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ANALYSIS OF MODERN TECHNIQUES FOR MACHINING OF PIECES WITH CYLINDRICAL SYMMETRY

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ABSTRACT
Machining pieces with cylindrical symmetry are realized through classic processes for example turning, mortising, etc or recently through no conventional methods, for example vibrorolling and vibrofinishing. Solution adopted by the authors to realize vibrorolling equipment are composed of one electromagnetic vibrator with two coils out of time operating, static contactors with transistors for driving coils, one sinusoidal signal generator and one modulator which realize changing of frequency and vibrations amplitude.
Keywords: vibrorolling, machining, cylindrical

1. INTRODUCTION
Vibrorolling is a combined cool finishing technology, which consist in superposition of a rolling with reel and ball process, over one oscillatory process on parallel direction with machining piece axle [1]. Pieces machining by longitudinal vibrorolling accede to upper roughness grades, and on piece surface appear a hardened layer which confer upper property at contact pressure or stress. On machining surface appear systems of fibbers which have role to retain and orientate oil skin, after superposition vibration movement over rolling movement. Execution element is an electromagnetic vibrator with two coil out of time operating, coil driving by static switches.

2. DRIVING WITH TWO INDEPENDENT SWITCHES
Variant of command, with two independent switches is presented in figure 1. Transistors switches are commanded with pulse width modulation (PWM), for determine in load a current semi-sinusoidal pulse signal. If inductivity of driving coil is high, this thing is not possible in interval [π/2,π] because decline slope of load current is non significant comparative with prescribed value, and current reacting not permitting opening transistor T_1, measurement value is bigger then prescribed value. Vibrators 2a and 2b are with magnetic circuit E, and inductivity of one coil is:

$$L_a = \frac{N_a^2 \cdot \mu_0 \cdot A}{l_0} \cdot \frac{1}{1 - x/l_0} = \frac{L_0}{1 - x/l_0} = \frac{L_0}{1 - \varepsilon \cdot \sin(\omega t - \gamma)}, \quad (1)$$

where: L_a is inductivity of mobile coil, μ_0 - blank permittivity, N_a – coiling number of mobile coil, A – magnetic pole area, l_0 – air gape length, x – mobile furniture displacement, ω – power supply voltage throb, ε – ratio of amplitude *x* of vibration and air gape spell length.

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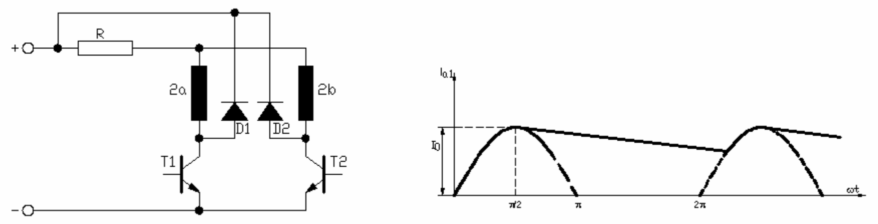

Figure 1. Command circuit for coils of vibrorolling equipment

And where suppose that mobile fixture movement is by form:

$$x = x_0 \cdot \sin(\omega t - \gamma), \tag{2}$$

condition in concordance with reality, if elastic system come true some conditions. If at discharge supposing drops voltage constant U_D on diode D_1 and neglect effect of resistor R (introduced to recovery the energy) can writing:

$$\frac{d}{dt}(L_a \cdot i_a) + R_a \cdot i_a = -U_D; \frac{di_a}{dt} + A(t) \cdot i_a = B(t), \tag{3}$$

where:

$$A(t) = \frac{1}{L_a}(\frac{dL_a}{dt} + R_a), B(t) = -\frac{U_D}{L_a}. \tag{4}$$

Solution of differential equation (3), is:

$$i_a(t) = C \cdot e^{-\int A(t) \cdot dt} + e^{-\int A(t) \cdot dt} \cdot \int B(t) \cdot e^{\int A(t) \cdot dt} \cdot dt, \tag{5}$$

or:

$$i_a(t) = (1 - \varepsilon \cdot \sin(\omega t - \gamma)) \cdot e^{\frac{-t}{T_0} - \beta \cdot \cos(\omega t - \gamma)} (C - \int e^{-\frac{t}{T_0} + \beta \cdot \cos(\omega t - \gamma)} \cdot dt), \tag{6}$$

with :

$$T_0 = \frac{L_0}{R_a}, \beta = \frac{\varepsilon}{\omega \cdot T_0}. \tag{7}$$

Simplified form of current (15), is expression of discharge current through inverse current diode *D_1* on interval [π/2, 2π], idealistic represented (neglecting inductivity variation).

