# TWO-SPEED INDUCTION MOTORS FOR THE ENERGY SAVING MEASURES.

*D.Rismukhamedov*

Induction motors are very widely spread in all countries of the world because of their simplicity, reliability and cheapness. Many millions of induction motors are exploited in the New Independent States of the former Soviet Union and about 60% of them operate with the propeller torque characteristics line to the torque characteristics of such mechanisms as fans, pumps and so on. Just as the speed adjusting of pumps and fans in connection with the technological or seasonal variation of load allows to economize more than 25% of consumed energy. One part of these mechanisms has a variable-speed drive (for example pumps, fans and other mechanisms at the electric power peants, at the mines, etc.), another part has only constant speed although the use of speed adjusting is very actual for it also with point of view of the energy saving by means of electrical drive.

One of the main types of variable-speed electrical drive for similar mechanisms is the electrical drive on the basis of two-speed induction motors. However, the existing two-speed motors with two separate windings on the stator have essentially large dimensions and weight, essentially worse performance and energy characteristics in comparison to the one-speed motors, they are more complicated for the producing and repairing.

These disadvantages restrict a wide application of two-speed motors instead of the normal one-speed motors in the aims of energy saving. Therefore, improving of the two-speed motors is an important task and use of a single pole-changing winding (PCW) can be considered as one of methods to improve the two-speed motor.

In the present work, the principle of operation of an improved design of pole-changing windings with a minimum number of output leads and contact switches is presented. A great number of such PCW with various pole pair ratios have been worked out for various induction motors. These improved design have been developed by the Discretely Specified Spatial Function Method (DSSFM) [1].

According to this method, the development of the proposed PCW is carried out by simultaneous consideration of the discretely specified spatial functions of two ordinary windings. The basis of this process is a principle of “approximation” of the current distribution and magnetomotive force pattern of the PCW to the current distribution and magnetomotive force of a standard winding. The “approximation” consists in determining of the state sign of the conductor in each slot of the DSSF of the synthesized winding, depending on the conductor state in the DSSF of the standard winding in the same slot, and on the mutual orientation of the phase current vectors in the three-phase system [1,3].

The proposed designs of PCW, as replacement of the two separate windings of the stator of the two-speed standard squirrel-cage motor, are shown in Figures 1 and 2. These improved PCW can be constructed under the following schemes:

“Three–Stars” and “Three–Stars with additional branches” for pole pair ratios 5/6, 3/4 ad 2/3, as illustrated in Figure 1(a) and (b).

“Star-Double Star” and “Star–Double Star with additional branches” for pole pair ratio 1/4, as illustrated in Figure 2 (a) and (b).

The number of “additional branches” (Fig.1) theoretically can be from **1** up to **n** but in practice it is in the range of 1 to 3.

The proposed designs of PCW, as shown in Figures 1 and 2 have a minimum number of six or nine output leads with two additional contact switches and the methods used for their construction was identical to the method used for the production of ordinary double-layer simplex lap winding with equal pitch and number of turns in the coils.

When a three-phase ac power supply is connected to the terminals A, B, C of the windings shown in figures 1 and 2 with contact switches (S1) open, a rotating magnetic field is developed in the air gap of the induction motor with initial pole pair number $P_2$. If the power supply is connected to the terminals D, E, and F of the windings shown in Figures 1 and 2 with contact switches (S1) closed, a rotating magnetic field is developed with lower pole pair number $P_1$ since the current direction in the coils between the terminals D,E,F and contact switches (S1) has been reversed.

Working out of the PCW schemes for a wide range of pole pairs and phases number ratios that have a simplified manufacturing technology is a first step of the way to create a new type of two-speed motors. Solving of the problem of their gesign is a second important step.

The design of the two-speed motor with including of the calculation and design of the magnetic core as well, which is a complex projecting process, gives the opportunity to develop completely the advantages of the proposed PCW use. However, in most cases, the problem is limited to the application of the PCW on the existing standard magnetic core with the aspiration to exploit its maximal advantages with respect to the motor mass, its dimensions and energy characteristics. This is a complication of the design process.

To solve this problem, a new approach for the calculation and design of two-speed motors with PCW is elaborated. The new method consists of the following stages: first, the selection of the appropriate winding scheme, then the definition of the number of turns in the coil, after that the calculation of the wire's cross-section area and finally, a calculation of the magnetic core to check the result. The selection of the winding rational scheme is possible with an analysis based on the values of the winding factor, the differential dispersion coefficient and the energy characteristics. The magnetic induction value ratio in the air gap and level of use of the motor dimensions are also main condition of the selections of the winding scheme. The number of turns of the coil is defined in accordance with the given power rated ratio with the goal to exclude the magnetic core saturation for both pole pair number sides.

