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PS 2 Asset management of electrical machines

Optimization of turbogenerator's core suspension system reconstruction methods for life time extension in the power plant conditions.

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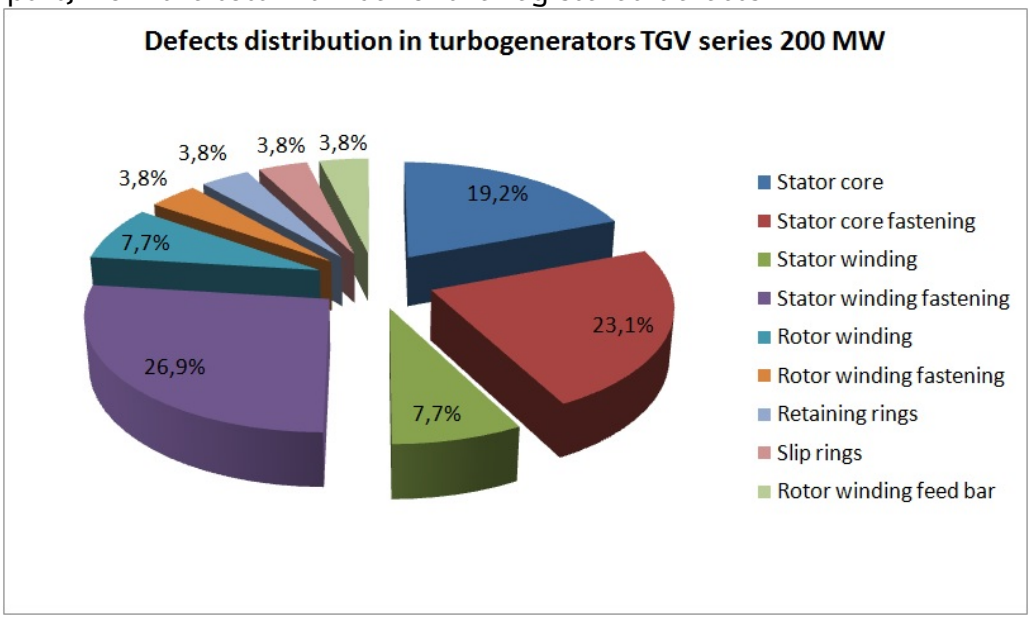
Today the problem of life time extension and ensuring reliable operation of the powerful highly-used turbogenerators has high relevance. Experience of this problem solution on the example of turbogenerators of the TGV series with direct hydrogen cooling produced by the «Elektrotyazhmash» plant is given in this report. These generators make about 1/6 part of all the turbogenerators which are in operation at the thermal power plants of the Russian Federation. Long-term experience of comprehensive diagnostics examinations of considered turbogenerators allowed to reveal characteristics of their failure rate [fig. 1]. As possible to see, defects of the stator core suspension system takes essential part [about 1/4 part] from the total number of the registered defects.



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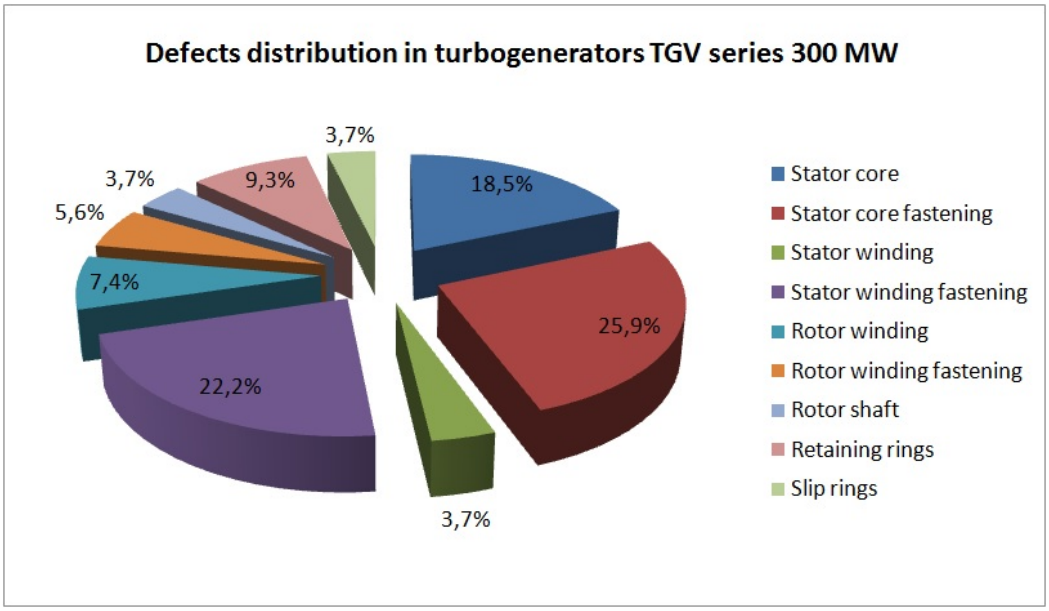

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Fig. 1. Data of revealed defects on turbogenerators TGV series.

