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QUALITY IMPROVEMENT IN MANUFACTURING OF SLIDING BEARING JOURNALS OF TURBINE ROTOR BY OPTIMAL CHOICE OF OPERATING REGIME USING THE VIBRATION AMPLITUDE METHOD

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ABSTRACT
During the normal operation, basic parts of the turbines are in relative sliding and are exposed to mechanical and temperature overloading. This phenomenon makes a significant influence to the roughness of the surfaces. By establishing the structure of system goals, an technology optimization is enabled, giving quality increase in a production of vital parts of steam and gas turbines-rotors.
Key words: optimization, quality, rotors, system goals

1. INTRODUCTION
Steam and gas turbines are complex joints where many elements are in relative sliding contact. During normal operation, vital parts of turbine are under influence of mechanical and thermal loads. Surface roughness of mechanical components has strong influence on fatigue resistance and stress concentration therefore is necessary to have high quality surface finishing, especially at highly loaded parts. Also, assembly process of turbine rotor and turbine in total has to be done very carefully.
Improvement of surface quality has positive influence on stability, working life and maintenance of turbine. The goal to definition of system structure is to optimize rotor construction. It allows constructor to concentrate on vital parts of rotor and by improvement of technology to get parts with higher quality.

2. GOAL SYSTEM FOR TURBINE ROTOR
Calculation of influence coefficients of rotor demands is done by decomposition of goal function in algorithmic steps. Demands can be strong, minimal and wishes. Structure of goals for turbine work is given on fig.1. Improvement in quality of vital parts helps in satisfaction of many goals in different goal groups.

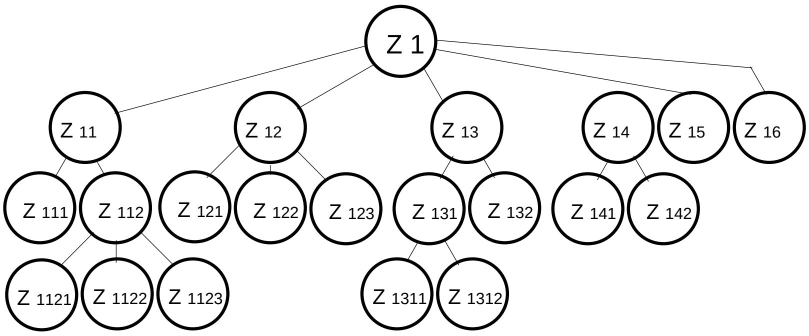


Figure 1. General structure of goal system for turbine work

Z1 - selection of optimal rotor of steam or gas turbin, Z11 - good assembly characteristics,
Z111 - smaller mass, Z112 - smaller assembly dimensions, Z1121- small length, Z1122 - small diameter, Z1123 - higher tolerance, Z12- adequate driving system, Z121- higher maximal power, Z122 - higher elasticity on variation of load, Z123 - short time to reach nominal speed, Z13 - lower consumption of driving materials, Z131 - lower consumption of fuel
Z1311 - lower consumption of coal or gas, Z1312 - lower Hd number, Z132 - lower consumption of lubricants, Z14 - balanced turbine rotation, Z141 - balanced mechanical rotation
Z142 - good acoustics of turbine, Z15 - wear resistance and Z16 - easy maintenance

3. OPTIMIZATION OF VITAL PARTS BY VIBRATION AMPLITUDE METHOD

Quality parameters are classified as technological and geometrical. Production of turbine rotor consists of many operations. The final of them is CNC turning. It operation requests optimization of technological and geometrical parameters. The relevant technological parameters are: cutting speed, feed, axial feed, depth of cut $\mathbf{a_p}$, rpm. Geometrical parameters are cutting edge angles: side-relief angle γ, side-cutting edge angle $\aleph_r$, side-rake angle α, end cutting-edge angle, etc.
By decomposition of influence parameters, method of vibrations amplitude allows as to optimize:

- depth of cut $\mathbf{a_p}$
- turning feed per rotation, f
- side-relief angle γ,
- side-cutting edge angle $\aleph_r$.

Parameters above have strong influence on surface roughness and on the integrity of surface, fig.2.

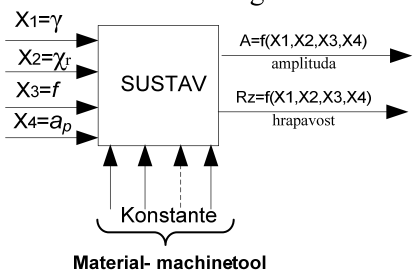


Figure 2. Stochastic model of self-excited vibrations

4. EXPERIMENTAL RESEARCH OF CUTTING REGIME INFLUENCE ON SURFACE ROUGHENSS

Geometrical and technological parameters: depth of cut $\mathbf{a_p}$, turning feed per rotation, side-relief angle γ, side-cutting edge angle $\aleph_r$ have strong influence on vibration amplitude of cutting system and, directly, on surface roughness.
For experimental measurements we use the system for data acquisition presented on fig.3. It consists of: Data Acquisition Interface Unit and ADRE for Windows Version 3.1, 7200, Proximity

Transducer Systems and Velomitor Piezo- velocity Sensor. The system does a linear transformation of mechanical acceleration into electrical signal. Electrical signal is stored and can be analyzed by spectroscope.

