Some Peculiarities Of Mass-Overall Dimensional Characteristics Of Brushless Motors

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Abstract - Brushless motors (polyphased AC induction, synchronous and brushless DC motors) have no alternatives in modern electric drives. They possess highly efficient and very wide range of speeds. The objective of this paper is to represent some equations giving a relation between the basic parameters and magnitudes of electrical machines. This allows to be made a comparative analysis and a choice of motor concerning each particular case based not only on catalogue data or price for sale.

Keywords - Brushless DC motors, Brushless DC motors PM.

I. INTRODUCTION

Some different requirements such as high output power, high rotational frequency, full controllability, highest efficiency and low price could be insisted on modern high-speed brushless motors (AC, BLPM, SR motors). The selection of any type of motors for a particular application is a difficult task and is always accompanied with a compromise between price and quality.

II. RESULTS AND DISCUSSION

The analysis and juxtaposition of the mass-overall dimensional characteristics of these motors allows the possibility of their use in every particular case to be assessed. The mass-overall dimensional characteristics used frequently as criteria for comparison include: relative weight (motor weight per unit of useful power); relative weight of the active materials put in such as electrical sheet steel, wires, permanent magnets; torque per weight; power per unit of weight; price of the active materials put in per unit of power; developed torque per unit of price or weight, etc.

According the authors of Ref. [1] the relative power (p) characterizing the extent of use of the active materials is as following:

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$$p = \frac{P^{'}}{D^2.l_\delta} = \frac{m.I_n.E}{D^2.l_\delta}, \qquad (1)$$

where:

p is the relative power, $[W/m^3]$;

$P^{'}$ is calculated power, $[W]$;

m is the number of phases of stator winding;

I_n is the nominal current of the motor, $[A]$;

E is the electromotive force, $[V]$;

D is the stator diameter, $[m]$;

l_δ is the active length of the stator, $[m]$.

A more common criterion is the ratio between the developed motor torque and the volume of the active parts [1]. This ratio is called an utilization factor and can be expressed as:

$$f_u = \frac{P^{'}}{D^2.l_\delta.\Omega}, \qquad (2)$$

where

f_u is utilization factor;

Ω is the angular velocity of the rotor, $[rad/s]$.

Another approach for estimation the technical level of each motor [1] is the determination of relative weight (m^*). This is the weight of motor per unit of motor volume.

Some cases occur, more frequently among motors with low power, when it is necessary the motor chosen to be insert in definite spaces of electric tools, kitchen and special appliances, etc. This necessitates, on the one hand, the chosen motor to be more compact, and on the other hand, as an object of operation to possess high reliability and energy indices, and to have comparatively low price.

As a specific case a comparison between three recently widely used motors such as asynchronous induction motor (AC), brushless DC motor with permanent magnets (BLPM) and brushless DC motor with reactive rotor (SR) was done [3, 4, 5]. The three mentioned above motors have identical overall dimensions and the same type of cooling. Their stators are made of one and the same kind of steel with equal external diameters and active lengths (Fig. 1).

All rest dimensions are optimized with the goal the use of copper wire for stator windings, electrical sheet steel, permanent magnets if they are put in motor construction and air gap to be relatively balanced.

In order the comparison to be fairly done and the selection to be made using catalogue data and price for each motor has been approached individually.
Using the above-mentioned equal initial dimensions the data generalized are represented in Tables I-III.

Analyzing the results presented the following conclusions can be made. AC, BLPM and SR generate 3,7 kW, 10,5 kW and 6,6 kW output power, respectively. Thus, BLPM and SR generate 2,84 and 1,78 times higher power, respectively, in respect to the power that AC generates at equal stator dimensions and current density. AC motor has the biggest volume of stator and rotor, but generates the smallest torque and lowest power per unit of active materials weight. The data analysis presents an advantage of BLPM first and then of SR. The last possesses very good energy characteristics (η = 92 %) and because of the lowest price of the materials used it is the cheapest. BLPM possesses excellent energy characteristics (η = 94%) and electromagnetic parameters. The last motor is the most compact but is 8,17 and 6,5 times cheaper than SR motor and AC motor, respectively.

