IMPACT OF THE INCREASING ENERGY EFFICIENCY ON THE THERMAL STATE OF MEDIUM-POWER ASYNCHRONOUS MOTORS

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*Abstract.*The text deals with electrical engineering problems of design of the 3-phase induction electrical efficiency motors with IE3, and IE4 levels with squirrel cage. The text can beuseful for engineers who are involved in the design and development of energy efficiency motors and enhancing the design of the motors.
The proposed work aims to find some interconnections between the temperature state and energy efficiency, which, in turn, may have a positive impact on the global energy –saving problems and their solution. The scientific novelty of the study lies in examining the thermal and electrical fields of the existing motors design; establishing correlation between the thermal state and motor efficiency levels; optimizing the design of the housing and cooling scheme and electromagnetic core on the basis of the research findings.
Keywords. Induction motors, asynchronous motors, energy-efficiency motors, thermal state, temperature state, heating state, cooling optimization, thermal state energy-efficient motors, and cooling energy-efficiency motors.

*Introduction.*This study aims to examine the area of design of the three-phase induction motors with squirrel cage rotors and shed light on the problem of creating motor constructions with an optimal balance of energy efficiency and temperature state. New approaches and relevance are needed to address the problem of creating motor constructions with an optimal balance of energy- efficiency and temperature state. The relevance of this work is in the novel approach based on the estimation temperature state of the motors. There are typically, exploited designs of electric motors with higher efficiency in contrast with the serially produced motors AIR, 4A, and others types. As a fact, high prices on the market and substantial differences in technology production interfere with a wider production, operation, and application of these motors. The use of some series of these motors was reduced to a minimum. As a rule, these motors were designed based on existing technological tools, molds, and equipment used in series, only aimed at achieving the target level of energy efficiency and without solving the problems of optimizing the temperature state of the motors.

We should highlight that during the last 50 years, the world has faced several energy crises, which made the global community more aware of the energy problems in general, and the energy efficiency of consumer-devices in particle. Thus, humanity faces the challenge of the annually growing volume of energy consumption per capita in the world and the high percentage of fossil energy sources (79.68%), the quick pace of depletion of the world's proven fossil fuel reserves. As a result, all these negative factors contribute to a global energy crisis in the foreseeable future.

The issues are the following:

- from 50 to 65% of all the generated electricity in the world is consumed by electric motors;
- up to 70% of the electric motor fleet are squirrel cage induction motors.

The largest quantity of operating motors is used in industry. Applied in fan systems or pumping stations, these motors operate almost 24 hours a day and 7 days a week. Increasing energy efficiency and thus reducing energy consumption is directly related to the topic of global energy savings.

This situation can be solved with the help of developing renewable energy-generating sources. The problem is the share of renewable energy resources in the overall volume of generated electricity and heat today is still small, and the cost of renewable energy is several times higher than that of conventional energy. The biggest challenge is that alternative energy projects are costly and their payback is not quick enough. The accompanying financial crisis challenges the ability to mobilize all the energy investments needed to meet growing energy needs.

Enhancing the energy-efficiency of the squirrel cage induction motors is still in its developmental stages. This trend was significantly intensified with the adoption and implementation of technical regulations of the EU and China, standards of the International Electro technical Commission IEC 60034-30 and 60034-31. Referring to the findings from selected scientific databases we infer that this area is still the field of active research in the world, mainly in China, the USA, India, EU. At the same time, the overwhelming number of research are focused on achieving the target level of energy efficiency, without considering the tasks of optimizing the thermal state of the electric machine, and also using the mostly active cooling of the motors.

Also, it is also worth mentioning that all these circumstances restrain the strategy's implementation and increase the risk of a global energy crisis. With this in mind, saving energy resources on a global scale is a top priority. One of the steps to be taken is to save energy consumption generated from traditional sources by increasing the energy efficiency of consumers' devices.

The overall research in this field has a great impact on the global economics and it might be assumed as a huge benefit for the world community, since the major part of the cost of operating motors (up to 96%) is the cost of electricity and only 3% is the cost of purchasing the motor and maintenance.

The estimated savings from the implementation of motors with energy efficiency level are IE3 IEC about 135kWh, compared to the case when no measures are applied.

It is consistent with the level of electricity generation in a European country such as Sweden. Another positive impact of the research addresses end-users since the major part of the cost of operating motors refers to the electricity consumption of the motors. Moreover, enhancing the temperature state of the motors leads to a lesser probability of faults throughout the motor life-cycle.

Development and introduction of energy-efficient motors can be implemented in a relatively short period, and the investments required to arrange the production are much less than those needed to build new generating renewable energy sources. Needless to say, designing these energy-saving motors with enhanced optimized temperature states is one of the first and vitally important steps towards the global energy transition from fossil fuels to renewable resources.

To fulfill some further steps, several declarations, technical regulations, and standards have been adopted at international and regional levels in recent years, regulating mandatory minimum levels of energy efficiency of consumer-devices. Solving tasks require detailed analysis of existing designs of energy-efficient motors and technical solutions, and cooling schemes of motors; careful study and comparison of their thermal state and identification of the influence of structural elements and their changes.

The novelty of the study lies in the optimization of the efficient motors design with heating state and level of efficiency criteria with the purpose of finding useful engineering instruments and defining criteria for changing the design with active and passive cooling. The objective is to analyze and examine different existing motor designs with efficiency levels (IE3 and IE4) and cooling designs with formal code IC411 (with internal and external air circulation).

The methodology of the work focuses on the performing mathematical modeling and experimental validation of the following directions:

- Modeling and examining the electromagnetic and thermal fields for motors of different poles with different energy efficiency classes.
- Investigating the effect of the motor’s cooling scheme and shell element design and cooling flux magnitude on energy efficiency and thermal condition of the machine.

The methodology of the research involves the direct method of measuring temperatures with sensors and thermal camera. Temperature condition studies are carried out by means of embedding sensors into the highest heating points of the machine. These sensors are included in the frontal parts of the stator winding, the outer ring of bearings, and the inside in the terminal box. The temperature distribution on the surface of the housing

details is measured with a thermal camera. The temperature of the incoming and outgoing air and air inside of channels (in the case of the motor with a double cooling circulation system) are also measured. The tests of motors efficiency and performance align with IEC 60034-30, IEC 60034-2-1.

The research is carried out in several directions changing the design of the parts of the shell and electromagnetic core. The study directions are the following:

-a motor with a single cycle of cooling air circulation;

-a motor with a double cycle of cooling air circulation;

-a motor with intensification of external airflow due to the modified design of the external (and internal) fan;

-a motor with different geometric data of the stator and rotor cores;

-a motor with passive cooling of motor's shell parts.

The balance of frictional losses spent on active ventilation and the impact on these losses on the motor's energy efficiency is investigated.

The practical results of the research are expected to be implemented in the design and production of energy-efficient motors with high levels of energy efficiency (IE3, IE4).

In conclusion, the relevance of the topic is confirmed by currently published studies and articles, and current international technical regulations and standards. The trend of efficiency increasing has proved its relevance and viability through the successful transition from IE2 to IE3 levels. The implementation of the research is fully aligned with the global trend to conserve energy by improving the design of electric motors. The research is planned the purpose of optimization of motors thermal state and efficiency level. At present, the problems of optimizing the balance between temperature state and energy efficiency of electric motors have not been solved yet, and their solution is an actual task.

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BIO-PACKAGING IN THE FOOD INDUSTRY AS THE BASIS FOR ENVIROMENTAL CONSERVATION

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Abstract. The article discusses the advantages and prospects of using bio-packaging made from biodegradable polymers in the food industry. Bio-