STUDY ON THE DYNAMIC BEHAVIOR OF MECHANIC ECCENTRIC PRESSES

ИССЛЕДОВАНИЕ ДИНАМИЧЕСКОГО ПОВЕДЕНИЯ МЕХАНИЧЕСКИХ ЗКСЦЕНТРИКОВЫХ ПРЕССАХ

Assoc. prof. dr. Burlacu C., PhD. eng. Iordan O., PhD. eng.Vicol I.
Faculty of Machine's Manufacturing and Industrial Management - Technical University "Gh. Asachi" of Iassy, Romania

Abstract: *To increase the productivity of mechanic eccentric presses may be achieved on the basis of knowing the influence of several factors on the dynamic behaviour of these machines. This paper presents the influences of some parameters (adjusting and constructive parameters) on the values of the rotation speed of the main shaft, based on a mathematical model achieved on the basis of reducing the moving masses (of the driving rod and of the slider) to the main shaft. For an easy study of mentioned influences, the authors achieved a graph interface.*
Keywords: MECHANIC ECCENTRIC PRESSES, SIMULATION MODEL

.

1. Introduction

This paper present a dynamic model which (relative to other models) is much closer to the physical model of the driving mechanism. This model was obtained on the basis of the known method of the reduction of all the components of the driving mechanism at an equivalent shaft, on which is actioning on one side the motor moment from the motor source, and-on the other side-the resisting moment from the working process and from de friction processes.

As new elements of the proposed model we can enumerate the following:

- the evolution essentially nonlinear of the force from the working process;
- the friction force from the slider guidings is considered as having a essentially nonlinear character too;
- the friction moments from the structure of the kinematic chain are considered different at the start relative to the function on the working process.

The ecuations which describe the movement of the system were inferred starting from Lagrange ecuations:

$$\frac{d}{dt}\left(\frac{\partial E_c}{\partial \dot{q}}\right)+\frac{\partial E_c}{\partial q}=0 \quad (1)$$

If we take as general coordinate the rotation angle of the main shaft crank, then q'=ω, and if we accept that the kinetic energy is $E_c=J\cdot(\omega^2/2)$-were J is the sum of the inertia moments reduced at the main shaft, we obtain the moving ecuations of the driving mechanism in the working phase (2).

The parameters who appear in relation (1) have the following signifiance: α -the rotation angle of the main shaft; ω-angular speed of the main shaft; ω_{0m}-the synchronism angular speed of the electric motor; i-transmision ratio between the motor and the main shaft; R-the crankpin radius (eccentricity) of the main shaft (adjustable in the case of the presses type PAI); λ-the mechanic characteristic of the press (λ=L/R, where L-is the length of the driving rod); $J_{red.const}$-the sum of the constant inertia moments at the main shaft; m_c-slider mass; G-the weight of the slider with the elements due to this; M_{mv}-the virtual maxi-mum moment of the motor, parameter introduced at the linearisation of the mechanical characteristic of the motor, in the working zone; F_d-the deformation force developed for the working process; F_f-the friction force from the slider guidings; M_f-the friction moment of the flywheel togheter with the working mechanism;

For an easy study of the influence of some constructive and adjusting factors on the rotation speed of the main shaft and also on the evolutions of the motor moment and the consumed power on the driving motor, it was achieved by the authors a graph interface, with the help of which we could modify the values of the following parameters: the inertia moment of the flywheel; the transmision ratio between the motor and the main shaft; the crankpin radius (eccentricity) of the main shaft; the length of the driving rod; the slider mass; the driving rod mass; the friction moment of the flywheel with the working mechanism; the friction force between the slider and its guidings; the deformation force; the moment of applying the deformation force (expressed by the angular position of the crankpin).

