The self-action agreement system of electronic generator with the piezoelectric oscillatory system.

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***Abstract*— In article variants of agreement of piezoelectric oscillatory system with the electronic generator for self-action maintenance of optimum operating mode are considered. The special device is developed for its implementation.**

I. INTRODUCTION

THE piezoelectric oscillatory system generally is complex loading and at direct connection to an electronic generator there is a decrease of efficiency of an a power transmission. Therefore it is necessary to carry out the agreement of the electronic generator and ultrasonic oscillatory system (UOS) due to compensation of a reactive component of impedance UOS. Unfortunately, it is ideal to agreement the generator and UOS it is impossible for the several reasons. This change of parameters of technological medium, change of temperature (which influences own capacity UOS), and also changing output parameters of the electronic generator which in turn depend on supply voltage, work of systems of stabilization of an output power, and system of automatic frequency control.

Therefore automatic compensation of a reactive component of impedance UOS is necessary at changing external destabilizing factors during implementation of a process, for achievement of optimum conditions of an a power transmission, and an operating mode of the supply generator.

Compensation of static capacity of the converter

The piezoelectric oscillatory system cannot separately be considered from the electronic generator. The oscillatory system have own electrical impedance varying at change of operating conditions, influencing on operation of the electronic generator and technological device. It also demands to execute compensation of a reactive component of impedance UOS on working frequency for maintenance of optimum operating mode as electronic generator and piezoelectric oscillatory system.

The electrical equivalent circuit of the typical piezoelectric transducer is presented on Fig. 1, where C_{IN} represents an static input capacitance of the transducer, C and L the components determining frequency of mechanical resonance. Static input capacitance C_{IN} is peculiar to any piezoelectric element, and the aggregate capacitance of the transducer containing of some tens of the piezoelectric elements, can attain big value up to several tens nanofarads.

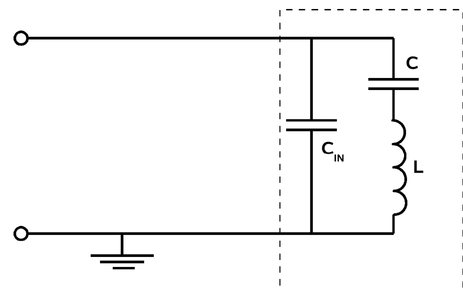

Fig 1. The equivalent circuit of the piezoelectric transducer

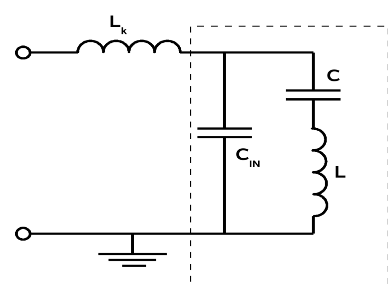

Fig 2. The circuit of compensation of static capacity

Direct connection of such load to the output cascade of the ultrasonic electronic generator will lead to extra charge [2] on load-bearing elements of the output cascade that reduces a system effectiveness as whole and can o put out of operation transistors of the output cascade. In this connection it is necessary to eliminate agency of a capacitive impedance of load (to compensate this capacity). For these purposes the among throttle which has been affiliate sequentially with the transducer (Fig. 2) usually is used. Inductance of among throttle L_K is selected such that there was the complete compensation of capacity C_{IN} on working frequency of the transducer [1]. It is possible only in case of when the resonance frequency of the loop organized by inductance LK and capacity of transducer C_{IN} coincides with working frequency of the transducer.

Input capacitance C_{IN} greatly varies with change of transducer temperature that changes conditions of compensation. At small capacity of the transducer or low operating temperatures of the transducer was possibly connection additional capacitor, in parallel the transducer. It allows to lower effect of temperature on general capacity (Fig. 3). In case of when the capacity of the transducer is great, it complicates compensation of change temperature the above described. Besides the input capacitance of the transducer is influenced also load, it is necessary to modify inductance of a operation of the transducer (Fig. 4).

