ATD-2500 INDUCTION MOTOR HEATING IN CASE THE ROTOR RODS DAMAGE

Geraskin O.A., Ph.D., associate professor, Voblikova A.O., Fetisov V.S., master degree students, Bazarov O.O., Moroko O.A., undergraduate students
Igor Sikorsky Kyiv Polytechnic Institute, electromechanics department

Introduction. One of the main components of the induction motors (IM) design is the short-circuited rotor winding (SCRW). In the process of long-term operation, especially powerful IM, there are damages of the SCRW elements - cracks and breakages of the rotor rods. Such damages at their considerable volumes can lead to an accidental stopping of IM with significant economic losses.

The causes of the SCRW primary damage are usually related to the defects that take place in the manufacturing process of a particular IM or to defects in materials. In the rods of undamaged SCRW, the distribution of induced currents is symmetric in nature, that is, the current values of the currents in all rotor rods are the same, which causes symmetric heating of all elements. When the rods of the SCRW are damaged, the symmetrical distribution of currents and temperature is disrupted, resulting in asymmetrical thermomechanical stresses that cause further rapid destruction of the SCRW. The mechanism of the occurrence of asymmetric thermomechanical stresses in the damaged SCRW is explained by the different linear expansion of individual rotor rods due to the asymmetric heating of the SCRW. This is especially evident in powerful IM that have a sufficiently large rotor length.

The accelerated destruction of the damaged SCRW is also due to its increased heating caused by the increase of the rotor and stator windings currents. The heating of the rotor and stator winding increase accordingly. Therefore, research of the causes and mechanisms of the SCRW rods destruction in order to prevent emergencies is of great scientific and practical importance. The study issue of heating in the elements of electric machines are devoted articles [1-3].

The purpose of the work. Study of non-uniform heating of IM SCRW rods in case of their break.

Material and results of the study. The article investigates three-phase IM of ATD type by 5000 kW with short-circuited rotor operating in nominal regime and the parameters of which are as follows: rated voltage 6 kV, stator current 276 A, efficiency 96,4%, power factor 0,905, rated frequency 2980 rpm, the number of pole pairs - 1; stator diameter - 1115 mm, air gap - 5 mm, number of rotor rods - 38, rotor diameter - 590 mm, length of rotor rods – 0,85 m, class of stator winding heat resistance – B (130 °C).

Studies were performed on different numbers of broken and adjacent rods: from 1 to 5.

Taking into account the heat dissipation increase in IM rotor and stator due to the currents increasing in the rotor and stator can be characterized by a factor calculated as the root middle squared (RMS) value of all currents in the rotor rods (k_{RMS_I}). This is due to the fact that the rotor currents rotate relatively to the rotor with

a slippery frequency and evenly (averaged or root middle squared) heat the rotor as a whole.

Table 1 – The coefficient of rotor currents increase when changing the number of damaged near located rods

	Number of nearby damaged SCRW rods					
	0	1	2	3	4	5
k_{RMS_I}	1,00	1,186	1,327	1,512	1,556	1,723

In the first stage of the study, the distribution of the temperature field in the undamaged IM was analyzed. It is established that the stator winding is heated more than the rotor, in particular the maximum stator temperature is 103,8 ° C and the rotor is heated to 77,5 ° C. The uneven distribution of the stator winding temperature along the height of the stator slot, which is approximately 5 °C, was detected (fig. 1).

According to the results of the IM rotor temperature field study, when the number of adjacent SCRW broked rods is changed, the following was revealed.

In undamaged IM the currents in the rotor rods are distributed sinusoidally and shift with a slip frequency (3… 5 Hz), resulting in that the entire rotor winding is heated evenly.

In fig. 2 the temperature distribution in the IM rotor rods presented in case of break from 1 to 5 adjacent rotor rods.

The total heating of the damaged rotor in comparison with the undamaged IM increases by 1,33… 2,27 times depending on the amount of damage, which is an important reason for the further rapid destruction of the SCRW rods. Thus, in case of break of one rod the maximum difference of temperature of rotor different rods consists 6 °C, then in case of damage of 5 IM rotor rods the temperature difference of different rotor rods is 23 °C. The difference in the lengths of the individual rods of the rotor rods due to their thermal expansion is: $\Delta L = 16,7 \cdot 10^{-6}\ °C^{-1} \cdot 0,85\ m \cdot 23\ °C = 0,33\ mm$.

