Increasing the Power of the Turbogenerator in the Process Of Modernization in the Mining and Energy Industry

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Abstract

In this paper the main focus is on the turbogenerator and positive changes in it. There is replacement the active steel end zone of the turbo-generator n.1 which operates in REK Bitola, with purpose to improve the condition of the turbo-generator from magnetic point of view during the modernization for increasing the power. Turbo-generator is type TVV 200-2A produced by "Elektrosila" – Russia. The stator winding is cooled directly with distilate. The rotor winding, the stator core and the housing are cooled with hydrogen.

The reconstruction itself covers replacing more elements which are: Replacement of five end packs of each active steel end zone, which are manufactured in monolithic (backed) version and with successive reducing of its height. Reconstruction of the pressure rings with simultaneous installation of new enlarged copper screen on the pressure rings. Additional fingers for better tightness and intensifying the cooling of the end zones.Stabilization of the pressing tightness of turbo-generator core active steel with installing special spring devices so called pressure accumulators

During the realization of the reconstruction special tools, devices and equipment have been used.

Also for all examination which has been done protocols (test reports) have been made. Every test report consist from: test object, basis, and criteria of control, test results and conclusion on the test results.

Keywords: *Turbogenerator, replacement, end packs*

I. INTRODUCTION

Turbo-generator long-term operation is characterized by active steel degradation processes. Under the influence of temperatures, electrical field strength, mehanical impact and vibration effects, cooling media influence the aging of active steel, insulation, conductors take place. As a rule, most of demages occurs on active steel in end zone of the stator core. Pressing slackness rezults in individual lamination vibrations, its breakage with consecutive demage of stator winding main insulation and inadmissible overheating of toothing on bore surface. Suuden failures become more frequent and cause considerable loss due to downtime and recovery.

All turbo-generators, which work beyond the bounds of their spacified life, have reduced possibilities in operation under maximum load conditions and under reactive power duty becouse of inadequate condition of active steel end zones.

One of cardinal solutions for turbo-generator renewal and its service life extension consists in modernization of the stator with its rewinding and partial active steel replacement. This modernization was done on the generators type TVV-200-2A in TPP Bitola, and is subject of this paper.

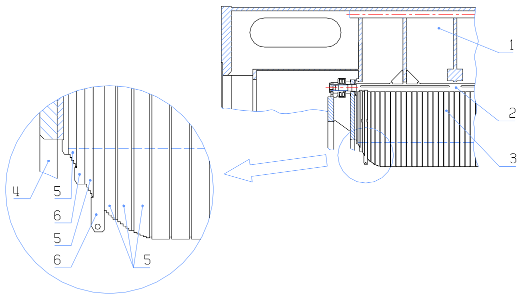
II. ANALYSIS

1. Description of the reconstruction)

The reconstruction itself is done by replacing more elements which are:

1. Replacement of five end packs of each active steel end zone, which are manufactured in monolithic (backed) version and with successive reducing of its height from inside towards the ends.

For reducing the looses and heating of the stator core so called "magnetic shunt" is applied. It represents special packs from electro-technical steel, similar to the packs from the basic core, but in length of 36.5 mm first, 31 mm second, 24 mm third, 18 mm forth and 18.5 mm the fift pack from the inside towards the end with hard pressure with fingers. (picture 1) The way they are placed these packs do not change the basic magnetic flow, but they short circuit the axial flows from dispersing on the end parts of stator winding with cutting from pressure cooper screen. For better ventilation of the magnetic shunt, magnetic shunt itself is separated from basic core with pressure fingers.



1.stator housing 2.stator rib 3.stator magnetic core 4.pressure ring 5.monolithic stator pack 6.pressure finger

Figure 1. Modernized end part of stator magnetic core for turbo-generator n.1 in TPP Bitola

On picture 2 monolitic (backed) packs which were mounted on the end parts of the stator magnetic core of turbo-generator n.1 in TPP Bitola are presented. As it can be seen packs are reducing in diameter going from the inside towards the end of the core but they are also reducing in thickness in the same direction.

Figure 2. Monolithic packs for replacement of the end part of stator magnetic core for turbogenerator n.1 in TPP Bitola

On picture 3 modernized end part of the magnetic stator core of turbo-generator n.1 in TPP Bitola is presented.

