DAMAGE ASSESSMENT OF EXPLOITED TURBINE BLADES USING BARKHAUSEN NOISE PARAMETERS

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1. General

A degradation level developing in the turbine blade material was analyzed experimentally using the magnetic method. A relationship between the exploitation time of turbine blade and selected parameters of the Barkhausen noise signal was identified. The results coming from the leading edge area of blade and the trailing edge area were compared. An influence of the blade deformation resulting from damage development on the Barkhausen noise level was also taken into account. Another issues taken into account theoretical background treated equation of oxygen level as an interface. Processes with oxygen layer can be considered such as the enhancement transport phenomena in the Navier-Stokes shell-like slip layer presented in earlier works [1-3].

2. Experimental results of the Barkhausen noise parameters

Exploitation time of the turbine blade material was analyzed experimentally using the magnetic Barkhausen noise method [4], [5]. A relationship between the exploitation time of turbine blade and selected parameters of the Barkhausen noise signal was identified. The results coming from the blades with and without oxidized layer were compared. An influence of the blade deformation resulting from damage development on the Barkhausen noise level was also taken into account. Table 1 presents notations of turbine blades investigated.

The number of turbine blade	Exploitation time [h]
A1, A2, A3	26 400
B1, B2, B3	36 100
C1, C2, C3	39 800
D1, D2, D3	60 800

Table 1: Exploitation time of the selected turbine blades

The diagrams presented in the Fig. 1 show comparison of amplitude of the Barkhausen noise amplitude measured without and with oxidized layer for the selected exemplary turbine blades. It is seen that the Barkhausen parameter measured on leading edge with removed oxidized layer increases slightly with exploitation time to 39 800 h and then decreases (Fig. 1b). Such relationship was not found for the areas close to the trailing edge of to turbine blade due to deformations introduced to the material as a result of turbine disassembly.

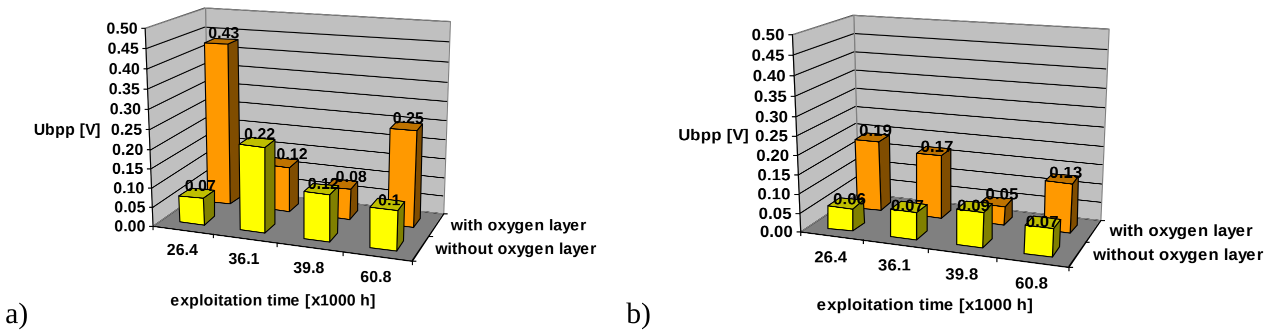

Fig. 1. The Barkhausen noise results coming from trailing edge a), leading edge; b) of turbine blades

3. Theoretical background

The generalized form of the boundary condition including phenomena of oxygen layer, can be expressed in the following way

(1)
$$\partial_t(\rho_z \mathbf{v}_z) + \mathrm{div}_s(\rho_z \mathbf{v}_z \otimes \mathbf{v}_{z|}) - \omega_n \mathbf{I}_s \rho_z \mathbf{v}_z + \mathrm{div}_s(\mathbf{p}_z) + \frac{\partial}{\partial n}(\mathbf{p}_z \mathbf{n}) + (\mathbf{t}_1 \mathbf{n}_1 + \mathbf{f}_1) + (\mathbf{t}_2 \mathbf{n}_2 + \mathbf{f}_2) = \rho_z \mathbf{b}_z + \dot{m}_z \mathbf{v}_z$$

where $\rho_z \mathbf{v}_z$ is the surface momentum density vectors, ρ_z is the oxygen layer density on the boundary. Thus it has been defined an excess of boundary density ρ_z [mass per unit of area; kg/m^2], the slip velocity between oxygen layer and original solid body $\mathbf{v}_z$ [m/s], and the surface momentum density vector $\rho_z \mathbf{v}_z$ ($\rho_z \mathbf{v}_z$ is just scalar multiplication). Next, $\mathbf{p}_z$ is the surface flux of momentum, $\mathbf{n}$ is the unit normal vector on the boundary surface, $\mathbf{f}$ is the boundary force, $\mathbf{b}_z$ is the body forces on the boundary, $\dot{m}_z$ is the oxygen layer mass influxes and ω_n normal pressure of fluid acting on the mill scale. Additionally, $\mathbf{p}_z$ in the boundary layer is usual spherical pressure tensor changes into but can be changed into an ellipsoidal pressure tensor due to Stokes normal surface pressure.

It should be added, that surface divergence div_s is defined as a right contraction of surface gradient: $\mathrm{grad}_s(.) = \mathrm{grad}(.)\mathbf{I}_s$. Tangent to surface component of the slip velocity is $\mathbf{v}_{z|} = \mathbf{v}_z \mathbf{I}_s$ where the surface Gibbs identity is defined to be: $\mathbf{I}_s = \mathbf{I} - \mathbf{n} \otimes \mathbf{n}$. In this approach it is postulated that the boundary force, responsible for a so-called generalized slip, can be separated by two components: $\mathbf{f}_1$ and $\mathbf{f}_2$ in two bodies. Both forces are the subject of constitutive modelling. Additionally, the bulk flux of momentum $\mathbf{t}_1$ and $\mathbf{t}_2$ have to be multiplied by proper unit normal vectors $\mathbf{n}_1$ and $\mathbf{n}_2$, respectively.

4. Summary

Equation (1) may help at least to decrease a number of experimental attempts to find the proper program of an experimental to find influence of oxygen layer on Barkhausen noise.

References

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