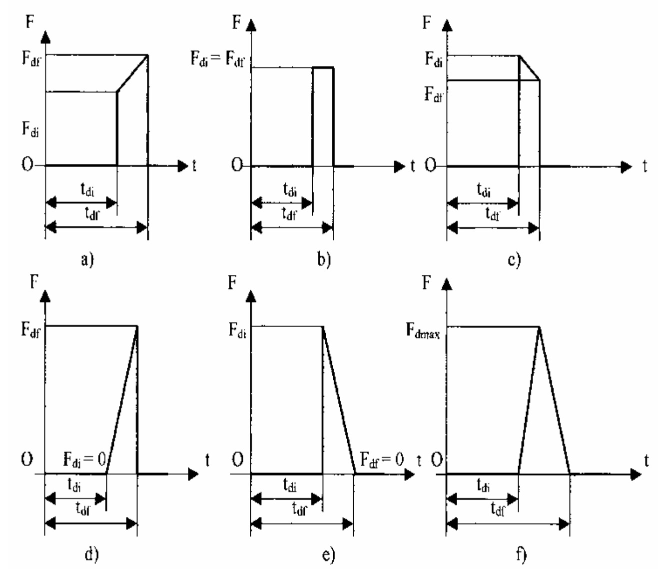
$$(2)\quad \begin{cases} \dfrac{d\omega}{dt}=\dfrac{M_{mv}\cdot\frac{1}{i}-M_{mv}\cdot\frac{\omega}{\omega_{0m}}\cdot\frac{1}{i^2}}{J_{red}+m_cR^2(\sin\alpha-\frac{\lambda}{2}\sin 2\alpha)^2}- \\ \quad -\dfrac{R(F_d+F_f+G)(\sin\alpha-\frac{\lambda}{2}\sin 2\alpha)-M_f}{J_{red}+m_cR^2(\sin\alpha-\frac{\lambda}{2}\sin 2\alpha)^2}+ \\ \quad +\dfrac{2m_cR^2(\sin\alpha-\frac{\lambda}{2}\sin 2\alpha)(\cos\alpha-\lambda\cos 2\alpha)\cdot\omega^2}{J_{red}+m_cR^2(\sin\alpha-\frac{\lambda}{2}\sin 2\alpha)^2}; \\ \dfrac{d\alpha}{dt}=\omega. \end{cases}$$

2. Working out the results

The study was made on the press PAI 63. The variations of the main parameters were in the neighbourhood of the characteristics of the press (in the actual construction): nominal force F_N = 63tf; motor type ASI 132M-38-6 (with the characteristics: P = 5,5 kW, n_0 = 1000 rot/min, n_n = 960 rot/min); the transmision ratio between motor and the flywheel: i = 0,10128; the frecquency of the slider drives: n = 90 cd/min; the crankpin radius: adjustable between 5 and 60 mm; the length of the driving rod: adjustable between 572 and 622 mm; the friction moment of the flywheel together with the driving subassembly: M_f = 199,6 N·m; the slider mass: m_c = 170 kg; the connecting rod mass: m_B = 89 kg; the inertia moment of the flywheel: J_v = 264 N·m.

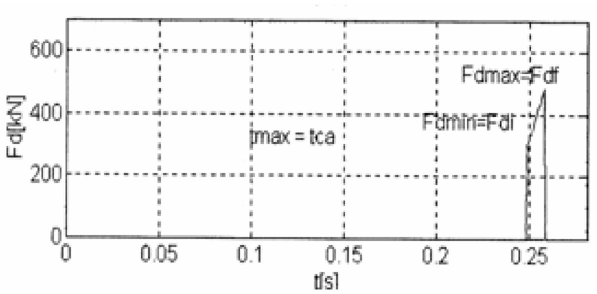
A facility offered by the mathematic model is the possibility to simulate loadings with variable forces (as value and as evolution manner). For that, the force was defined by an initial value and a final value, between these values considering a linear evolution. In this manner, it could be obtained different evolutions of forces (fig.1); that we can aproximate very good the evolution of the force corresponding to a certain deformation process.

The graph interface allows the modification of all the parameters mentioned before, and gives at the exit the variation graphs of the angular speed, of the motor moment and the consumed power at the electric driving motor, for different working conditions of the press as it is presented in fig. 2 (for a regime with a single loading, in fig.3 (for a regime with repeated loadings) and

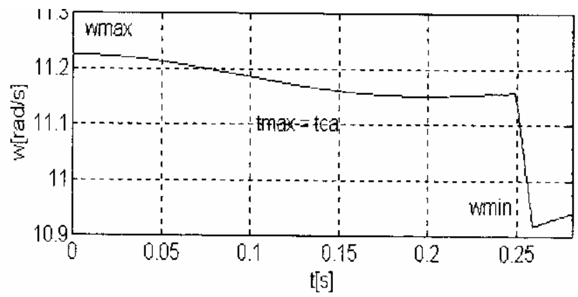


in fig.4 (for a regime without loading). In the case with repeated loadings the loading was achieved with a force of 480 kN, with a frequency of 3 cycles in a period of 2 seconds.

