DEVELOPMENT AND RESEARCH OF POLE-CHANGE WINDING FOR TWO SPEED ASYNCHRONOUS MACHINE

Bobojanov M.K.

Bobojanov Maxsud Kalandarovich doctor of technical sciences, professor. Tashkent State Technical University, Tashkent city. Republic of Uzbekistan, e-mail: mbobojanov@yahoo.com
https://orcid.org/ 0000-0002-6738-8463

Abstract: In this paper, the possibilities for constructing pole-changing windings with a ratio of poles 3:4 and improved electromagnetic properties are investigated. The results of experimental research work on two-speed machine with a new winding are presented, too.

Keywords: *electric machine, pole changer, electromagnet, pole.*

Annotatsiya: Ushbu maqolada qutblar nisbati 3:4 hamda yaxshilangan elektromagnit xossalarga ega bo‘lgan qutblar soni o‘zgaruvchan chulg‘am yaratish imkoniyatlari ko‘rib chiqilgan. Yangi chulg‘am bilan jihozlangan ikki tezlikli mashinani eksperimental tadqiq qilish natijalari ham keltirilgan.

Kalit so‘zlar: *elektr mashinasi, qutblari o‘zgaruvchi chulg‘am , elektromagnit, qutb.*

Introduction. Two-speed electrical machines can be carried out both with two separate windings or with one pole-changing winding (PCW). Undoubtedly, the second kind of construction has a lot of advantages in view of the smaller slot area which is occupied with a winding that allows a sation of improved 4nstitute4n an active part of the electrical machine, to enhance power parameters, to simplify manufacturing and repairing technologies. Many scientists from different countries of the world were engaged with the problem of PCW development and as a result of these researches, a great number of schemes for pole-changing windings on different ratio of poles and phases has been developed. However, the majority of these schemes have not found industrial application, since existing principles of PCW design do not currently allow the fabrication of a winding for a wide spectrum of ratios of numbers of poles and phases, that are coming nearer to manufacturing technologies of conventional windings of serial ac machines.

At the same time, PCWs should have a structure close to the structures of conventional windings with a width of the phase zone of 60 and 120 degree (2*m*-zone and *m*-zone windings). Here, the corner between the coils, belonging to different phases and laying in the next slots should be equal 60 degree ($\pi/3$) or 120 degree ($2\pi/3$), respectively. The deviation from these values will be defined as difference between the shear angle of conventional and new windings: $|\Delta\varphi| = |\varphi_{usual} - \varphi_{new}|$. Concerning the difference $\Delta\varphi$ between corners, it is better to take it in absolute values, since the deviation from normal shift to the left or right should be estimated equally.

New Method. The development of schemes for PCWs with a close structure to normal windings, i.e. with improved electromagnetic properties is possible, using the modernised method DSSF (discretely specified spatial function). This method has been developed by the chair „Electrical Energy Supply” of the Tashkent State Technical University [1,2,3].

On a basis of this method, the new principle for current or phase distributions of two simple lap windings of normal execution with the number of pole pairs p_1 and p_2 and phases m_1 and m_2 can be developed. They are simultaneously used in the process of winding design. Thus the winding scheme is not accepted as being ready and is formed in the process of construction, taking into account pictures of distribution of phase currents in slots of the machine for every pole.

Development of PCW using of new Method. One of the most common speed ratios in two-speed motors used on drives of mechanisms with a fan type of load is a ratio of 3:4.

At the same time, the first speed of 1000 rpm is the main one at which the electric machine will work in case of full loading of the mechanism, and the second speed (750 rpm) – auxiliary and is used to regulate performance for the responsible use of electricity and natural resources in underloading modes, and can also serve as the first stage in a step-by-step start-up. With this in mind, a winding scheme of PCW for a ratio of poles 3:4 in the number of slots 72 was developed using a new method.

As a basic scheme for this PCW is suitable PPO scheme „three three-phase star with additional branches", which is shown in Fig.1. To receive accordance of the above-stated winding with the diagram shown in fig.1, it is necessary to take out some coils in additional branches from the big pole side, removing two coils from the $2p_1$ pole side from each phase zone.

These coils are deduced in additional branches and, being redistributed on phases, contribute to build up a magnetic field of $2p_2$ pole [5].

