INDUCTION MOTORS SQUIRREL-CAGE ROTOR WINDING DAMAGES

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Introduction. Induction motors (IM) with squirrel-cage (SC) rotors often work in extremely hard operation conditions, with poor maintenance or sometimes even without it. Thus, the main reasons of the IM failures are: inappropriate operation conditions (15-35% of failures), damage that occurs during operation (35-50% of failures) or poor repairing quality. Approximately 30-35% of IM failures occur due to design and technology deficiencies in motor production. Only 10-12% of motor failures occur due to natural aging and wearing. However, it should be noted that the wear failures in the IM, operated in the conditions of frequent restarts, can occur after 2,5 – 4 years of operation [1, 4].

According to statistical researches, one of the most common reasons of IM failures is the damage of its rotor winding. Fig. 1 shows three-dimensional model of the IM with SC rotor. The heating of the IM with the presence of the damage of its structure is researched in articles [6, 7].

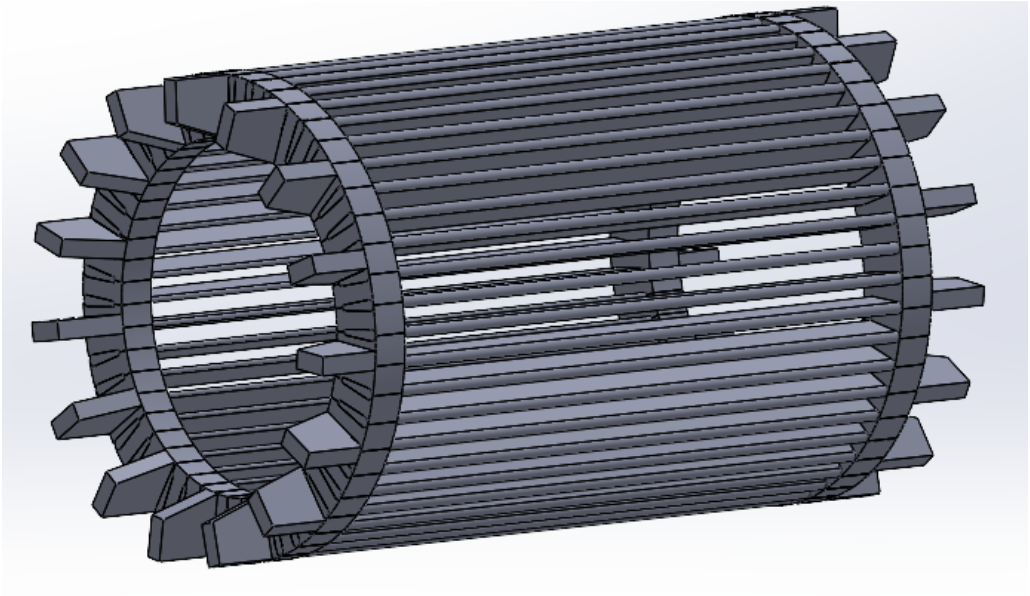

Figure 1 – Three-dimensional model of the squirrel cage of the IM type 4A355M4U3

The purpose of the research. To analyse the main damages of the winding of the IM with SC rotor and the reasons of their occurrence, determine the impact of these damages on the further performance of the motor.

The results of the research. We can note the following as the main reasons of the damage to IM rotor winding.

- *Deformations and breakdowns of the rotor winding rods as a result of mechanical overloads due to the rapid and uneven heating during the motor start* (80% of all damages of SC rotor windings are the results of this factor) [3].

• *Significant electrodynamic issues during motor start.* Fig. 2 shows the output of the rod from the slot due to the action of the electrodynamic forces when starting the motor. It is worth to note that this motor was operated in extremely hard starting conditions, although it was not designed for such operation modes [2].

Figure 2 – The output of the rod from the slot due to the action of the electrodynamic forces when starting the motor

• *Low quality casting of the SC rotor.* Fig. 3 shows a low quality casted SC rotor. The casting was performed with the violations of the technological processes, which led to the appearance of the air cavities inside the SC rotor, which led to its further damage [3].