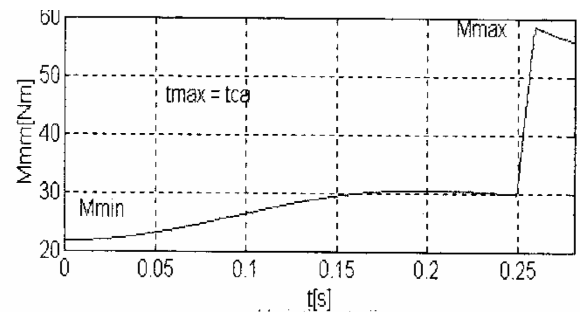
Fig.1 Possible evolutions of the deformation force



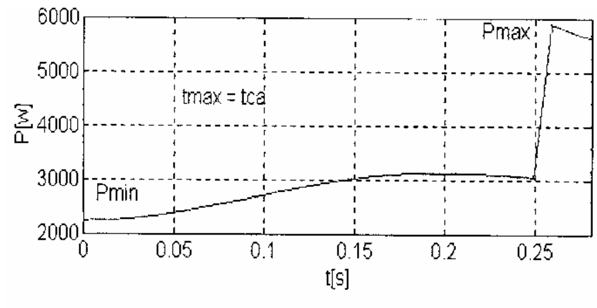
a) The evolution of the deformation force



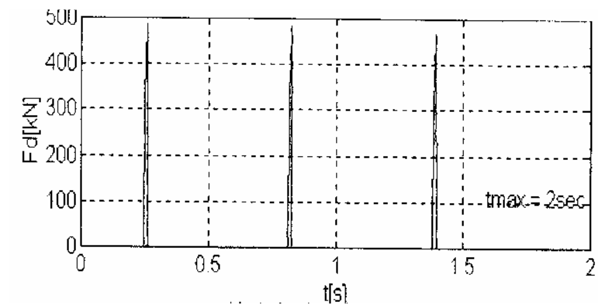
b) The evolution of the angular speed



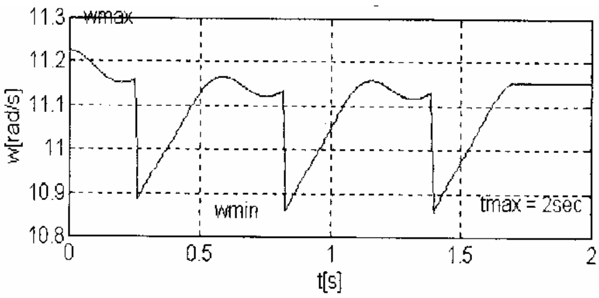
c) The evolution of the motor moment



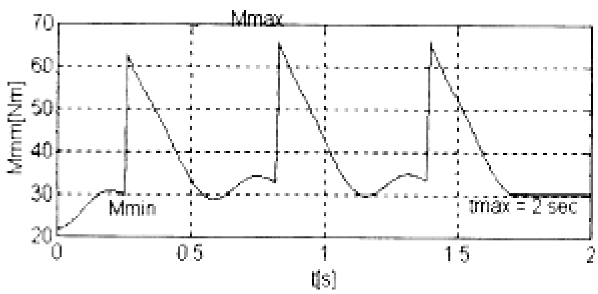
d) The evolution of the active power
Fig.2 The dynamic parameters evolutions in a regime with a single loading



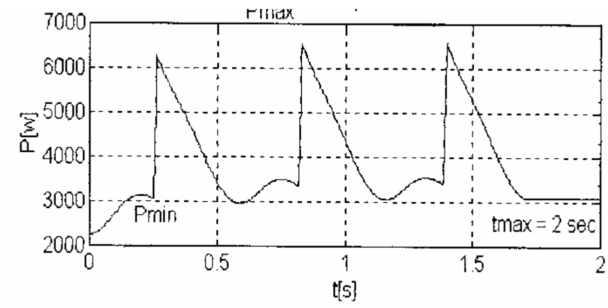
a) The evolution of the deformation force



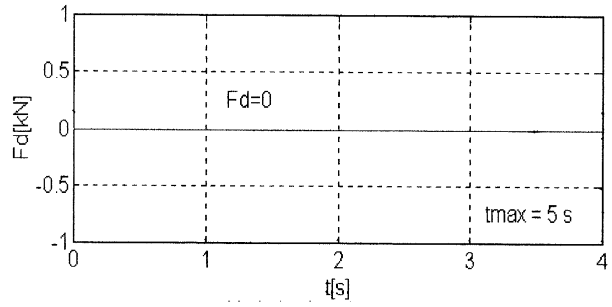
b) The evolution of the angular speed



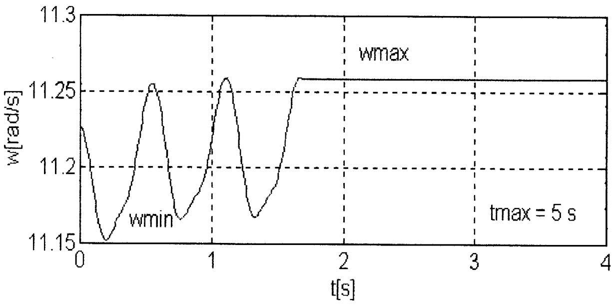
c) The evolution of the motor moment



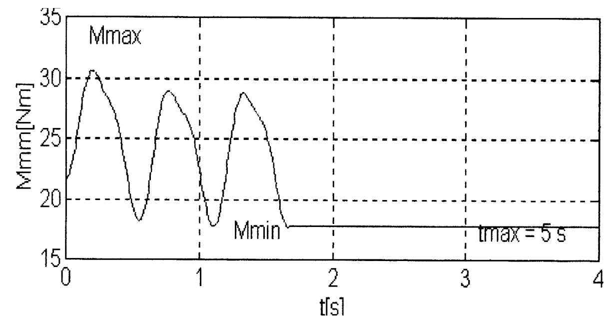
d) The evolution of the active power
Fig.3 The dynamic parameters evolutions for a regime with repeated loadings



