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CONSIDERATION ON MECHANICAL SYSTEM IN TRANSLATIONAL MOVEMENT WITH VISCOUS FRICTION

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Abstract: *This paper refers to superfinishing bores using a linear oscilomotor. In the paper is presented the structural scheme of a linear oscilomotor used at superfinishing bores, determination of the linear time dependence of roughness for each interval and ultimately determination of the total time required a roughness R imposed, where the function R(t) is strictly monotone descending.*

Key words: *Superfinishing, oscilomotor, frequency, roughness, friction.*

1. PRESENTATION OF THE SUPERFINISHING DEVICE

This super finishing device is designed at a super finishing device level, used with a normal/parallel lathe, where the parts with the bore can vary in size, and we can even use the same tool.

Instead of the lathe tool (if we use as a tool a parallel lathe) the finishing device is fixed in the carriage, being adjustable because of this, and manoeuvrable depending on the carriage movements.

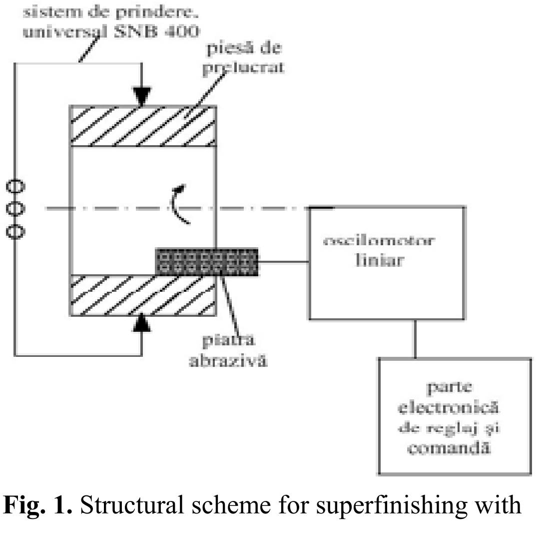

Fig. 1. Structural scheme for superfinishing with oscilomotor

1.1. Presentation of the frequency modulator

For the oscilomotor mounted on the universal lathe the vibration frequency can be adjusted using a microcontroller, stepper motor and a frequency variator.

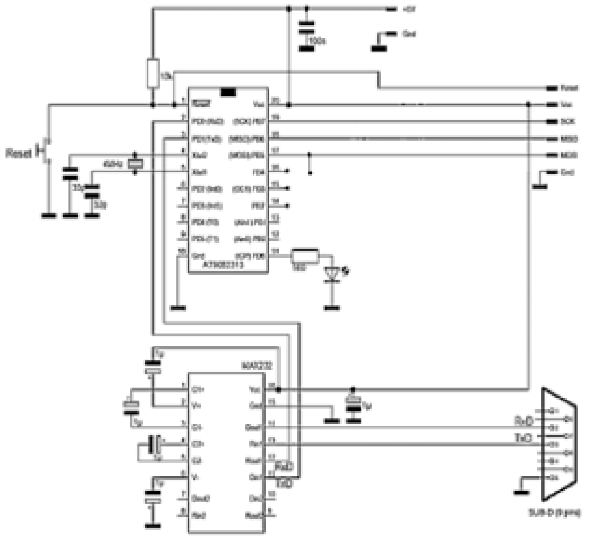

Fig. 2. Stepper motor command

The above circuit is used to receive commands from a computer and translate them as an analog signal for the microcontroller. This is done through the computer’s serial port.

Max 232 chip receives the signal and generates rs 232 levels. AVR microcontroller AT90S2313 is the base of the motor control. It is programmed to generate sequences of bits required for the motor control.

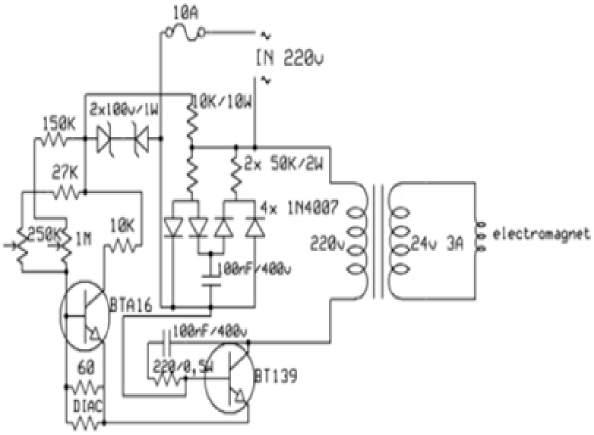

Fig. 3. AC frequency variator

The AC frequency variator is an AC-AC converter, which modifies, within certain limits, the actual value of the fundamental charge, resulting the adjustment of the electrical power dissipated in this.