For implementation of expedient presented in Fig. 4 the tunable among throttle and a control system is necessary for maintenance of demanded inductance throttle depending on change of capacity of the transducer. As a tunable throttle using throttle with a changed clearance in the core controllabled by the stepper motor (Fig. 5). In this construction (Fig. 5) it is used two throttle controllabled by one stepper motor. Metal plate on which the mobile parts of cores are anchored moves on steel guiding, for prevention of a skew. Use of the stepper motor allows to control inductance by means of change of magnetic clearance conductor during operation, and also set a minimum clearance in the core preventing saturation of a magnetic conductor. As is known, change of inductance of throttle from clearance nonlinearly, application of the stepper motor enables to inspect a current clearance in the core, and also linearize change velocity of throttle inductance by means of control of change velocity of clearance.

For deriving the maximum inductance of a tunable node of a winding are joined in series. In case of when it is necessary to gain the maximum operating current of a winding are joined in parallel. The total inductance in this case is equal to half of inductance of one throttle.

The control unit is developed for control stepper motor of a tunable throttle (Fig. 6). Operation of this block is grounded thereon what on a resonance frequency and at the full compensation of static capacitance of the transducer, oscillatory system is a active (resistive) load. In this case the phase shift between a current leaking through the transducer of oscillatory system and voltage on piezoelectic elements will be equal to null. Therefore, a condition of full compensation of static capacity of the converter on resonant frequency will be equality of phases of a current and a voltage.

On Fig. 6 scheme block of a control system is presented. It consists of sensors a current and voltage, detectors and the

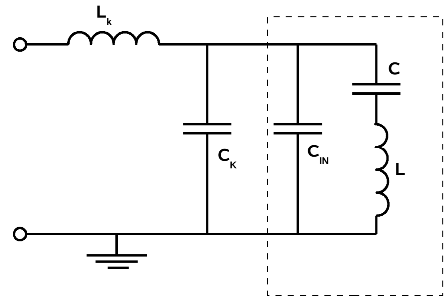

Fig 3. Way of decrease of effect of change of capacity of the converter

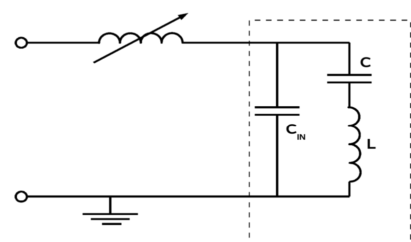

Fig 4. Turning on the tunable throttle for compensation of capacity of the converter

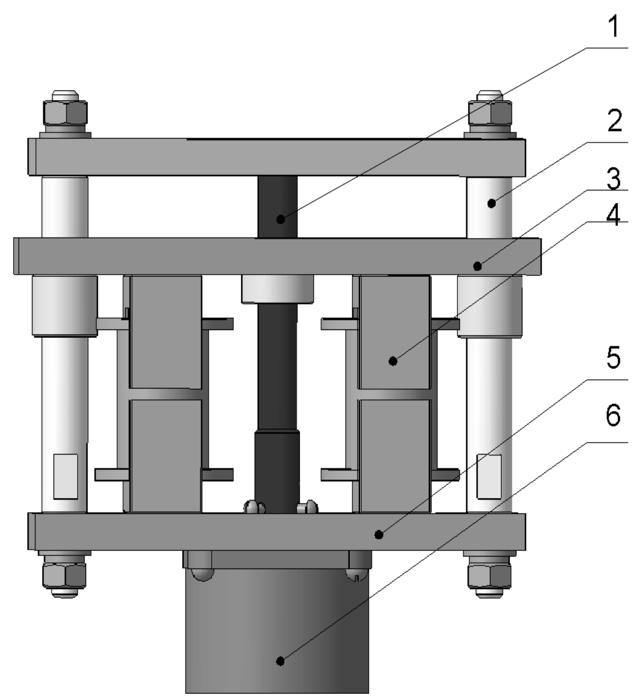

Fig 5. The throttle with an adjustable clearance

1 moving screw, 2 directing, 3 mobile plate 4 mobile magnetic core, 5 motionless plate (basis), 6 stepper motor.