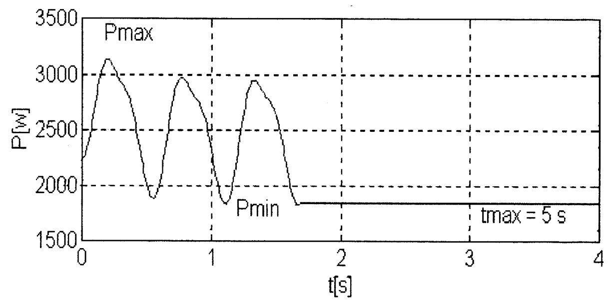
a) The evolution of the deformation force



The evolution of the angular speed



c) The evolution of the motor moment



d) The evolution of the active power

Fig.4 The dynamic parameters evolutions for a regime without loading

3. Observations and conclusions

From the analyze of the results obtained, the following conclusions can be drawn:

- the angular speed has a fall from the synchronism value to a value corresponding to the value of the friction moment of the flywheel together with the mobile subassembly; after that, it has a fall corresponding to the evolution of the deformation force; at the final of the period in which the deformation force action, the angular speed grows to the value corresponding to the regime where the friction moment of the flywheel together with the mobile subassembly action and this value tends to be steady (it would be the same result if the deformation force would not exist);
- the evolutions of the other parameters (the motor moment and the consumed power at the driving motor) are the same, with the difference that these evolutions are growing;
- there is also the possibility to simulate different regimes of loading, by modifying the evolution and the values of the deformation force and also by modifying the period of the application of the deformation force and of the beginning moment of the deformation process; in this way we can study the implications of some processes corectly positioned but also some processes total disadvantageous from the point of view of the position of the working stroke in the descending stroke of the slider;
- it can be pointed out, for the same constructive variant and for the same adjusting parameters, the working on the period of the active (descending) stroke of the slider, on a larger period with repeated loadings (automatic regim), on a larger period but with only one loading, etc.;

The evolutions presented in fig. 2 and fig.3 are theoretical evolutions, obtained in the conditions in which the parameters of the influence have known values and predictable evolutions. It is obvious that theese evolutions will be modified in the case of the appearance of some perturbing factors, which can determine the elaboration of some methods for diagnosing the functionning state of the machine or the tools.

4. References

1. BURLACU, C., *Theoretical and experimental researches on the optimization of the design, construction and exploitation of mechanic eccentric presses from the point of view of dynamic behavior of mechanical structure and the driving system,* Doctor's title thesis, Technical University "Gh. Asachi", Iaşi, 2000.

2. BURLACU, C., *Cercetări privind optimizarea proiec-tării, construcţiei şi exploatării preselor mecanice cu excentric prin utilizarea unui model de simulare*, Analele Universităţii din Oradea-Fascicola Mecanică, 2001.

3. BURLACU, C., *Cercetări privind studiul comportării dinamice a preselor mecanice cu excentric prin utilizarea unui model matematic*, Analele Universităţii din Oradea-Fascicola Mecanică, 2001.

4. BURLACU, C., MIRCEA, D., *Study on the influence of the transfer ratio value on the dynamic parameters of mechanic eccentric presses,* Buletinul Inst. Polit. Iaşi, Vol XLIX(LIII), Supliment, 2003.

5. BURLACU, C., MIRCEA, D., MAXIM, L., *Theoretical researches on the optimization possibilities of the design of mechanic eccentric presses on the basis of a simulation model*, Buletinul Inst. Polit. Iaşi, Vol LI(LV), Supliment, 2005.

6. BURLACU, C., MIRCEA, D., MAXIM, L., *Study on the improvement possibilities of mechanic eccentric pres-ses exploitation on the basis of the evolution of the active power*, Buletinul Inst. Polit. Iaşi, Vol LI(LV), Supliment, 2005.

7. BURLACU, C., *Study on the influence of the working process beginning moment on the dynamic para-meters of mechanic eccentric presses,* Buletinul Inst. Polit. Iaşi, Vol XL(L), Supliment, 2007.