It is known from operating experience that feature of turbogenerators of TGV series 200 and 300 MW is the high level of their stators vibration (over 100 microns). It leads to the emergence of the core suspension system elements fatigue damages and subsequent labor-consuming and expensive repair. Increased vibration of the core also negatively affects on the technical condition of a stator winding and elements of its fastening. Thus, technical condition of the core suspension system is one of the key factors defining stator life time in general.

Elastic core suspension system is applied in these turbogenerators. It is made from the tangentially focused flat springs one end of which is rigidly fastened to the section plate of the case, and the other end – to the inner frame (fig. 2). Segments of active steel are gathered on keybars in the inner frame. For the bigger reliability in turbogenerators 300 MW core is regularly wedged in a frame by means of radial and tangential counter wedges (fig. 3).

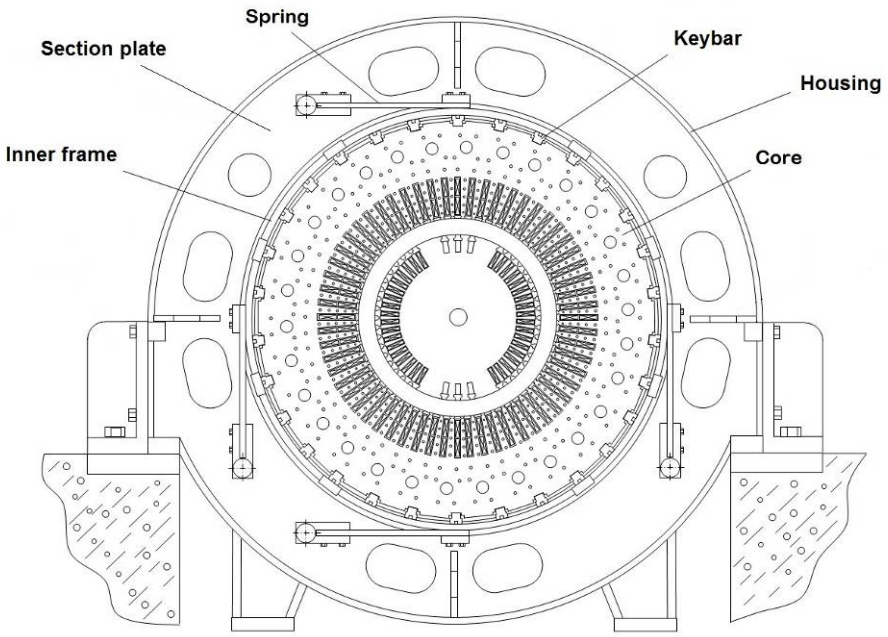

Fig.2. Transverse cross section of turbogenerator 300 MW.

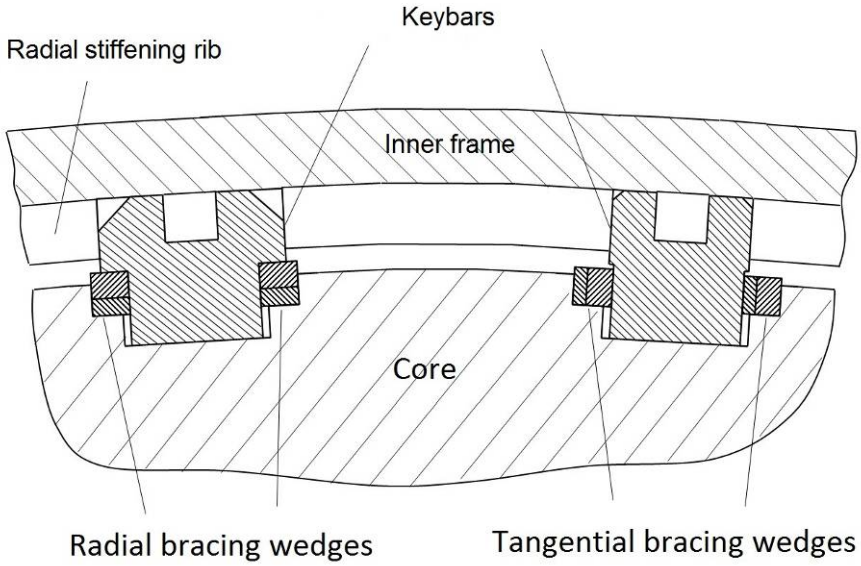

Fig. 3. Sketch of the factory-installed bracing wedges between core and keybars.

