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COMPARED ANALYSIS OF LSPMSM AND SQUIRREL-CAGE MOTOR EXPLOITATION WITH VARIABLE ROTATIONAL SPEED

ANALIZA PORÓWNAWCZA SILNIKÓW SYNCHRONICZNEGO MAGNETOELEKTRYCZNEGO O ROZRUCHU WŁASNYM I INDUKCYJNEGO PRACUJĄCYCH Z REGULOWANĄ PRĘDKOŚCIĄ

Abstract

In this paper, the steady-states operation of a line start permanent magnet synchronous motor (LSPMSM) and a squirrel-cage motor have been compared. The stator of a Sg 100L-4B type, 3 kW induction motor, was used in both structures. The squirrel cage in the rotor of the LSPMSM is made from copper. The influence of the frequency change of the supply voltage on the motor's efficiency and current as well as the power factor has been examined.

Keywords: *permanent magnet synchronous motor*, *asynchronous motor*, *power factor*, *efficiency*, *variable rotational speed*

Streszczenie

W artykule porównano pracę w stanie ustalonym dwóch silników: synchronicznego magnetoelektrycznego z klatką rozruchową (LSPMSM) oraz indukcyjnego klatkowego (IM). W obu konstrukcjach wykorzystano stojan silnika indukcyjnego typu Sg 100L-4B o mocy 3 kW. W silniku synchronicznym zastosowano klatkę rozruchową wykonaną z miedzi. Zbadano wpływ zmiany częstotliwości napięcia zasilającego oba silniki na sprawność, współczynnik mocy i prąd pobierany z sieci.

Słowa kluczowe: *silnik synchroniczny magnetoelektryczny*, *silnik indukcyjny*, *współczynnik mocy*, *sprawność*, *regulowana prędkość obrotowa*

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1. Introduction

In order to reduce the operating costs of electric drives, induction motors are more frequently being replaced with permanent-magnet synchronous motors (PMSM), which with the same dimensions, provide a greater power efficiency and power factor [10]. In recent years, many interesting structures of these motors have been developed i.e. with a surface mounted permanent magnet [7, 9]. A disadvantage of the PMSM is that it necessitates the use of power converters during start-up, which increases the total cost of the drive. This cost can be minimized by using a synchronous motor adapted to start when directly connected to the supply voltage (Line Start Permanent Magnet Synchronous Motors – LSPMSM). Studies on this type of motor have been conducted in many research centers [3, 4, 6, 8].

This paper presents the results of the analysis of selected power parameters. The effects of changes in the motor's speed: permanent magnet synchronous and squirrel-cage induction motors on efficiency, power factor and current in the stator windings were tested. Changes in rotor speed were achieved by supplying the motors with an adjustable frequency.

The present paper is a continuation of the work carried out by the authors on the development of a new construction and testing of the LSPMSM [1, 2, 5].

2. Structure of examined motors

A squirrel-cage motor (IM) and line start permanent magnet synchronous motor were tested. In the considered constructions, the stator and frame of a 4 pole, Sg 100L-4B type, 3 kW induction motor, were used. The rated line to line supply voltage of the base IM was equal to 400 V (star connection) and the nominal speed was equal to 1415 rpm. The stator consisted of 36 slots and was wound with a single layer 3 phase winding. The rotor cage had 28 bars manufactured from aluminium (Fig. 1a). In the rotor of the LSPMSM, the bars were placed over a *U* arrangement of N42SH magnets embedded into the laminated rotor core (Fig. 1b).

Figure 2 shows the complete structure of both of the rotors of the considered motors.

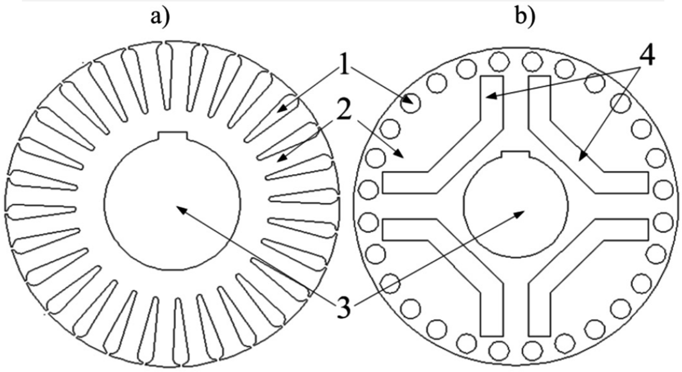

Fig. 1. The structures of rotors: a) IM, b) LSPMSM
(1 – rotor bars, 2 – rotor core, 3 – shaft, 4 – magnets)