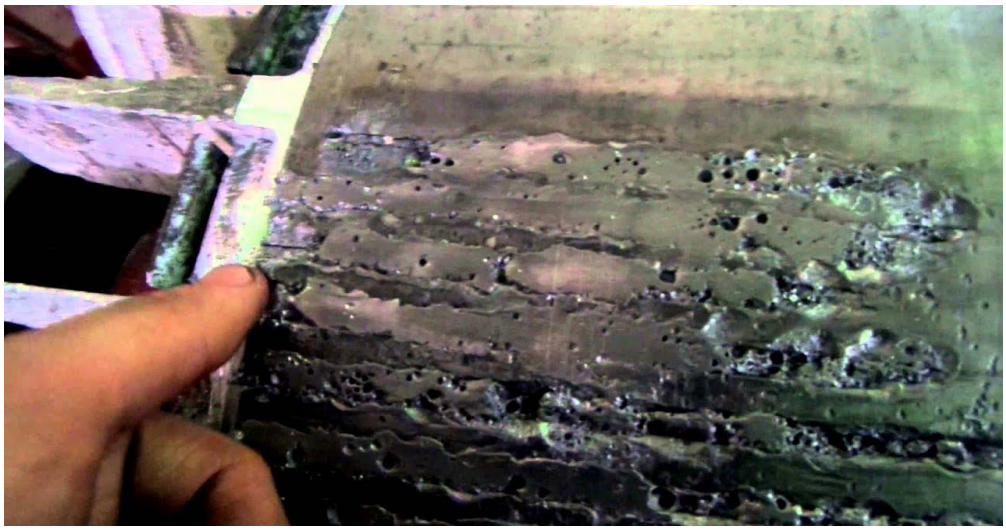

Figure 3 – Damage of the inappropriately casted SC rotor of the IM

• *Frequent restarts of the IM in the heated state.* Under such operation conditions, the overheating of the winding (Fig. 4) reaches the highest values, especially in motors with hard starting conditions, which can lead to the damage, in particular the melting of the SC rotor material from the slot [1].

Figure 4 – Thermal damage of the rod of the SC rotor due to frequent restarts in the heated state.

• *Low quality welding* (in motors with a welded SC rotor).

• *Reversing or dynamic breaking of the induction motors that are not designed for such operation modes and abrupt changes of the load on the rotor shaft.*

One of the most common reasons of the damage of the IM rotor winding is the separation of the rotor rods from the short-circuited ring.

At the initial stage, the breakout of the rotor rod has almost no effect on the operating characteristics of the motor and can't be detected immediately. When the rod breaks, the load is redistributing to the other conductors (winding rods). The main load is redistributed to the rods, adjacent to the broken, creating the abnormal operation conditions of the rotor. Thus, the breakout of the one rod often leads to the damage of the other rods. Later on, the broken rod can bend (usually during motor start) and damage the stator winding, which will lead to serious consequences for the motor, which requires the major repairs or replacement of the damaged IM with a new one.

Fig. 5 shows two rods that separated from the short-circuited ring and bent under the action of the significant electrodynamic forces [5].

Figure 5 – Separation of rods from the short-circuited ring

Fig. 6 shows the stator winding, on which is clearly seen the damage caused by bent rods [5].

Figure 6 – Stator winding damaged by the bent rods

Conclusions. The main damages of the rotor winding of the IM with SC rotor and the reasons of their occurrence are analysed in this article, also determined the impact of these damages on the further performance of the motor. Usually, damage to the rotor winding is caused by the operation in starting modes. As a result of the starting processes, the rod separates from the short-circuited ring due to frequent restarts, high electrodynamic forces, hard starting conditions, etc. Moreover, starting with an already separated rod can lead to the separation of other (undamaged) rods, as the load from the separated rod is redistributing to undamaged rods. Violation of the technological processes during the motor production can also lead to the damage of the rotor winding.

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