In the above circuit, the AC frequency variator is used to generate electromagnetic field pulses.

2. MECHANICAL SYSTEM IN TRANSLATIONAL MOVEMENT WITH VISCOUS FRICTION

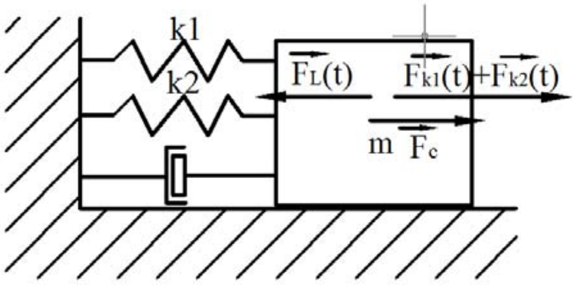

Fig. 4. Mechanical system in translational movement with viscous friction

$$F_a(t) = F(t) - (F_{K_1}(t) + F_{K_2}(t)) \qquad (1)$$

forces equation

F_a – resultant force

$$\left.\begin{aligned} & m.a(t) = F(t) - k_1.x(t) - k_2.x(t) \\ & a(t) = \frac{d^2x(t)}{dt^2} \end{aligned}\right\} \Rightarrow$$

$$m.\frac{d^2x(t)}{dt^2} = F(t) - (k_1 + k_2).x(t) \qquad (2)$$

$$m.\frac{d^2x(t)}{dt^2} + (k_1 + k_2).x(t) = F(t) \qquad (3)$$

$$m.s^2.x(s) + (k_1 + k_2).x(s) = F(s) \qquad (4)$$

$$[m.s^2 + (k_1 + k_2)].x(s) = F(s) \qquad (5)$$

$$\frac{X(s)}{F(s)} = \frac{1}{m.s^2 + (k_1 + k_2)} = H(s) \qquad (6)$$

transfer function

$$H(s) = \frac{X(s)}{F(s)} \qquad (7)$$

2.1. Determination of the linear dependence of roughness for each interval

At superfinishing, we have three distinct slopes for roughness decrease, so, for a slope (Fig. 5) we have:

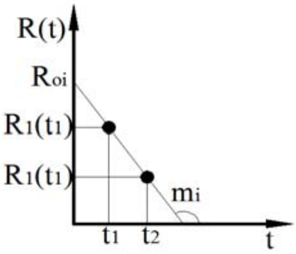

Fig. 5. R dependence grapf of t

$$\begin{cases} R_1(t_1) = m_1.t_1 + n_1 \\ R_1(t_2) = m_1.t_2 + n_1 \end{cases} \qquad (8)$$

$$R_i(t) = m_i.t + n_i \qquad (9)$$

R_i segment equation

$$n_1 = R_1(t_2) - m_1.t_2 \qquad (10)$$

$$R_1(t_1) = m_1.t_1 + R_1(t_2) - m_1.t_2 \qquad (11)$$

$$R_1(t_1) - R_1(t_2) = m_1.(t_1 - t_2) \Rightarrow$$

$$m_1 = \frac{R_1(t_1) - R_1(t_2)}{t_1 - t_2} \qquad (12)$$

$$n_1 = R_1(t_2) - \frac{R_1(t_1) - R_1(t_2)}{t_1 - t_2}.t_2 \qquad (13)$$

$$n_1 = \frac{R_1(t_2).t_1 - R_1(t_2).t_2 - R_1(t_1).t_2 + R_1(t_2).t_2}{t_1 - t_2} \qquad (14)$$

$$R_i(t) = \frac{R_i(t_{i1}) - R_i(t_{i2})}{t_{i1} - t_{i2}}.t + \frac{R_i(t_{i2}).t_{i1}}{t_{i1} - t_{i2}} -$$

$$-\frac{R_i(t_{i1}).t_{i2}}{t_{i1} - t_{i2}} \qquad (15)$$

$$R_i(t) = m_i.t + n_i \qquad (16)$$

m_i – proportionality constant between time and roughness (slope)

n_i – global initial roughness (not range)

