PRINCIPAL ELEMENTS IN RIGHT CHOICE OF KINEMATIC PARAMETERS OF LEADING MECHANISMS FOR NC MACHINE-TOOLS

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Abstract: Actually the most usually cases are when we know ρ_s and ρ_m obtained from the selecting of the engine in the first phase from the condition of driving, the next step being the optimization of the ratio of transmission in concordance to the presented methodology. Many times it is not technical possible the choose of a optimal i_T, but it is possible to action in order to obtain a value as near is possible by the optimal value of i_T.

Keywords: transmission, trajectory, machine-tools, numerical control, load.

Usually the leading linkage is a part from the closed loop structure, so his behavior influences the behavior of the respective axis.

Practically the major difficulty of the behavior of the axis under dynamic appearance is holded by the driving motor and by the mechanical part from the structure of the linkage

The projecting of servo-mechanisms (this type must respect the imposed conditions of stability, precision, answering time using a compromise between the accepted level of stationary deviation and desired degree of stability.
The transitory regime characterized by answering time is the main indicator who characterizes "the error of trajectory".

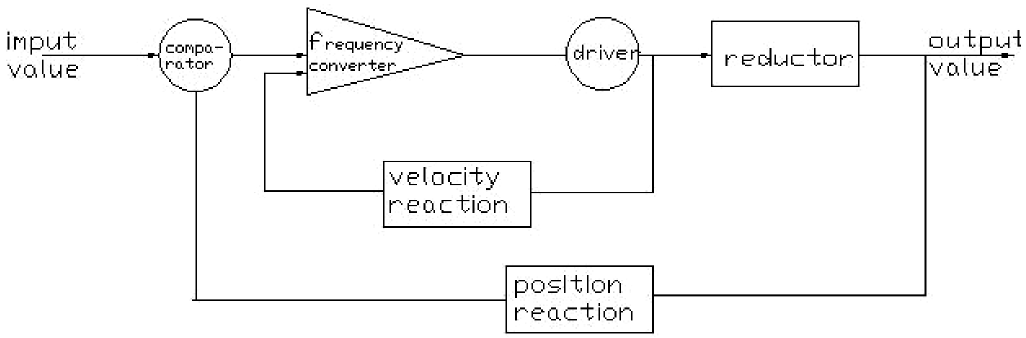

Fig. 1.

The answering time of servomechanism is necessary from the phase of projection a major part having the choosing of the engine and of the reduction aria between the engine ant the load from the condition that the acceleration to be maximum. The low chart of a servomechanism of a axis to a machine tool with numeral control is represented in fig.1.

Considering separately the alternomotor, reductor – fig.2 (care who is interesting for the mechanical designers)

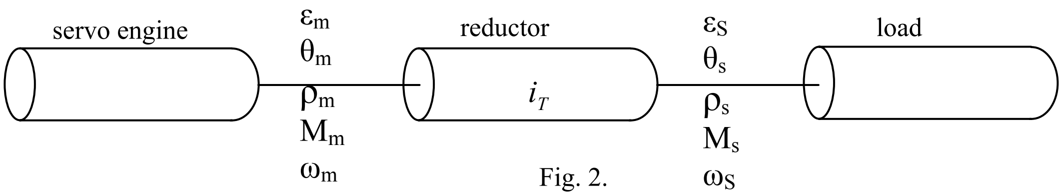

Fig. 2.

Where: $\varepsilon_m, \varepsilon_s$ - angular acceleration engine, load

θ_m, θ_s - angular motion engine, load;

ρ_m, ρ_s - rotative moment, load

M_m, M_s - moment of rotation

ω_m, ω_s - rotational speed engine

It is considered that the inertia of gear from demultiplier is negligible. It also is negligible the moment of fiction and the coefficient of efficiency η=1. The demultiplier is not detected yet and the only important parameter is ε_s .

