C = \dfrac{P_u}{P_c} = \dfrac{F_u \cdot \dot{s}_2}{F_m \cdot v_m} = \dfrac{F_m \cdot \cos\varphi \cdot v_B \cdot \cos\varphi}{F_m \cdot v_B} = \cos^2\varphi \\ \eta_i^{DC} = \dfrac{P_u^D}{P_c} = \dfrac{F_u \cdot v_u}{F_m \cdot v_m} = \dfrac{F_m \cdot \cos\varphi \cdot v_m \cdot \cos\varphi}{F_m \cdot v_m} = \cos^2\varphi = \eta_i^C \\ \begin{cases} \eta_i^{DC} = \eta_i^C = \cos^2\varphi \\ \eta_i^{DC} = D^C \cdot \eta_i^C \end{cases} \Rightarrow D^C = 1 \end{cases} \tag{4}$$

The calculation relations for the case when the mechanism works in the motor mode are given by the system (5):

$$\begin{cases} \begin{cases} F_u = F_m \cdot \cos\varphi \\ F_i = F_m \cdot \sin\varphi \end{cases} \begin{cases} v_m \equiv \dot{s}_2 = \dot{y}_B - \dot{y}_C = \dot{y}_B \\ = l_1 \cdot \omega \cdot \cos\varphi = v_B \cdot \cos\varphi \\ v_u = v_m \cdot \cos\varphi = v_B \cdot \cos^2\varphi \end{cases} \\ \eta_i^M = \dfrac{P_u}{P_c} = \dfrac{F_u \cdot v_B}{F_m \cdot \dot{s}_2} = \dfrac{F_m \cdot \cos\varphi \cdot v_B}{F_m \cdot v_B \cdot \cos\varphi} = 1 \\ \eta_i^{DM} = \dfrac{P_u^D}{P_c} = \dfrac{F_u \cdot v_u}{F_m \cdot v_m} = \dfrac{F_m \cdot \cos\varphi \cdot v_m \cdot \cos\varphi}{F_m \cdot v_m} = \cos^2\varphi \\ = \begin{cases} \eta_i^{DM} = D^M \cdot \eta_i^M = \cos^2\varphi \\ \eta_i^M = 1 \end{cases} \Rightarrow D^C = \cos^2\varphi \end{cases} \tag{5}$$

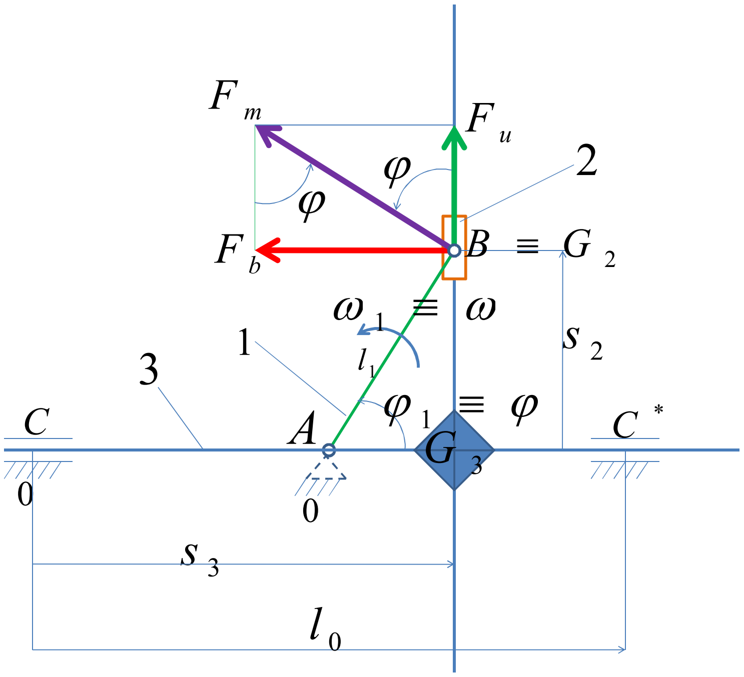

Fig. 5: Distribution of forces to the cross-machine mechanism for the compressor cycle