Various technical actions were undertaken for the stator vibration decrease. Serious changes to the design and manufacturing techniques were made. However, as practice shows, problem of the increased vibration still remains and it is especially visible on generators with service life exceeding standard. The repair technologies applied in the past did not provide long reliable effect.

Solution of increased vibration problem challenges more detailed study of the factors affecting its vibration characteristics (first of all – resonant properties) that would allow to develop more effective technology of recovery work.

For this purpose the simulation mathematical model [1] which analytically describes flexural oscillations caused by the rotating magnetic field action (prototype – a turbogenerator of 300 MW) was developed. Core, inner frame and the case are approximately considered as three thin concentric rings making flat flexural oscillations. Core and inner frame connections are modelled as radial and tangential elastic elements. Springs are presented as elastic and weightless bars. Base fastening – as two vertical and two horizontal elastic elements. The tooth zone of the core with a winding is presented as absolutely pliable thin inertial layer. Other structural elements are approximately presented as concentrated masses (in fig. 4 are designated by the circles).

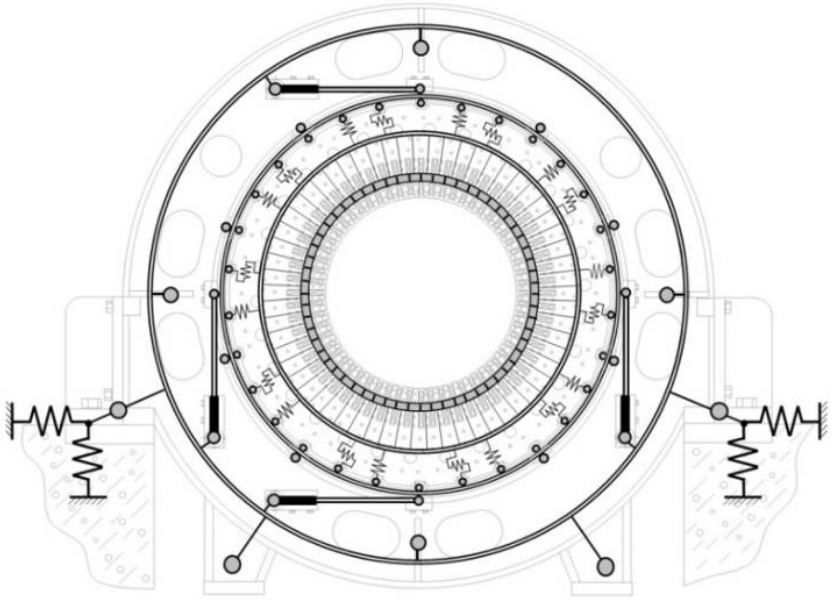

Fig. 4. Calculation scheme for the stator turbogenerator 300 MW.

Developed mathematical model allows to provide calculation of the natural frequencies and space shapes of the stator oscillations at variation over a wide range rigidity values of elastic connections between the core and inner frame and base support with a possibility of adding or exception connections between the core, inner frame and case.

Results of the study demonstrated essential practical interest. In particular it was established that the serviceable stator first natural frequency is above doubled grid frequency $2f_1$ with which magnetic forces influences on the stator. At the same time, violation of solidity between active steel interface and keybars leads to decrease of system "core - inner frame" natural frequency and its approach to $2f_1$, having caused thereby the resonant growth of "magnetic" oscillations of the stator.

Multiple calculations of the various ways of toughening core suspension system were carried out by means of developed mathematical model. The goal was to prove the choice of the best technology of repair by optimization of the scheme of installation additional fixing elements. Comparative analysis of influence of the way core fastening on resonant characteristics showed that the most effective vibration decrease is reached under condition if toughening connections between core and frame are made not only in the radial (as usually), but also in the tangential direction.

Results of theoretical studies were realized in practice at the solution for the problem decrease and stabilization vibration on the stator generator 300 MW. Repair program implemented by the results of research allowed to stabilize a condition of generator core and effectively restore and prolong its service life from 2015 up to the present. Level of steel stator units vibration was reduced approximately by 1.3 times on the core, and by 1.7 times on the case [1].

Proposed solutions are most relevant and were successfully implemented during the generators with tangential design of core suspension system modernization.

In general it should be noted that results of the joint analysis of turbogenerators operational condition parametrs (vibration, heating temperature, etc.) and mathematical modeling can be interesting for development and use of on-line systems of monitoring, extension of service life, optimization of the corrective maintenance, and also in determination of the necessary modernization scope.

References.

[1] D.V. Kuznetsov, F.A. Polyakov, M.I. Shandybin, A.I. Syromyatnikov, A.A. Galkin, G.A. Debrinov.“Analysis of causes, experience in monitoring and reduction of increased stator vibration of turbogenerators with tangential elastic core suspension designs.”// Power Technology and Engineering, Vol. 52, No 5, January, 2019, pp. 575-583.