Usually it is known the moment of rotation ρ, it is selected a usual engine with $M_m \geq M_s$ and with ρ_m from the prospect in scope to determinate the best total transmission ratio between and the load i_T .
The equation of equilibrium of reduced moments at the engine at the axe is:

$$M_m = \rho_m \cdot \varepsilon_m + \frac{\rho_s}{i_T^2} \cdot \varepsilon_m \tag{1}$$

$$M_m = \rho_m \cdot \varepsilon_s \cdot i_T + \frac{\rho_s}{i_T^2} \cdot \varepsilon_s \cdot i_T = \varepsilon_s \cdot \left(\rho_m \cdot i_T + \frac{\rho_s}{i_T} \right) \tag{2}$$

$$\varepsilon_s = \frac{d^2\theta_s}{dt^2} \quad \varepsilon_m = \frac{d^2\theta_m}{dt^2} \quad \varepsilon_m = \varepsilon_s \cdot i_T \tag{3}$$

$$\varepsilon_s = \frac{d^2\theta_s}{dt^2} = \frac{M_m}{\rho_m \cdot i_T + \frac{\rho_s}{i_T}} \tag{4}$$

Making the notations:

$$C_1 = \frac{M_m}{\rho_s} \quad C_2 = \frac{\rho_m}{\rho_s} \tag{5}$$

the equation will be

$$\varepsilon_s = \frac{A}{B \cdot i_T + \frac{1}{i_T}} \text{ or } \varepsilon_s = \frac{A \cdot i_T}{B \cdot i_T^2 + 1} \tag{6}$$

Deriving the relation in rapport with i_T , result:

$$\frac{d\varepsilon_s}{di_T} = \frac{A \cdot \left(1 - B \cdot i_T^2\right)}{B \cdot i_T^2 + 1} \tag{7}$$

Which become zero, when:

$$i_T^2 = \frac{1}{B} \text{ or } i_T = \sqrt{\frac{1}{B}} = \sqrt{\frac{\rho_s}{\rho_m}} \tag{8}$$

So the best total transmission ratio between engine and load is realized for an ideal demultiplier when:

$$i_T = \sqrt{\frac{\rho_s}{\rho_m}} \tag{9}$$

In this way it is maximized the function by replacing of the ratio:

$$\varepsilon_{s\max} = \frac{A}{2\sqrt{B}} = \frac{M_m}{2\sqrt{\rho_m \cdot \rho_s}} = A \cdot \frac{1}{2} \cdot \frac{\rho_s}{\rho_m} \tag{10}$$

or replacing in the equation of acceleration $B = \frac{1}{i_T^2}$, result $\varepsilon_{s\max} = \frac{A}{2} \cdot i_T$

(11)

So, the locus of maximum at the mechanical date's variation is a line that passes through the origin of the coordinate axis.

In fig. 3, we represent the diagrams:

$$\frac{\varepsilon_s}{A} = \frac{i_T}{B \cdot i_T^2 \cdot A} \qquad \frac{\varepsilon_{s\max}}{A} = \frac{1}{2} i_T \text{ and } i_T^2 = \frac{\rho_s}{\rho_m} \tag{12}$$

In conclusion we can make the following indication for the designer of machine-tools with numerical control:

- the load must be dimensioned in order to have a minimum rotative moment;
- the servo engine must have a maximum rotative moment (high speed, a small motor);
- scaling ratio result from the relation (9) and from kinematic reasons.

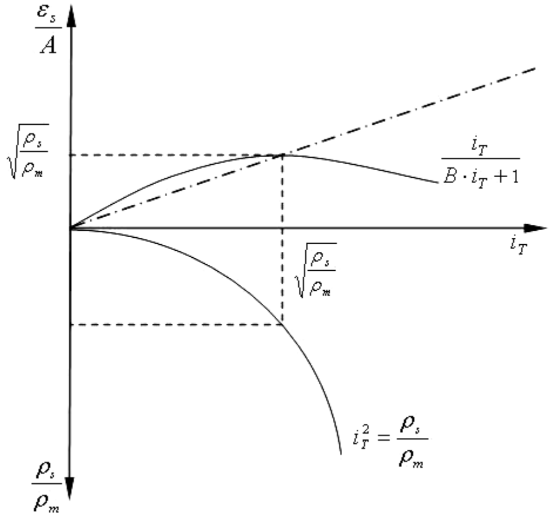

Fig.3.

