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RESEARCH ON THE INFLUENCE OF THE CONNECTING ROD MASS AND THE SLIDER MASS ON THE DYNAMIC BEHAVIOR OF MECHANIC ECCENTRIC PRESSES

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Abastract. The increase of the productivity of mechanic eccentric presses may be achieved on the basis of knowing the influence of several factors on the dynamic behavior of these machines. This paper presents the influence of some constructivr parameters on the values of the values of the reactions applid by the bearings to the crankpin, based on a mathematical model.

1. PRESENTATION OF THE MATHEMATIC MODEL

The mathematic model used for studying the above mentioned influences was achieved on the basis of the dissociation of the driving rod mass in three equivalent point masses, obtaining the so-called equivalent dynamic system. The three discrete masses are placed in the symmetry centres of the driving rod bushes and in its weight center. This system has to accomplish the following conditions in order to be equivalent with the initial one:

a) The sum of the three discrete masses must be equal to the total mass of the connecting rod;

b) The center of the mass system formed by the three discrete masses must coincide with the mass center of the connecting rod;

c) The kinetic energy of the three discrete masses system must be equal in any moment with the connecting rod energy, which performs a plane-parallel movement.

To the point mass placed in the center of the connecting rod connection to the slider is associated the mass m_C of the subassembly ram + tool clutch system + tool moving part, which performs a linear alternative movement.

The model is viable, because it has been found that by dissociating the mass of the driving sub-assembly in the equivalent dynamic system formed by the three point masses, the torque load of the three inertia forces corresponding to the three discrete masses is identic to the torque load of the inertia forces field corresponding to the moving equipment made by the connectingrod + ram + tool clutch system + tool moving part.

On the basis of this mathematic model, the expressions of the two components of the inertia forces reduced to the main shaft have been found. The first component-Nj-is contained in the plane of the crankpin and it is guided parallel to the crank axis, and the second-Tj-is perpendicular on the crankpin plane.

The following notations have been used:

-R-the crankpin radius (eccentricity) of the main shaft;

-L-the lenght of the driving rod;

-L_1,L_2-the distances between the mass centre of the connecting rod and the symetry axes of its two bushes;

-a-the rotation angle of the main shaft crank;

-m_B-the connecting rod mass;

-J_C-the moment of the axial inertia of the crank in comparison with a perpendicular axis on its movement plane and which passes through the center of the crank masses;

-m_C-the mass of the ram togheter with the tool clamping system and the moving part of the tool;

-?=R/L-the mechanic characteristic of the press;

-l-the distance between the perpendicular planes on the rotation axis of the crank-shaft which pass through the symetry centres of the shafts;

-Fja-the centrifugal inertia force corresponding to the crankpin and the eccentric housing for adjusting the stroke length;

-Vj1, Hj1, Vj2, Hj2-the components contained in the crankpin plane and respectively perpendicular on its plane belonging to the reactions applied by the bearings on the axle bearings adjacent to the crankpin, resulting from the action of the inertia force corresponding to the crankpin and the moving equipment attached to it:

The expressions of the components Nj and Tj are:

$$
\begin{cases}
\begin{aligned}
& \Big\{ N_j = ?\,^2 R \Big[\Big[?\frac{L_2}{L}\left(m_B - \frac{J_C}{L_1 L_2}\right)\sin^2 a - \frac{1}{1-?^2\sin^2 a}\Big\{\left(\frac{J_C}{LL_2} + m_C\right) \\
& \frac{\cos\alpha\sqrt{\left(1-\lambda^2\sin^2\alpha\right)^3} + \lambda\left(\cos 2\alpha + \lambda^2\sin^4\alpha\right)}{1-\lambda^2\sin^2\alpha} + \left(m_B - \frac{J_C}{L_1L_2}\right)[\cos\alpha\cdot \\
& \sqrt{\left(1-\lambda^2\sin^2\alpha\right)^3} + \lambda\frac{L_1}{L}(\cos 2\alpha + \lambda^2\sin^4\alpha)]\}] \cdot (\cos\alpha\sqrt{\left(1-\lambda^2\sin^2\alpha\right)} - \\
& \lambda\sin^2\alpha) - \frac{L_2}{L}\left(m_B - \frac{J_C}{L_1L_2}\right)\sin\alpha\{\lambda[\cos\alpha + \lambda\frac{L_1}{L}\frac{\cos 2\alpha + \lambda^2\sin^4\alpha}{\sqrt{\left(1-\lambda^2\sin^2\alpha\right)^3}}] + \\
& + \frac{L_2}{L}\sqrt{1-\lambda^2\sin^2\alpha}\}\sin\alpha\left(\lambda\cos\alpha + \sqrt{1-\lambda^2\sin^2\alpha}\right) - \frac{J_C}{LL_1}]; \\
& T_j = \Big\{ ?\,^2 R \Big[\Big[?\frac{L_2}{L}\left(m_B - \frac{J_C}{L_1 L_2}\right)\sin^2 a - \frac{1}{1-?^2\sin^2 a}\Big\{\left(\frac{J_C}{LL_2} + m_C\right) \\
& \frac{\cos\alpha\sqrt{\left(1-\lambda^2\sin^2\alpha\right)^3} + \lambda\left(\cos 2\alpha + \lambda^2\sin^4\alpha\right)}{1-\lambda^2\sin^2\alpha} + \left(m_B - \frac{J_C}{L_1L_2}\right)[\cos\alpha\cdot \\
& \sqrt{\left(1-\lambda^2\sin^2\alpha\right)^3} + \lambda\frac{L_1}{L}(\cos 2\alpha + \lambda^2\sin^4\alpha)]\}]\sin\alpha\cdot \\
& \left(\lambda\cos\alpha + \sqrt{1-\lambda^2\sin^2\alpha}\right) + \frac{L_2}{L}\left(m_B - \frac{J_C}{L_1L_2}\right)\sin\alpha\{\lambda[\cos\alpha + \\
& +\lambda\frac{L_1}{L}\frac{\cos 2\alpha + \lambda^2\sin^4\alpha}{\sqrt{\left(1-\lambda^2\sin^2\alpha\right)^3}}] + \frac{L_2}{L}\sqrt{1-\lambda^2\sin^2\alpha}\} \cdot \cos\alpha\sqrt{\left(1-\lambda^2\sin^2\alpha\right)} \\
& -\lambda\sin^2\alpha)].
\end{aligned}
\end{cases}
\tag{1}
$$

