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Analytical Method for Calculating the Exact Value of Friction Coefficient for Crank-Connecting Rod Sheet Metal Forming Press Mechanism

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Introduction

In the present literature as well as in text books of by pressure metal forming machines, the calculations of energy losses due to friction for crank- connecting rod stamping machines are carried out by calculating the torque resulting from friction force ,which contains the value of friction coefficient .

Referring to L. I Jivov [1], he had been used the value of friction coefficient μ = 0.03 to 0.04 using fluid lubricants and μ = 0.05 to 0.06 using grease, E.N.Lanskoy [2] suggested to use in practical calculations the value of friction coefficient μ = 0.06 when grease lubricants are used and μ = 0.04 with use of fluid lubricants in automatic metal forming machines , while researchers in reference [3] have appointed that by increasing the pressure on the friction surface ,friction coefficient is decreased in definite limits. Majority of metal forming technological processes are done using variable values of deformation forces, pressure in the joint of crank-connecting rod mechanism also has variable values, and energy losses due to friction are proportional to friction forces resulting from normal forces due to this pressure. In our research we offer a method which allows defining the exact values of friction coefficient for crank-connecting rod mechanism. Fig (1)

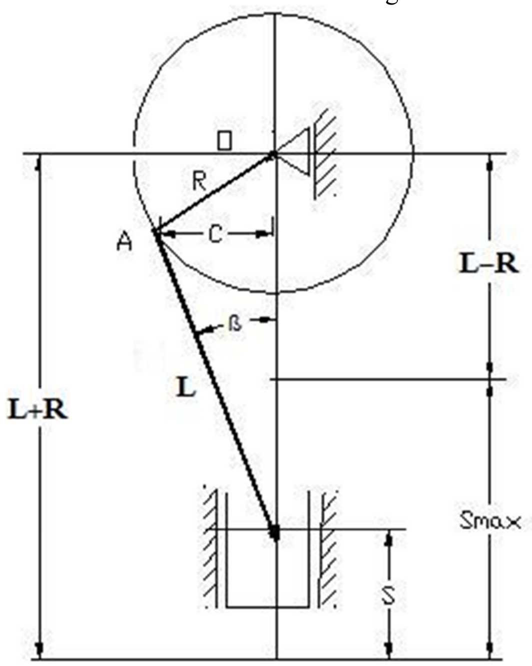

Fig.1. schematic illustration of(central) axial crank – connecting rod mechanism.

Nomenclature:

E - Energy losses due to friction,
μ - Friction coefficient,
- Friction coefficient as function of main shaft turning angle, μ_α
- Value of instantaneous friction coefficient, μ_i
B – Value depends on kinematical characteristics of mechanism,
- Angles of start and end of working stroke of crank stamping machine, α_f α_s
R – Radius of crank shaft,
- Radii of crank shaft and main journal bearing, r_a r_o

- Radius of connecting rod pin bearing, r_b

L – Connecting rod length,

- force acting on slider as function of main shaft turning angle, F_α
- The force acting on slider which corresponds (i) section, F_i

Torque on main shaft for any angular position, T_α -

The ideal arm of useful resistance forces of central crank-connecting rod mechanism, m_α^i -

n - Number of sections into which the loading curve of pressing machine was divided,

Analysis

In present, the energy losses due to friction for crank-connecting rod mechanism are calculated using a constant value of friction coefficient as in equations [1] and [2]

$$E = \mu B \int_{\alpha_F}^{\alpha_S} F_\alpha . d_\alpha \qquad (1)$$

$\lambda = \frac{R}{L}$, $B = (1 + \lambda \cos\alpha) r_o + r_b \cos\alpha + r_o$ Where:

If to conceder μ as a variable value, equation (1) becomes:

$$E = B \int_{\alpha_F}^{\alpha_S} \mu_\alpha . F_\alpha . d_\alpha \qquad (2)$$

Replacing the variable value of friction coefficient by the constant value gives the same results for energy losses due to friction calculated by equations (1) and (2), so this equality will be

$$\mu B \int_{\alpha_F}^{\alpha_S} F_\alpha . d_\alpha = B \int_{\alpha_F}^{\alpha_S} \mu_\alpha . F_\alpha . d_\alpha \qquad (3)$$

The constant value of friction coefficient μ can be determined by equation (3) which will be:

$$\mu = \int_{\alpha_F}^{\alpha_S} \mu_\alpha . F_\alpha \Big/ \int_{\alpha_F}^{\alpha_S} F_\alpha \qquad (4)$$

to calculate the value of friction coefficient by equation (4) it is necessary to know the values of instantaneous friction coefficient and forces acting on slider as functions of main shaft turning angles.

Torque for any angular position of main shaft can be calculated by the following equation:-

$$T_\alpha = F_\alpha (m_\alpha^i + \mu_\alpha B) \qquad (5)$$

$$m_\alpha^i = R(\sin\alpha + \alpha / 2 \sin 2\alpha) \qquad (6)$$

where :

If to calculate the instantaneous value of friction coefficient by (5) its value will be

$$\mu_\alpha = (\frac{T_\alpha}{F_\alpha} - m_\alpha^i) / B \qquad (7)$$

Equations (4) and (7) have no analytical computations, values of friction coefficient are determined experimentally. So equation (4) will be

$$\mu = \sum_{i=1}^{i=n} \mu_i . F_i \Big/ \sum_{i=1}^{i=n} F_i \qquad (8)$$

is calculated using numerical method based on equation (7) using experimental curves of μ_i torque on crank shaft and forces acting on slider of pressing machine.

Experimental results

The values of friction coefficient were calculated for punching operations using a steel sheet of 2mm thickness ,maximum punching load of 115 KN, and working angle of 10^o ,angles were marked in 1^o interval,10 instantaneous values of friction coefficient were calculated, the minimum value of μ_i = 0.034 and maximum value was μ_i = 0.1,friction coefficient calculated by (8) was μ = 0.048. the same calculations were carried out for another punching operation but with 235KN punching load ,and diameter of punch two times more than in first experiment while all other conditions were the same. from second experiment it was obtained that the minimum value of friction coefficient μ_i = 0.023, maximum μ_i = 0.12 ,friction coefficient calculated by (8) was μ_i = 0.031. in both cases the lubricant of crank shaft bearing was grease.

Increasing the deformational force to two times more ,results in decreasing the friction coefficient by 35%,which was unexpected result for us. So for calculating the error of experimental system we used method [3].this experimental system consists of : strain transducer-strain amplifier ,mirror –galvanometer oscillograph ,oscillogram and method for calculating oscillogram. maximum experimental error of system was ± 6% .if to suggest that the maximum calculated friction coefficient was more than 6%,and minimum value less than 6%,even in this case the increase of stamping force results in decreasing of friction coefficient to 27%.

Conclusions

1. The method achieved in our study allows defining the exact value of the friction coefficient for crank-connecting mechanism of press based on the experimental values of the torque- moment and the force on the slide block.
2. To decrease the energy losses due to friction for sheet metal forming processes we suggest choosing a press with a nominal force as nearly as possible to the stamping force.

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