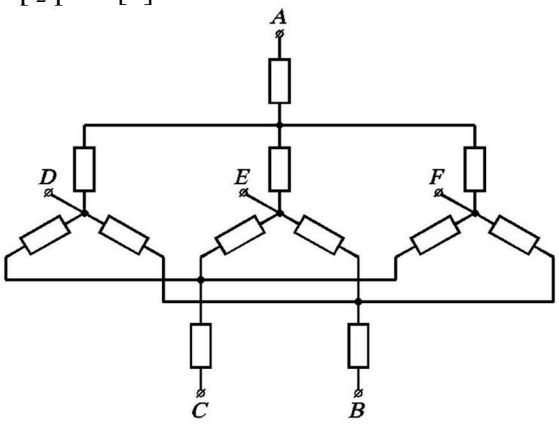

Fig.1

At the same time, the resulting (total) values of electromotive forces (EMF) should be equal to zero in an additional branch from the $2p_1$ pole side, and as a whole, they should have no influence on the functioning of the motor. Mutual compensation EMF of additional branches is carried out by a consistent connection of coils of additional branches and a circular distribution of the magnet core, while the relation to each other on the corner of shift is equal to 120 electrical degrees and the winding in the magnetic field has a small number of poles. For the coils of additional branches, it is expedient that the wire has a three times larger cross-section and accordingly a three times less number of turns than in other coils. In this case, practically full coordination of the magnetic inductance in the air gap is achieved by gaining the same performance:

$$\frac{w_1 \cdot \xi_1}{w_2 \cdot \xi_2} = \frac{p_1}{p_2} = \frac{3}{4} \quad (1)$$

There might be a small deviation in the magnetic inductance, which can be provoked by various winding factors. Development and Test of New Machines. At the Tashkent State Technical University (TSTU), a sample model of the new two-speed machine was designed, having a PCW with a speed ratio of 1000/750 rpm. It is based on a magnetic core of a common 6-pole squirrel-cage motor AGM100L6 with an output power of 1.5 kW and a nominal speed of 925 rpm [5,7].

This machine was tested in the electromechanical laboratory of the chair "Electrical energy supply" at the TSTU. The results of experimental researches of the new machine in motor duty have shown the following: For 6 poles, the useful power of the new motor reaches 1200 W, efficiency and cos φ corresponding to this power amount to 76.9 % and 0.722, the nominal stator current is equal to 3.7 A, and the slip s is equal to 3.9 %.

For 8 poles, the value of useful power of the two-speed motor almost amounts to 982 W, the values for efficiency, the power factor and the slip corresponding to this power are equal to 73 %, 0.663 and 5.6 %. The mechanical characteristics have a smooth appearance. The starting torque for 8 poles is higher and the starting current is less than for 6 poles, which allows using such motors for drives with heavy conditions during start-up and in areas with a weak power line. Due to a low starting current, the power line loading by a starting current will be the least.

The experimental tests in generator duty were carried out at direct connection of the two-speed induction machine to the network, and in an independent mode with connection to condenser batteries.The shape of the voltage obtained is close to a sine wave, the harmonic content in a voltage curve changes minimally, i.e. the shape of the voltage is very close to a sine wave.Analysing the received experimental test results, it is possible to say, that the new two-speed induction generator has weight-dimensional and power parameters similar to the parameters of the usual induction

generators. Thus, there is a real opportunity of creating new types of compact and reliable induction generators which can be used in wind installations or in separately standing hydrostations.

Reduction of weight in wind devices, except for consideration of economy of material means, would simplify processes of manufacturing, transportation and installation of wind installations.As a whole, it can be noticed, that thanks to new PCWs with improved electromagnetic properties, it is possible to realise two-speed machines having weight-dimension and power parameters, as much as possible approached to parameters of normal one-speed electrical machines [6-10].

The use of such machines as motors allows to modernise existing electric drives with two-speed motors and to replace some conventional one-speed motors by two-speed pole-changing motors for the purpose of energy saving in small loading duty, in connection with technological or seasonal changes of loading and also to facilitate start-up processes for powerful motors.

Conclusion

1. The new method allows the design of PCWs of different ratios of pole pairs and phase numbers, whithout differing by their manufacturing and repairing technology from usual two-layer windings.
2. The offered PCWs do not have switching devices and possess improved electromagnetic characteristics and energy parameters in comparison with windings obtained by other methods.
3. Two-speed electrical machines with PCWs differ only marginally from usual serial one-speed induction machines and can perfectly substitute them with respect to energy saving.

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