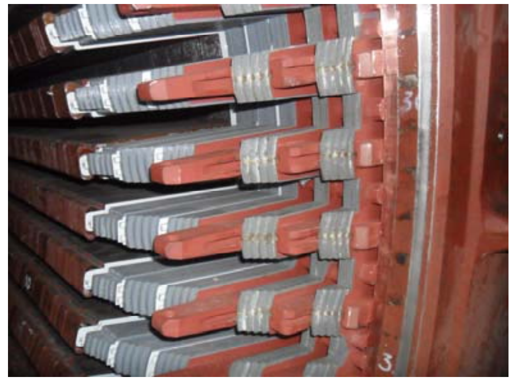


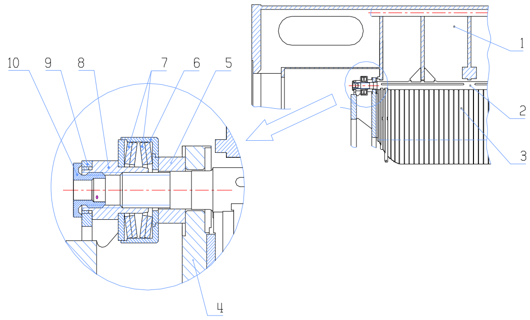
Figure 3. Modernized end part of the magnetic stator core of turbo-generator n.1 in TPP Bitola

Figure 4. Monolithic end pack of the stator magnetic core in the process of mounting for turbo-generator n.1 in TPP Bitola

2. Reconstruction of the pressure rings with simultaneous installation of new enlarged copper screen on pressure rings. Active steel end zone manufacturing as a “magnetic shunt” with simultaneous installation of new enlarged copper screen on pressure rings ensures low temperatures under reactive power consumption conditions
3. Additional fingers for better tightness and intensifying the cooling of the end zones
4. Stabilization of the pressing tightness of turbo-generator core active steel with installing special spring devices so called pressure accumulators.

In the process of the turbo-generator operation the core tightness may loosen as a result of working influences on the active steel end zone (i.e. temperature, vibration)

The efficient method of restoring the active steel tightening force at the first and the second loosening stages is the installation of special spring devices having the specified and adjustable pressure under the core tightening nuts.(picture 5)



1.stator housing 2.stator rib 3.stator magnetic core 4.pressure ring 5.fixing pad 6.housing 7.spring 8.nut 9.brake 10.screw

Figure 5. Spring blocks which are used for pressure on the stator magnetic core, so called pressure accumulators

The spring blocks (pressure accumulators all together 20 from each side of the core) are mounted after carrying out the works on the teeth local repairs and additional works ensuring the core pressure rings movability.
The technology of mounting the pressure accumulators has its own peculiarities, which lie in observing the measures for preventing the penetration of particles of steel parts machined into the stator winding (into the slot part and end winding).
On picture 6 one pressure accumulator which has been mounted on turbo-generator n.1 in TPP Bitola is presented.

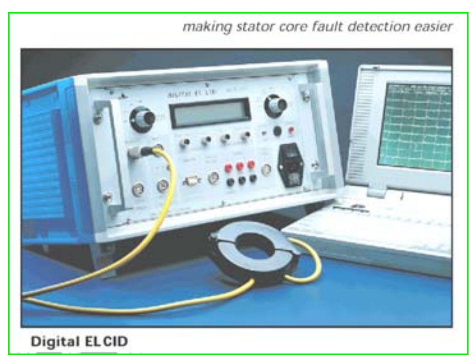
Figure 6. Pressure accumulator mounted on turbogenerator n.1 in TPP Bitola

Into the process of mounting the pressure accumulators the measurement aimed at detection of short-circuits between active steel partial laminations shall be performed. For this purpose the most appropriate is the active steel test at low induction densities (ELCID)

2. *Realization of the reconstruction*

Reconstruction, that is to say replacement of the end packs from magnetic stator core was done successive and during the performance of the operations special equipment and contemporary diagnostic methods were used. Also, examinations were made for assessment of technical conditions of the turbo-generator stator core before and after the reconstruction.
For all examinations protocols (test reports) were made. In every protocol exactly is known: test object, basis, criteria of control, used equipment, test results and conclusion on the test results. Examinations which were carried out during the reconstruction were:

1. Check of core linear dimensions
   a) Core dimensions before disassembly
   b) Thickness of the newly installed packs, Exciter side
   c) Thickness of the newly installed packs, Turbine side
   d) Core dimensions in pressed condition
2. Electromagnetic inspection of active iron lamination faults by using automatic inter-lamination fault monitoring system (ELCID) according to standard IEEE 62.2-2004 in which current bigger than 100mA while induction in yoke is 4% from nominal one, indicates isolation disturbance



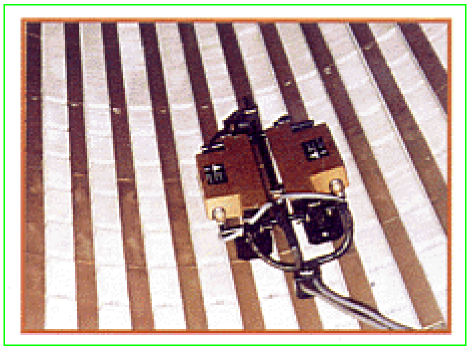


Figure 7. Instrument ELCID and probes in process of electromagnetic control of stator core