$$i_a(t) = I_0 \cdot \frac{1 - \varepsilon \cdot \sin(\omega t - \gamma)}{1 - \varepsilon \cdot \cos\gamma} \cdot \frac{1 - \frac{t}{T_0}}{1 - \frac{\pi}{2 \cdot \omega \cdot T_0}}. \tag{15}$$

Modulation of this through the agency of coefficient έ, depend on phase shift value γ between instantaneous movements *x* of mobile fixture and discharge current, phase shift determined by equilibrium equation of forces. Load current variation at frequency of 10 Hz is presented in figure 2.
Is for underlined fact that high value of modulation coefficient έ can determine instable running points, practically through appearance "soldering" phenomenon of mobile fixture, and those lowest involve a inadequate using by the energetic point of view.

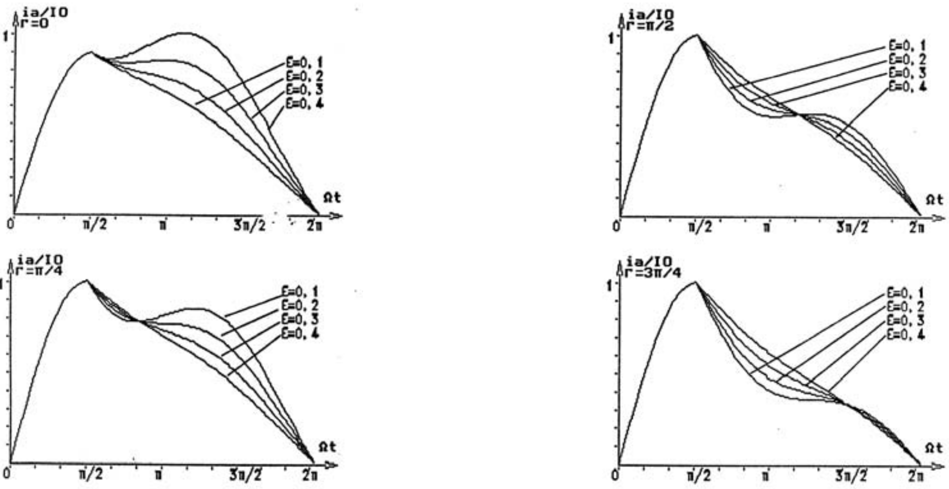

Figure 2. Load current variation

3. DRIVING SYSTEMS PERFORMANCE

Solution presented in anterior paragraph present the following disadvantages: decreasing load current slope has a small value, modulation degree of inductivity influence negative desired variation of load current, instable running with possibility to appearance of mobile fixture "soldering" phenomenon and low efficaciousness.

Indeed, presented solution, is the most simply variant for driving of vibrator coils, but must have in view disadvantages, the authors has orientated to solutions much efficacious, presented in figure 3.

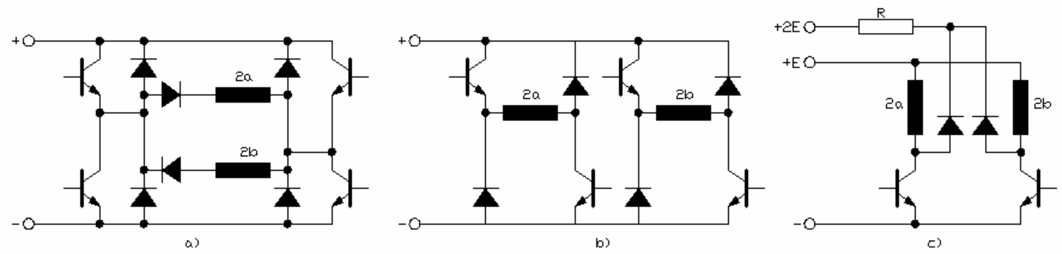

Figure 3. Driving variants for vibrorolling installation

Variant *c*, derive from solution presented in paragraph 2, but current decreasing slope is equal with charging slope.

Variant *b*, combine advantages of solution c, with a independence of coil driving and was using by the authors to realized vibrorolling installation VR-02 [1].