2. WORKING OUT THE RESULTS

The study was processed on the press P.A.I. 63, which has the following characteristics:

- nominal force: 63 tf;
- ram stroke: 10...120 mm;
- race: 90 cd/min;
- power of driving motor: 5.5 kw;
- connecting rod mass: 89 kg;
- ram mass: 170 kg;
- driving rod minimum length: 572 mm.

The study of the influence of modifying the connecting rod mass on the values of the components of inertia forces has been made starting from m_B = 79 kg and increasing this with 5 kg up to 99 kg.

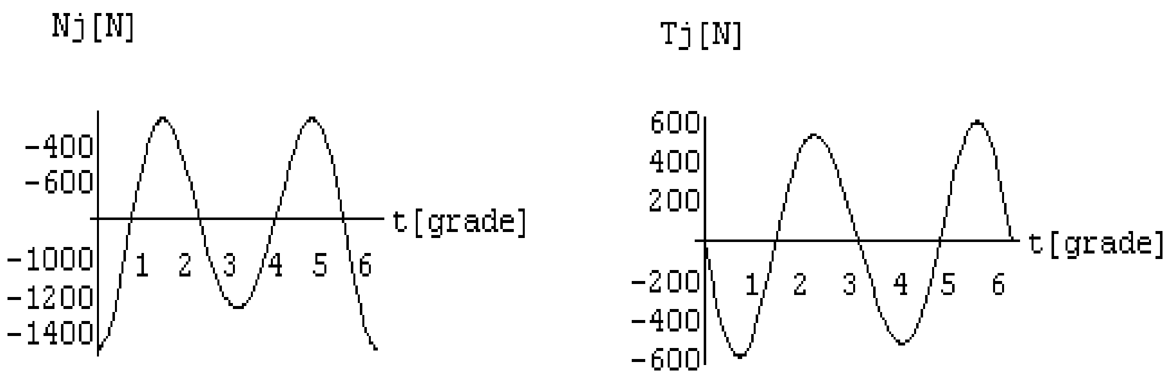
For the cases sudied the values of the components of the inertia forces are:

1) N_{jmax}=-254.035 N; N_{jmin} = -1457.24 N; T_{jmax} = 593.544 N; T_{jmin} = -593.544 N;
2) N_{jmax}=-271.696 N; N_{jmin} = -1484.52 N; T_{jmax} = 598.291 N; T_{jmin} = -598.291 N;
3) N_{jmax}=-289.358 N; N_{jmin} = -1511.81 N; T_{jmax} = 603.04 N; T_{jmin} = -603.04 N;
4) N_{jmax}=-307.02 N; N_{jmin} = -1539 N; T_{jmax} = 607.783 N; T_{jmin} = -607.783 N;
5) N_{jmax}=-325.46 N; N_{jmin} = -1564.35 N; T_{jmax} = 612.529 N; T_{jmin} = -612.529 N.

The study of the influence of the ram mass (together with the tool clamping system and the moving part of the tool) on the values of the components of the inertia forces has been made starting from m_C = 150 kg and increasing this with 20 kg up to 230 kg. For the cases studied, the values of the components of the inertia forces are following:

1) N_{jmax} = -297.652 N; N_{jmin} = -1520.1 N; T_{jmax} = 603.037 N; T_{jmin} = -603.037 N;
2) N_{jmax}=-289.358 N; N_{jmin} = -1511.81 N; T_{jmax} = 603.04 N; T_{jmin} = -603.04 N;
3) N_{jmax}=-294.708 N; N_{jmin} = -1640.83 N; T_{jmax} = 664.043 N; T_{jmin} = -664.043 N;
4) N_{jmax}=-292.764 N; N_{jmin} = -1762.55 N; T_{jmax} = 725.05 N; T_{jmin} = -725.05 N;
5) N_{jmax}=-288.82 N; N_{jmin} = -1882.28 N; T_{jmax} = 786.056 N; T_{jmin} = -786.056 N.