3. Core ring flux test (for heating and looses) with measurement of core bore surface temperature using infra-red equipment according to which:

- Biggest allowed core teeth heating 25^0C
- Biggest allowed difference of heating the teeth compared to core 15^0C
- Specific loses when induction is 1.4T should not be bigger than 2.2 W/Kg

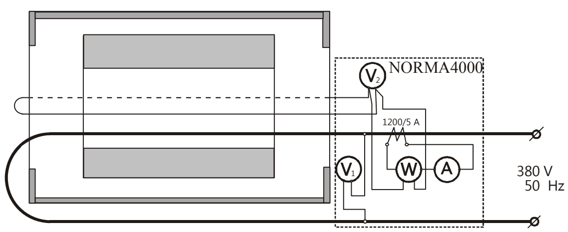


Figure 8. Connection scheme for core ring flux test

The examinations were carried out with current of 400A, 50Hz from 0.4kV source with one magnetization winding around the core, one control winding and induction of 1T in duration 72 min. according to the following scheme.
For discovering the hot spots infra-red digital camera type IR928 was used while for measurement of the looses power analyzer type NORMA 4000 was used.
5. Visual control of the yoke and the elements of reinforcements of the magnetic core (magnifying glass 4x and hammer 400g were used)
Ultrasonic control of the tightness of the pressured stator core according to criteria from the instruction "Conduction of overhaul and modernization of the active steel with using contemporary methods for diagnostics and technical control of the condition of the stator of the turbo-generator" i.e. average value of the velocity of the wave on 1mm length of the packs for monolithic (backed) and ordinary packs (in µs/mm)

- Good condition of the teeth: less than 0.8 for backed 1.5 for ordinary
- Satisfactory condition of the teeth: 0.8-1.2 for backed, 1.5-2 for ordinary
- Initiation of loosening the tightening force:1.2-1.8 for backed 2-2.5 for ordinary
- Loosened tightness: bigger than 1.8 for backed and 2.5 for ordinary

For the system of pressure finger-pack

- Good condition: less than 15 µs
- Satisfactory condition: less than 20 µs

(Ultrasonic defectoscope with frequency of 60 Hz type YD2N-PM and complete of probes were used)

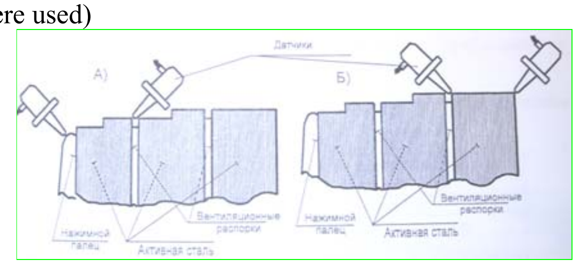


Figure 9. Handling the probes for measurement of:

A) pressure finger – pack
B) pack from tooth

6. Technical examinations for determining the condition of the pressure accumulators which consist of: 1. condition of the stator core, 2. Position of the pressure ring of the stator core towards the housing, 3. Correction of the clearance between the pressure ring and the stator housing, 4. Installation (setting) of the pressure accumulators with special hydraulic equipment with force of 1 ton, which is equal to the pressure of the stator core of 18 Kg/cm^2, 5. Control of the tightness of the pressure accumulators, 6. Position of the pressure ring of the stator core towards the housing after tightening the pressure accumulators, 6. Subsequent recommendations

III. CONCLUSIONS

Taking into consideration that with this reconstruction of the end packs of the stator core work of the generator in regime of under-excitation is allowed and knowing that the thermo power plant Bitola is at the big distance from the consumption of the energy, conduction of the modernization is obligatory.

Also, this reconstruction is a part of a complete modernization which involves replacement of the stator winding and reconstruction or complete replacement of the rotor with the new one. It must be emphasized that this reconstruction is performed only if complete replacement of stator winding was planned in advance. If complete replacement of stator winding was not planned in advance, this reconstruction should not be performed because of the real risks of possible damages on the stator winding as a result its removing and putting it back.

Magnetic shunt reduces the heating of the end packs stator core 2-3 times compared to the basic construction. It also allows generator work in capacitive regime, that is to say regime of under-excitation without large heating of the end packs of the stator core.

Effectiveness of modernization

- Service reliability of the generator is improved
- Operational characteristics range of the generator is enlarged including operation with more profound reactive power consumption
- Stator service life is extended by 15 years (120000 working hours)
- Overhaul life is 6 years (50000 working hours)
- Availability factor of the turbo-generator is increased

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