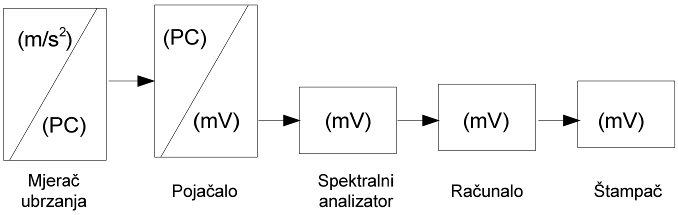


Figure 3. Transformation of mechanical acceleration into electrical signal

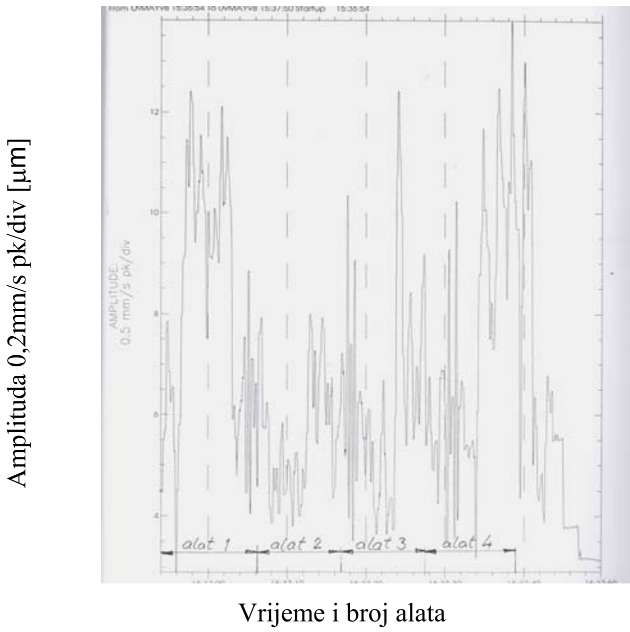


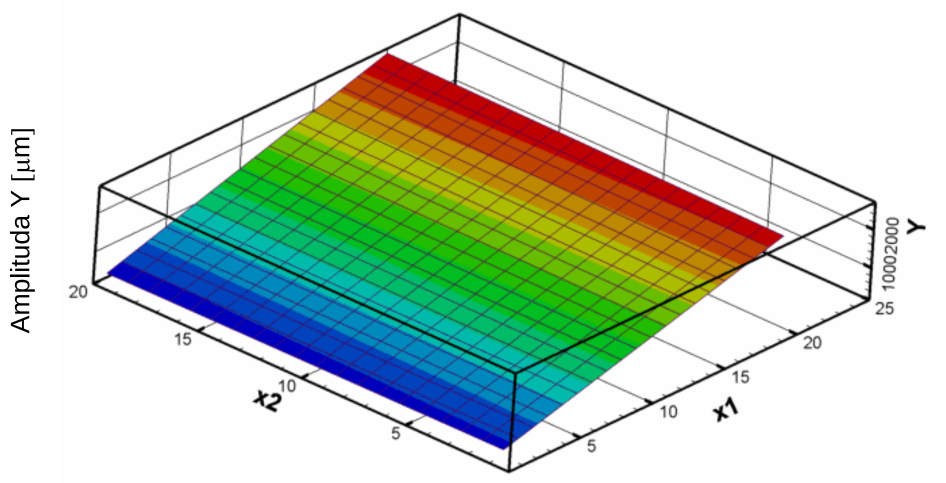
Figure 4. Amplitude and frequency measurement

On the basis of given model and computed influence coefficients, after calculations of significance, we get the equations:

$$\begin{aligned} Y = A = 220,26x_o + 113,87x_1 - 3,75x_2 + 10x_3 + 18,37x_4 - \\ - 4,25x_2x_3 + 4,25x_2x_4 + 2,62x_1x_2x_3 + 2,375x_1x_2x_3x_4. \end{aligned} \quad (1)$$

Optimization of the model of self-excited vibrations is done by Hooke-Jeeves method.
Correlation of self-excited vibrations amplitude and coefficients X_1 and X_2 (X_3 and X_4 are held constant) is presented on fig.5. The optimization goal is to have lowest possible amplitude of vibrations and the highest surface quality. The minimum amplitude and maximum surface quality of rotor sleeve is reached with these cutting regime parameters:

- depth of cut $a_p = 0.15$ mm.
- turning feed per rotation, f=0.15 mm.
- side-relief angle $\gamma = 2^o$.
- side-cutting edge angle $\aleph_r = 88^o$.



Legend:
X_1 -coded value of angle γ,
X_2 -coded value of angle $\aleph_r$.
X_3 - constant value of feed, f=0,15mm/r
X_4 – constant value of depth of cut, a_p =0,15mm

Figure 5. Dependence of vibrations amplitude on influence parameters

5. CONCLUSIONS

Fallowing conclusions can be drawn:

- Surface quality improvement of rotor sleeve has positive influence on stability and working life of turbine rotor.
- Application of vibration amplitude method has theoretical and practical significance.
- Improvement in surface quality of vital turbine parts lead to satisfaction of different goals (balanced operation, lower friction losses and better wear resistance).
- By optimizing cutting regime parameters we can achieve designed surface quality.

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