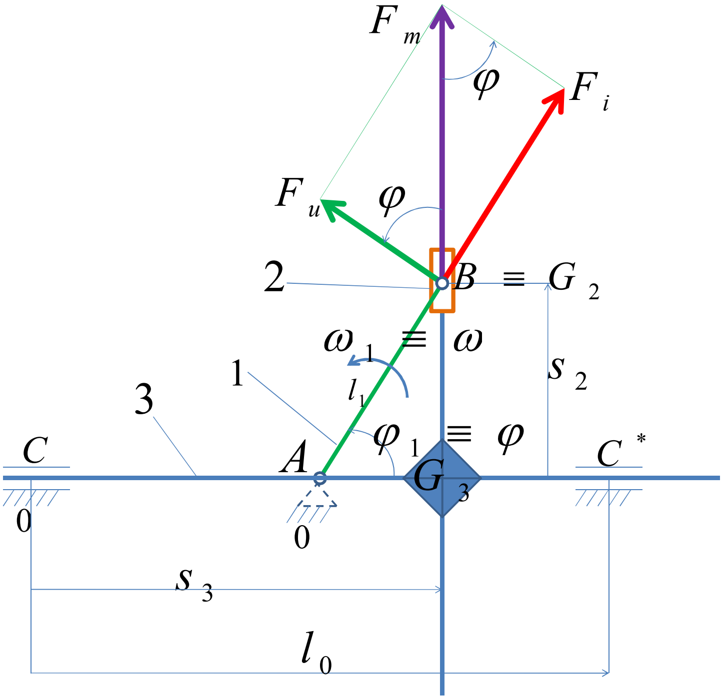

Fig. 6: Distribution of forces to the cross-machine mechanism for the motor cycle

If we used an oscillating sliding mechanism or a crosshair mechanism for the internal combustion engines, the instantaneous and final mechanical efficiency would be higher than those achieved by the conventional piston crank shaft. Mechanical yield is greater for the oscillating sliding mechanism and it increases even more for the crosshairs. The same happens with dynamic returns (which are actually the real ones, i.e., operating returns).

Besides the fact that the mechanical and dynamic yields are higher in the cross-machine mechanism, additionally, the general dynamics is greatly improved by this mechanism and due to the fact that it has fewer rotation or rotation movements and even the momentum of mechanical inertia (mass) the reduced crank has a much simplified expression (see relation 6, the tree-type crank, i.e., element 1 is already balanced, $G_1 = A$):

$$\begin{aligned}
&J^* = J_{G_1} + m_2 \cdot s_2'^2 + m_3 \cdot s_3'^2 = J_{G_1} + m_2 \cdot l_1^2 \cdot \cos^2\varphi \\
&+ m_3 \cdot l_1^2 \cdot \sin^2\varphi = J_{G_1} + l_1^2 \cdot \left(m_2 \cdot \cos^2\varphi + m_3 \cdot \sin^2\varphi\right) \qquad (6) \\
&for\, m_2 = m_3 = m \Rightarrow J^* = J_{G_1} + m \cdot l_1^2
\end{aligned}$$

Conclusion

The cross-machine has frequent uses in mechanical assemblies, automation, robotics and mechanisms with various uses. In the present paper we want to present this type of mechanism with its main, geometric, cinematic, strengths and propose its study in its possible use as an internal combustion engine. In this novelty, the mechanism will have two types of operation, one when operated from the crank (a compressor operation) and another when actuated from the piston (a motor operation). The forces have been presented along with their distribution (how the forces are distributed from one element to the other) in both modes of operation, compressor and engine.

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Author's Contributions

All the authors contributed equally to prepare, develop and carry out this manuscript.

Ethics

This article is original and contains unpublished material. Authors declare that are not ethical issues and no conflict of interest that may arise after the publication of this manuscript.

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