The results of these investigations and calculation were applied to several samples of the two-speed motors with PCW. The magnetic cores for these samples

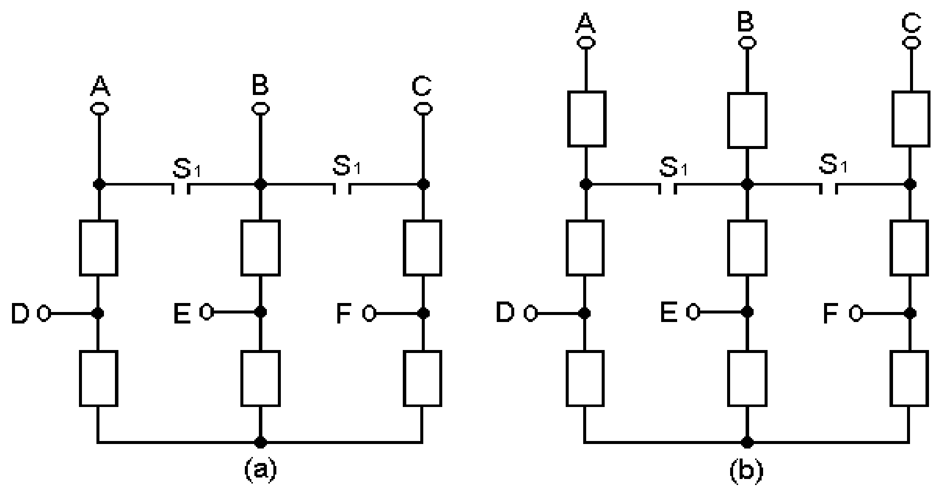
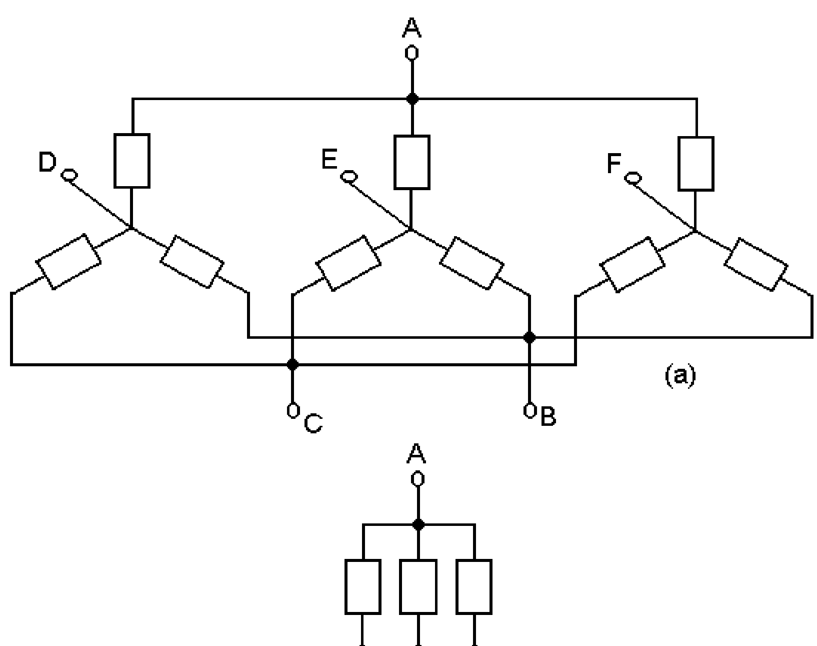



Figure 1.



were manufactured by the company “KONE” (Finland), by electrical machine building plants in Yaroslavl, Vladimir (Russia), Kharkov (Ukraine) and by the “Schindler” firm (Switzerland). These motors were produced and tested in industrial conditions and have given good operational results with considerable saving of the copper and steel. For example, an experimental type MD17MB2/8L motor (Russian mode) with the proposed PCW, constructed on a standard magnetic core of a standard motor (type 4AM160M4), has undergone a complete cycle of industrial tests (including transient condition tests) in the lift installations of the Karacharovsk Mechanical Plant in Moscow, which are 33 m high [2,3]. The motor essentially met all reguirements imposed on motors used in lift installations.

Tests were also conducted in the laboratories of the Tashkent State Technical University on a standard 6.7/1.7 kW 160MW 4/16CR Swiss made induction motor which was rewound with the proposed PCW. This motor develop a power of 10/2.5 kW instead of 6.7/1.7 kW of the standard 160MW 4/16CR motor with two separate windings [4].

All tested motors with PCW have given the good operation results despite of the use of standard magnetuc cores of standard motors. The results of laboratory and industrial tests and studies have shown that the use of the PCW in the two-speed induction motors can increase the power output of the motors, can simplify their manufacturing process and can maximal approximate the two-speed motors to the ordinary one speed motors by the dimensions and characteristics. For example, on the same dimensions and for the same pole number (six) the motor 4A132M8/6УЗ with two separate windings develops a power of 3.2 kW, the motor 4A132M6/4УЗ with PCW – of 6 kW and the normal one speed motor 4A132M6УЗ – of 7.5 kW (all Russian made motors). The additional possibilities arise when the calculation and design of two-speed motors with PCW will be carried out with taking into consideration the operating condition of mechanisms (for example, with taking into consideration the propeller type of torque characteristics).

In conclusion, it is possible to note that the motors with PCW being maximal approximated to ordinary one speed motors can be used in many cases not only instead of the existing two-speed motors with two separate windings, but also as the energy saving measure (without additional expenses practically) instead of the ordinary one-speed motors for numerous installations (mechanisms), where the load variations are possible, and such adjusting of the conument power is most simple, cheap and reliable.

## REFERENCES

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