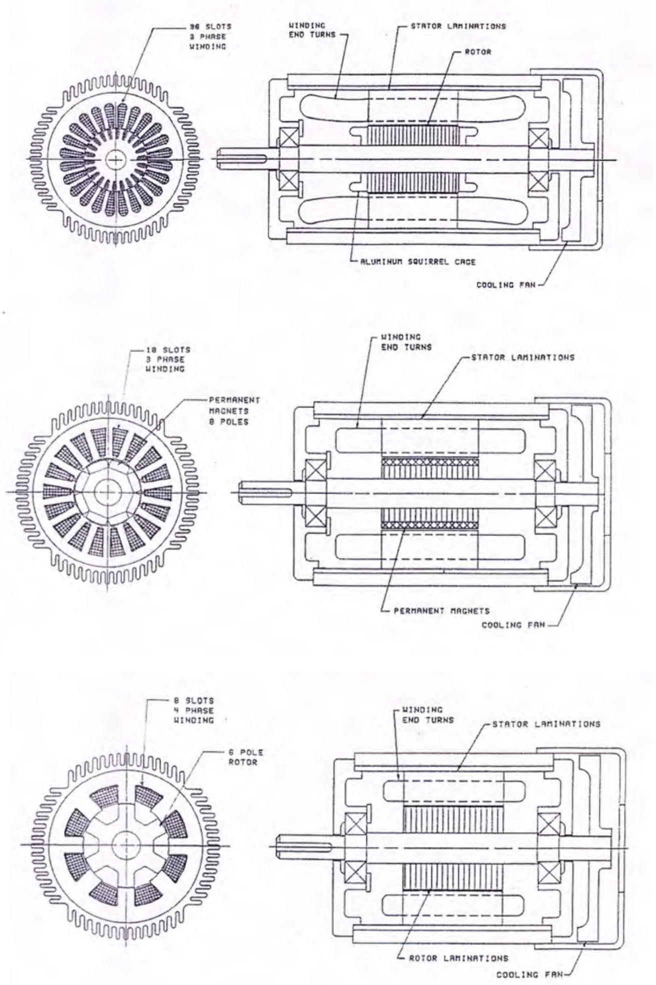

Fig. 1.

TABLE I

Motor type	Continuous torque (1800 rpm), Nm	Continuous power (1800 rpm), kW	η,%	Current density, A/mm^2
AC	19,78	3,7	90	7,8
BLPM	56,5	10,5	94	7,65
SR	36,6	6,6	92	7,7

TABLE II

Motor type	Stator		Rotor	Air gap, mm
	External diameter, mm	Internal diameter, mm	External diameter, mm	
AC	193,6	112,6	112,2	0,38
BLPM	193,6	96	95,6	0,38
SR	193,6	108,8	107,6	0,38

TABLE III

Motor type	m^*, kg/m	Torque per unit of weight, Nm/kg			Power per unit of weight, kW/kg		
		Rotor	Stator	Total	Rotor	Stator	Total
AC	4,04	2,31	1,35	0,9	0,43	0,25	0,2
BLPM	5,43	8,19	3,19	2,3	1,52	0,59	0,4
SR	5,18	5,3	2,57	1,7	0,98	0,48	0,3

III. CONCLUSION

Each of the motors considered has its peculiarities, which are defined by the selection of: electromagnetic materials; heat and mechanical loadings with reading the dynamic indices; use of permanent magnets; regime of regulation.

Recently the tendency is the optimal design of such motors to be orientated towards their weight minimization at optimal electromagnetic loadings and, investment of new materials and construction improvement .

The results illustrate an advantage of BLPM due to the use of highly energetic magnets (NdFeB, Sm-Co). This allows the device to be changed in principle. As a result the motor overall dimensions are reduced, the power per unit of active materials volume increases and the highest efficiency is considerably improved.

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