The mathematical relationship of the roughness time dependence is:

$$m.\frac{d^2x(t)}{dt^2} + c.\frac{dx(t)}{dt} + (k_1 + k_2).x(t) = F_L(t) +$$

$$+k_f\frac{dx(t)}{dt} \qquad (17)$$

$$m.s^2x(s) + c.s.x(s) + (k_1 + k_2).x(s) = F_L(s) +$$

$$+k_f.s.x(s) \qquad (18)$$

$$[m.s^2 + c.s + (k_1 + k_2) - k_f.s].x(s) = F_L(s) \qquad (19)$$

$$\frac{X(s)}{F_L(s)} = \frac{1}{m.s^2 + (c - k_f).s + (k_1 + k_2)} = H(s) \qquad (20)$$

2.2 Determination of the relationship between the current position of the tool tip and surface roughness on each interval

$$R_i(t) = k_i.\frac{4a}{T}.t + r_{0i} \qquad (21)$$

$$R_i(t) = k_i.d(t) + r_{0i} \qquad (22)$$

k_i – constant of proportionality between the distance traveled by the tip of the tool and surface roughness

a – tool tip moving amplitude

T – oscillation period

r_{0i} – offset constant from the beginning of measurements

– roughness at ϕ moment

– initial global roughness (at ϕ moment)

$$\begin{cases} k_i.\dfrac{4a}{T} = \dfrac{R_i(t_{i1}) - R_i(t_{i2})}{t_{i1} - t_{i2}} \\ r_{0i} = \dfrac{R_i(t_{i2}).t_{i1} - R_1(t_{i1}).t_{i2}}{t_{i1} - t_{i2}} \end{cases} \qquad (23)$$

$$T = \frac{1}{f} \qquad (24)$$

f – oscilation frequency

$$k_i = \frac{R_i(t_{i1}) - R_i(t_{i2})}{4.a.f(t_{i1} - t_{i2})} \qquad (25)$$

$$t = \frac{R_i(t) - r_{0i}}{k_i.\dfrac{4a}{T}} \qquad (26)$$

t – necessary time for obtaining a desired roughness

maximum movement = 2.amplitude
= 2.a

distance for a period = 2.2a = 4a

total distance = N.4a

N – number of periods

total time = N.T

T – oscillation period

$$R(t) \approx t.4a \qquad (27)$$

$$R(t) \approx t \qquad (28)$$

$$R_{final} \approx N.4a \qquad (29)$$

$$R_{final} \approx N.T \qquad (30)$$

$$\int_0 4a.dt = 4a.t \qquad (31)$$

$R_i(t) = k_i.4a.t$ roughness on i interval;
$i = 1,2,3$ (32)

$$R_i(t) = k_i.\int_0^{\tau_{if}} 4a.dt \qquad (33)$$

τ_{if} – i interval duration

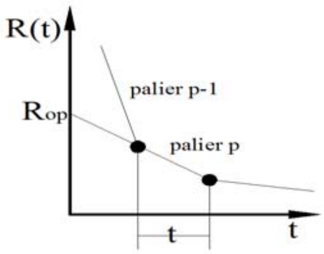

Fig. 6. Roughness slopes

$$t_{total} = \sum_{i=1}^{p-1} t_{palier,i} + \frac{R - r_{0p}}{k_p \cdot \frac{4a}{T}} \qquad (34)$$

t_{total} – total time necessary to obtain roughness R

$t_{palier,i}$ – total processing time on the i slope

p – slope that fits the desired roughness

r_{0p} – global initial roughness for p slope

k_p – k_i constant of the p slope

Observation: The method can be applied only for R(t) strictly monotone descending.

3. CONCLUSION

The presented device has the advantage that it can be installed easily on universal classic tools, but we also observe the fact that with the frequency variator, stepper motor and the programmer, frequency modulation is possible in 99 points, which means a wide range of adjusting the finishing regimes, which is another advantage of the presented method. These advantages are essential and can be applied easily in manufacturing SMEs, which is a characteristic of Romania's industry at the moment.

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Consideratii privind sistemul mecanic în mişcare de translaţie cu frecare vâscoasă

Rezumat: Această lucrare se referă la suprafinisarea alezajelor cu ajutorul unui oscilomotor liniar. Este prezentată schema structurală a unui oscilomotor liniar, utilizat la suprafinisarea alezajelor, determinarea dependenței liniare a rugozității de timp pe fiecare interval și în final determinarea timpului necesar obținerii unei rugozități R impuse, în cazul în care funcția R(t) este strict monotonă descrescătoare.

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