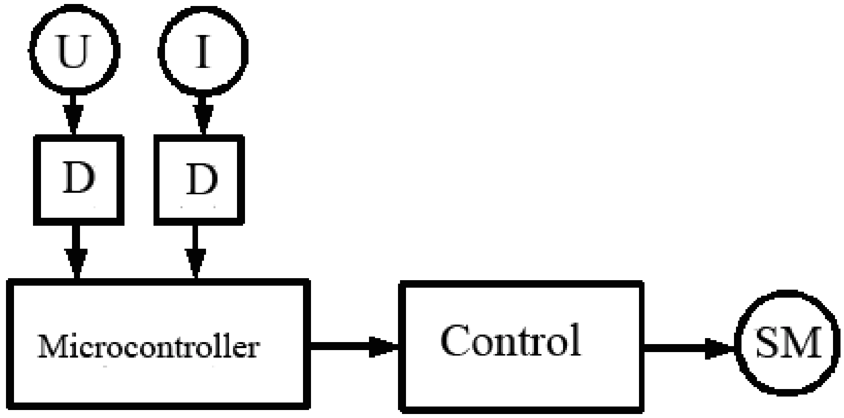

Fig 6. The block the scheme diagram of a control system of the tunable throttle

D –detector, SM – stepper motor, U – voltage sensor, I – current sensor

driving microcontroller. The signals receive from sensors of current and voltage act on detectors where after a amplification the moments of crossing through a zero are determined. Further, the received signals act in the microcontroller. The control program of the microcontroller makes calculation of phase shift between current and voltage and on the basis of the getting result the driving signal for increase or decrease of inductance. For increase of smoothness of change of throttle inductance, the received of phase shift averages. The subsystem of control the stepper motor ensures commutation of windings of the stepper motor according with a required direction of motor shaft rotation. As the subsystem of stepper motor control executes some subfunctions, such as initial initialization of a position mobile core which consists in decrease of clearance up to null and increase up to initial in before defined values. Besides control of velocity of clearance change in magnetic conductor depending on a time of the continuous one-way direction (or a leaking clearance) is executed, that allows to increase velocity of throttle modification at greater changes of a clearance, and to save exactitude at small changes. Adjustment of initial clearance, and also the definition of the maximum and minimum clearances of a magnetic conductor allows to avoid a undesirable condition saturation of a material of the core.

The control unit allows to realize connection and control of several actuating mechanisms (stepper motors) of tunable throttle for increase of summary inductance (windings are joined series) or increase of a peak current (windings are joined in parallel).

II. Conclusion

As a result of work the system of self-action tweaking of throttle for compensation of effect of a static capacitance of the transducer and its optimum agreement with the electronic generator during operation of the ultrasonic technological

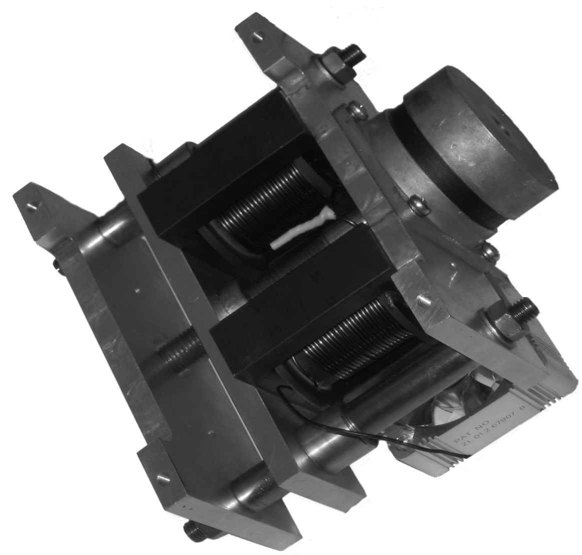

Fig 7. Photo of the tunable throttle

devices has been developed and practically realized. System of self-action tweaking practically realized in the form of the separate electronic block is built in generator of ultrasonic technological devices and ensures an opportunity of control with several actuating mechanisms depending on a demanded gamut of change inductance. The system has ensured very high accuracy of tuning inductance and sufficient fast operation owing to control change velocity of clearance in the core. The designed and practically realized devices of a tunable throttle (a photo on Fig. 7) have allowed to change a clearance in cores from 0 up to 8 millimeters, ensuring change of inductance of one allowed over the range from 2mH up to 36μH at the maximum operating current up to 20A.

REFERENCES

[1] Miodrag Prokic. Piezoelectric transducers modelin and characterization. Published 2004 in Switzerland by MPI.

[2] Theoretical bases of electrotechnology. K.M. Polivanova. K.M. Polivanov. Energija, 1972.

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