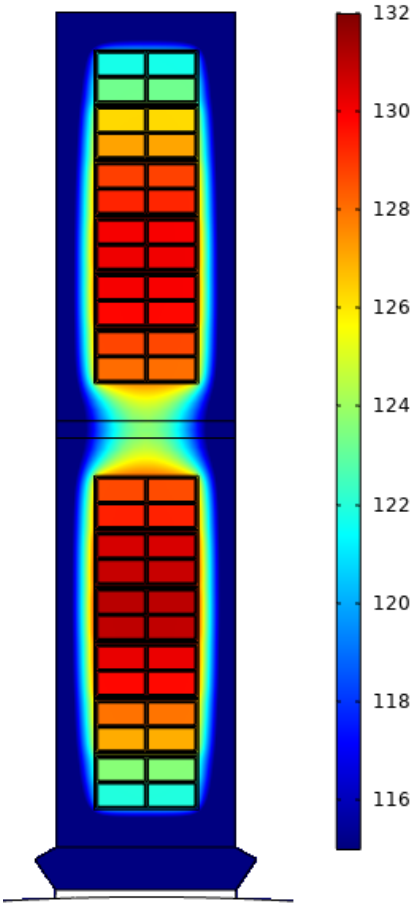

Figure 1 – Non-uniform heating in the stator slot of the winding

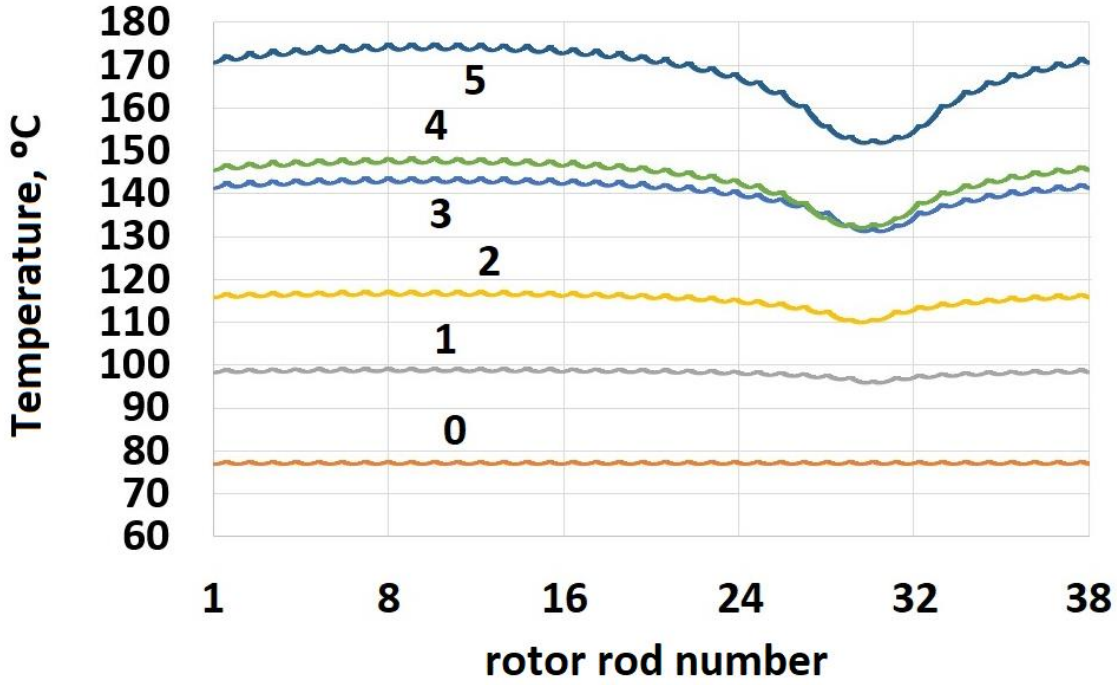

Figure 2 – Temperature in rotor rods depending on number of damaged rods

Conclusions. Characteristic damages of the short-circuited rotor winding of high-power motors, resulting from prolonged operation and difficult operating conditions (such as brakes of the rotor rods), contribute to the further accelerated destruction of the rotor.

Such factors are an increasing of overall heating and the appearance of an asymmetrical temperature distribution between individual rotor rods, which causes the appearance of asymmetric thermomechanical stresses in the rotor winding.

References

1. Geraskin O.A. Temperature gradient in stator elements of induction motor ATD-5000 in the change of load / O.A. Geraskin, A.O. Voblikova // Міжнародний науково-технічний журнал молодих учених, аспірантів і студентів "Сучасні проблеми електроенерготехніки та автоматики" – Київ: «Політехніка». – 2018. – № 1. – С. 320-323.

2. Geraskin O.A. Temperature heating of the turbo generator TGV-200 rotor elements while excitation winding damaging / O.A. Geraskin, K.M. Tatarinov // Міжнародний науково-технічний журнал молодих учених, аспірантів і студентів "Сучасні проблеми електроенерготехніки та автоматики" – Київ: «Політехніка». – 2018. – № 1. – С. 317-319.

3. Васьковський Ю.М. Температурне поле синхронної машини при короткому замиканні витків обмотки збудження / Ю.М. Васьковський, О.А. Гераскін // Гідроенергетика України. – 2017. – № 1,2. – С. 56-59.