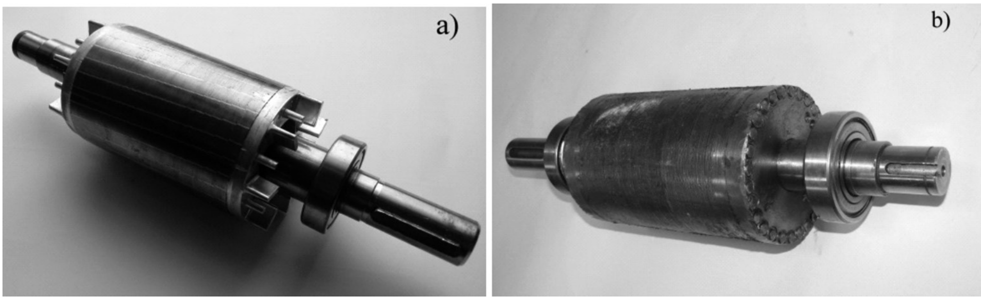

Fig. 2. Rotor of a) squirrel-cage motor and b) LSPMSM with a squirrel-cage manufactured from copper

3. Results

Measurements were performed by supplying the motors with an adjustable frequency, while maintaining the condition *U*/*f* = const. The influence of the load torque on the motor efficiency η, power factor cosφ as well as phase current *I* were examined. The results for the selected frequencies for the IM and the LSPMS motor are shown in Figs. 3 and 4 respectively.

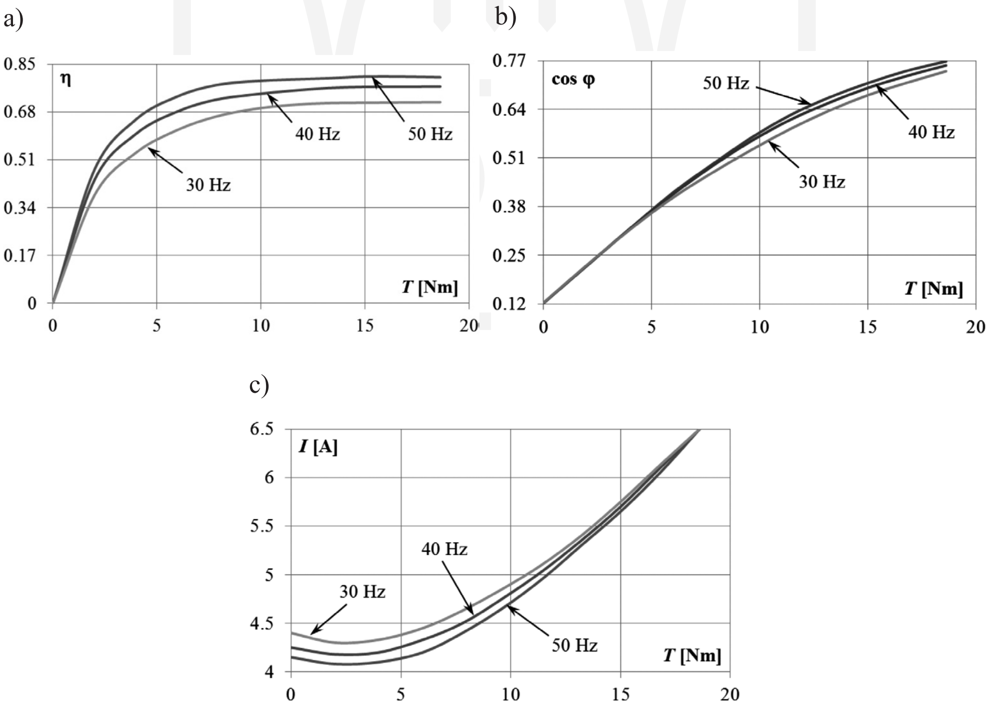

Fig. 3. Efficiency (a), power factor (b) and phase current (c) vs. load torque of the IM