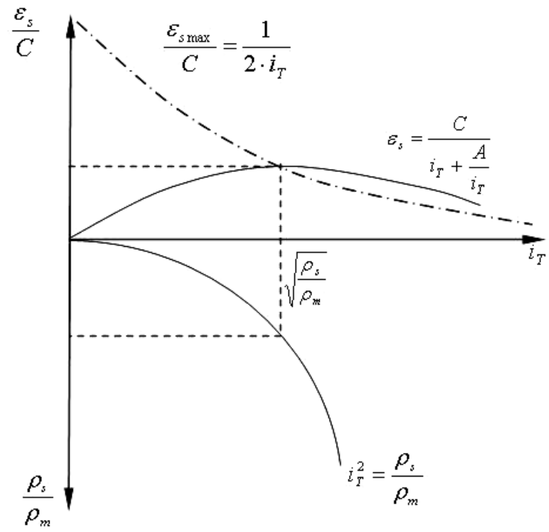

Fig.4.

We can write the strength N, transmitted by the load:

$$N_s = \rho_s \cdot \varepsilon_s \cdot \omega_s = \frac{\rho_s}{\rho_m \cdot i_T \cdot \frac{\rho_s}{i_T}} \cdot M_m \cdot \frac{\omega_m}{i_T} \tag{13}$$

$$N_s = \frac{\rho_s}{\rho_m \cdot i_T^2 + \rho_s} \cdot N_m \tag{14}$$

considering $q = \frac{\rho_s}{\rho_m \cdot i_T^2 + \rho_s}$, result $N_s = q \cdot N_m$

(15)

We observe that if $i_T = \sqrt{\frac{\rho_s}{\rho_m}}$ we obtain q=0.5, so

$$N = 0.5\ Nm \tag{16}$$

By this things we can make a important conclusion the necessary strength for the load acceleration is equal (in this ideal case) with the one necessary to accelerate the mobile parts of the servo engine.
In the case when ρ_m is imposed by the application (rare cases) to find the best value for i_T we proceeded in the same

way and we consider $\frac{M_m}{\rho_m} = C$ and $\frac{\rho_s}{\rho_m} = A$ result $\varepsilon_s = \frac{C}{i_T + \frac{A}{i_T}}$ (17)

Derivating and equalizing with zero, we obtain the maximum angular rotation for

$$i_T = \sqrt{A} = \sqrt{\frac{\rho_s}{\rho_m}} \tag{18}$$

Result that the maximum acceleration is the same as the precedent case. From the relation

$$\varepsilon_{s\,\max} = \frac{C}{2 \cdot i_T} \tag{19}$$

we deduct the locus of the maximum at the variation of mechanical parameters which is a equilateral hyperbola tourned at 45°. In fig. 4 we represented the diagrams:

$$\frac{\varepsilon_s}{C} = \frac{i_T}{i_T^2 \cdot A} \quad \frac{\varepsilon_{s\,\max}}{C} = \frac{1}{2 \cdot i_T} \text{ and } i_T^2 = \frac{\rho_s}{\rho_m} \tag{20}$$

CONCLUSIONS

In the case of machines-tools with numerical control which can execute machining made by interpolation in plan surface or in space appear the necessary a new performance number of the machine-tool named: "the error of trajectory". Because of the continue increasing multitude of those machining made by interpolation (cams, helixes, stamps) and because the variation becoming smaller it become necessary the reconsidering of leading linkages at machines-tools with numerical control m order to obtain variations as small as is possible.

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