Variant *a*, is most performance, because combine advantages of solutions b and c with the current interaction through coil 2a and 2b. It must underlined that variants *a* and *b* are much difficult to realized, because of the floating potentials existent on emitters of the superior switches.

Also the authors have in view using sinusoidal modulation, such who is presented in followings.

4. COMMAND OF STATIC SWITCHES

Has in view requirement of the technologic process for realize by vibrorolling a fibbers system with an assessed geometry on piece with cylindrical symmetry, the authors was orientated for a command system which determine a sinusoidal load current.

Synthesis of ideal load wave shape, represent an actual problem in power electronic and for example, if we refer at consumer supply voltage, this can be realized by three techniques [5]: simple modulation (Single PWM), multiple modulation (Multiple PWM), sinusoidal modulation (Sinusoidal PWM)

Actual semi-conductors commutation frequency being much bigger then regulation scale of asynchronous electrical machines or a electromagnetic vibrators (usually 10-100Hz), synthesis of wave shape is realized through single modulation or multiple modulation which have advantages that can realize simultaneous regulation of amplitude and frequency.

Solution adopted by the authors has on base one sinusoidal signal generator, presented in figure 4.

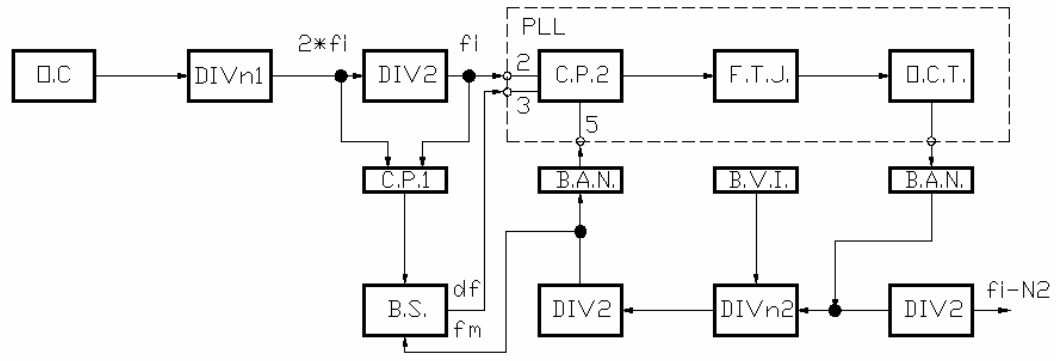

Figure 4. Programmable sinusoidal signal generator

Reference signal is obtained from digitally techniques who multiply frequency in interval 1-99 Hz, with frequency departure from 0,01 Hz. Component elements from bloc diagram are shown in figure 4 and described in followings: OC is quart oscillator, DIV_{N1}, DIV_{N2} is frequency divisors, CP1, CP2 are phase comparators, OCT is oscillator command in voltage, BAN is level adapter block, BVI is impulse value block, BS is synchronization loop.
Major difficulty of this solution is limited following belt of the PLL circuits, which allow frequency multiplication on the decade. Exists two methods, which using combined, allows frequency multiplication in a large scale:

- the first method using property of phase comparator CP2, to be synchronized by odd harmonics of the input signal, frequency of free oscillating being given by the relation (16).

Desired frequency is obtained by choosing suitable R_0C_0 group.

$$f_0 = \frac{1}{3{,}7 \cdot R_0 \cdot C_0}, \qquad (16)$$

- the second method interpolate between OCT and CP2, a programmable divisor as well as at the output of commanded oscillator in voltage be obtained frequency multiply assessed. Frequency scale is extended if between programmable divisor DIV_{N2} and commanded oscillator, is introduced loop synchronization BS, which modify frequency of free oscillation f_0 through changing equivalent resistance between source and commanded oscillator in voltage with a binary comparator. Information serial of frequency at output of cadence generator, assure memory sweep in what is write down sinusoidal function. The output in converted digitally-analog and it is input signal for PWM generator.

6. CONCLUSIONS

This paper is an analysis of driving and command possibility of electromagnetic vibrators from part of vibrorolling installations. Is analyzed in detail, independent coil driving variant and put in evidence disadvantages of this solution. Three variants are presented which eliminate disadvantages of independent switching solution. The authors get on conclusion that for this application is necessary of generation in load a sinusoidal current and for this in finally are presented a sinusoidal signal programmable generator for PWM modulator.
For the future authors recommend analyzing for this application, using DSP techniques [6] to command PWM modulator.

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