The variation curves $N_j(\alpha)$ and $T_j(\alpha)$ have all the same form, as they are presented in fig.1.



Fiog.1 The evolutions of the components of the inertia forces

The way N_{jmax}, N_{jmin}, T_{jmax}, T_{jmin} vary in accordance with the size of the connecting rod mass and in accordance with the size of the ram mass are presented in fig. 2 and fig. 3.

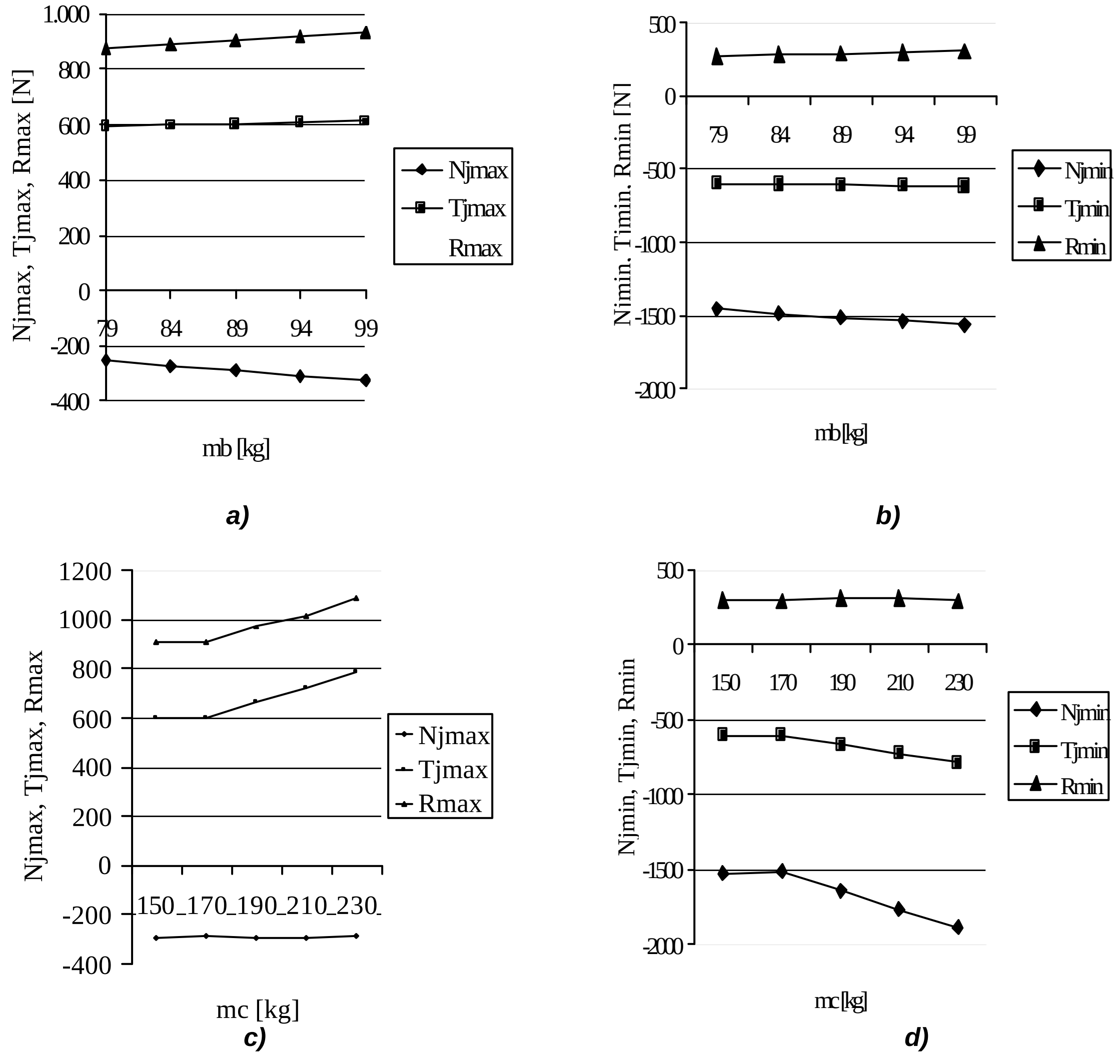


Fig. 2 The evolutions of the extreme values of the components of the inertia forces

3. FINAL CONCLUSIONS AND OBSERVATIONS

1) By modifying the crank mass (from 79 to 99 kg), the maximum and minimum values of the components of inertia forces increase in absolute value;

2) By increasing the ram mass, the maximum and the minimum values of the components of inertia forces increase in absolute value (N_{jmax}-slightly and T_{jmax}-rapidly);

4) By increasing the values of the constructive parameters m_B and m_C the values of the maximal variation of the components of inertia forces increase.

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