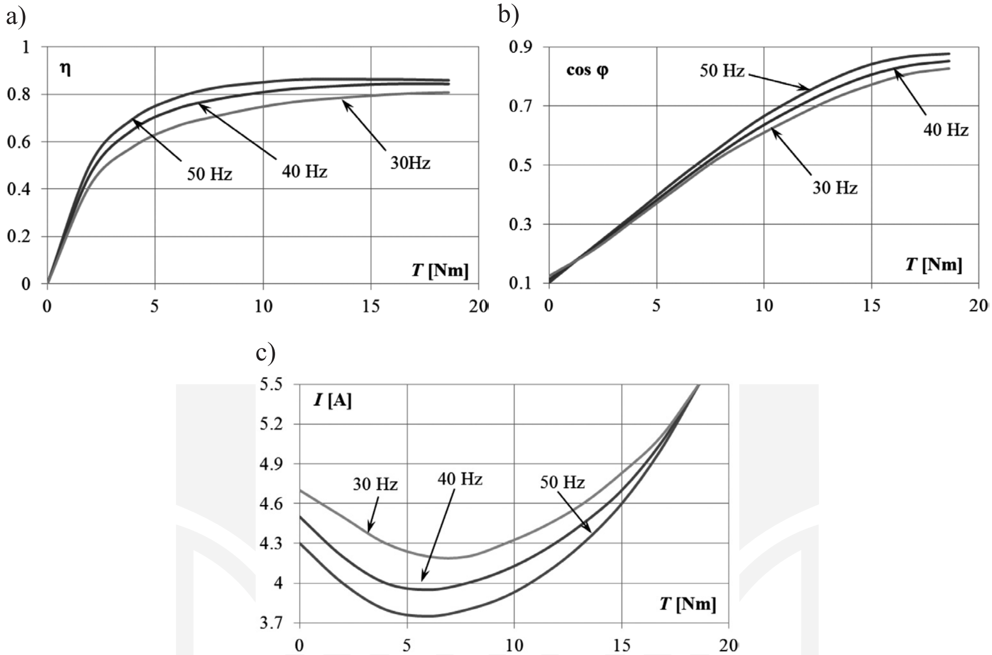

Fig. 4. Efficiency (a), power factor (b) and phase current (c) vs. load torque of the LSPMSM

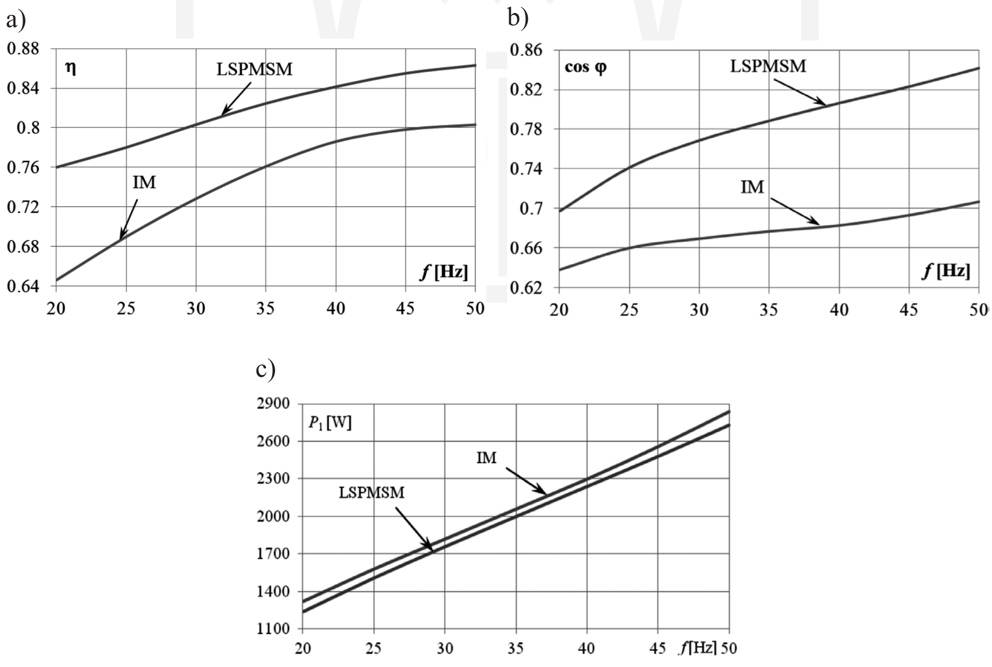

Fig. 5. Efficiency (a), power factor (b) and input power (c) vs. load torque of the IM as well as the LSPMSM

Measurements were also performed for motors supplied with an adjustable frequency at a constant load torque of T = 15 Nm. The influence of the frequency changes on the motor efficiency η, power factor cosφ as well as the input power P_1 is presented in Fig. 5. In order to compare the obtained functional parameters of both the considered motors in these operating conditions, the values of efficiency, power factor, currents in stator winding and useful power P_u are summarized in Table 1.

Table 1

Selected functional parameters in the steady state obtained during laboratory tests at *T* = 15 Nm and selected frequencies

Parameters	IM			LSPMSM		
	30 Hz	40 Hz	50 Hz	30 Hz	40 Hz	50 Hz
η [-]	0.728	0.786	0.803	0.803	0.842	0.863
cosφ [-]	0.669	0.683	0.707	0.769	0.806	0.842
I [A]	5.7	5.7	5.7	4.8	4.7	4.6
P_u [W]	1325	1808	2280	1414	1885	2356

4. Conclusions

The effective parameters of the LSPMSM are better than those of the induction motor. The power factor and efficiency of a motor with permanent magnets are significantly higher than those obtained from the induction motor. These parameters increase in both structures along with an increase in frequency. The effective current value of the LSPMSM in a steady--state with a load torque of over 10 Nm is also lower by approx. 10–20 % than that of the induction motor for the same load of both machines.

Based on the obtained results of the research, it can be concluded that synchronous motors with permanent magnets exhibit higher efficiency and higher power than induction motors. It has been shown that they can successfully replace induction motors as drive systems with frequency control. For this reason, this type of machinery should be implemented for production and operation.

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