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Efficiency Optimisation of Single Phase Motor Using GA Approach

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Abstract ***In this paper Genetic Algorithm for efficiency optimisation of single phase shaded pole motor is implemented. For this purpose an extensive mathematical model of the motor is developed. The efficiency of the motor as an objective function of the optimisation is selected. The optimisation process is performed for different set of optimisation parameters (three, four and five variables). The prototype as well as the optimised motor models afterwards are modelled and analysed using Finite Element Method. An analysis of the magnetic field distribution, as well as flux density values, in the whole cross-sectional area of all models has been performed in order to validate the improvements of the optimised models in relation to the basic motor model.***

1 Introduction

Induction motors are widely used in industry since they are rugged inexpensive and maintenance free. It is estimated that more than 50 % of the world generated electric energy is consumed by electrical machines. Improving efficiency in electrical motors is important from economical point of view, as well as from the point of reduction of environmental pollution [1]. Single phase shaded pole motor belongs to the most widespread single phase motors, due to robust and reliable construction and low production costs, although its operational characteristics are not its strong side. Here are some common figures for this type of motor: efficiency η (0.25÷0.4) and power factor $\cos\varphi$ (0.4÷0.6). Very important feature about this type of single phase motor is that the locked rotor current has a very close value to rated current meaning that motor is capable of sustaining overload or full load at locked rotor position which makes it irreplaceable driving force, especially in applications where a large starting torque is not required. In this paper the authors propose a methodology for improving the efficiency of this type of motor using Genetic Algorithm (GA) as an optimisation tool in the optimal design of AKO-16 motor, which is a product of MicronTech company. Firstly, an analytical model of the motor is developed based on the revolving field theory and current symmetrical components. The analytical model accuracy is verified using experimental and manufacturer test data. After the GA optimisation the basic motor model (BM) three motor models, where the first motor model is optimised with three variables (M1), where the second (M2) and third motor (M3) model is optimised with four and five variables, respectively, are gained. The aim of the GA optimisation is to maximise the efficiency of the motor, which is the objective function of the optimisation. The evaluation of all motor models is done using the Finite Element Method (FEM) analysis.

2 GA method results

Defining the input variables of the analytical motor model is the first step in the GA programming. In Table 1 the ranges of variation of the input variables for all motor models as well their values after the optimisation are presented. Optimisation is performed for rated operating point for motor slip s=0.16.

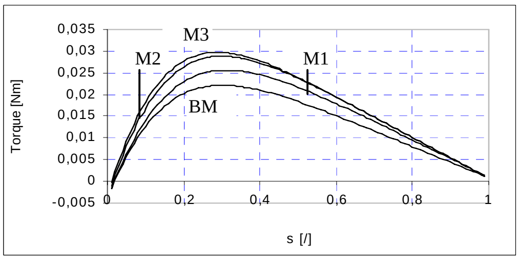
Table 1. Ranges of variation of GA parameters

	BM	Variation range	M1 output	M2 output	M3 output
Curr. density. Δ[A/mm^2]	8	5 ÷ 10	5.17	5.045	5
Magnetic induction B_δ[T]	0,404	0.4 ÷ 0.45	0.40035	0.40035	0.4
Angle of rotor skew α_{sk} [°]	17	15 ÷ 20	15.025	15.008	15.0035
Width of stator pole b_p [m]	0,016	b_p=0.012 ÷ 0.02	0.016=const	0.016=const	0.012
Shading portion of stator pole a [/]	0,25	a=0.2 ÷ 0.4	0.25=const	0.2	0.2

The obtained parameters from the GA optimisation afterwards are used for calculation of motor parameters and characteristics for all motor models. Some of them are presented in Table 2.

Table 2. Motor models characteristics

Quantity	BM	M1	M2	M3	Experim.	Producer
Stator current I_1 [A]	0.126	0.131	0.128	0.1235	0.129	0.11±10%
Power factor cosφ [/]	0.654	0.59224	0.6283	0.643	0.667	0.6376
Input power P_1 [W]	18.11	17.14	17.74	17.46	19.1	16±10%
Output power P_2 [W]	4.149	4.73	5.61	6	/	/
Torque M_{em} [mNm]	18.075	20.28	23.6	25.1	/	/
Efficiency factor η [/]	0.229	0.276	0.31	0.35	/	/



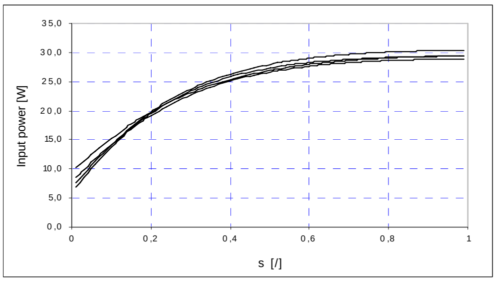


Fig.2. Characteristics of input power

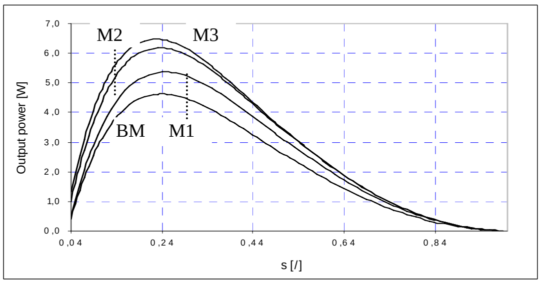


Fig.3. Characteristics of output power

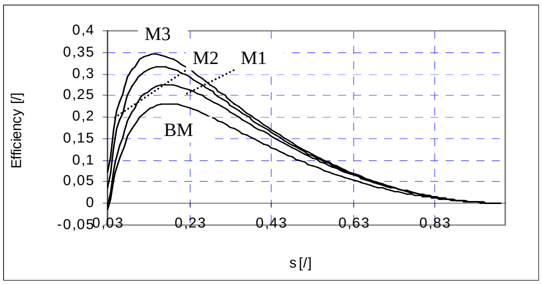


Fig.4.Characteristics of efficiency factor

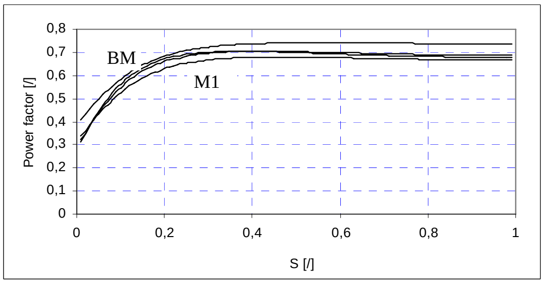


Fig.5.Characteristics of power factor

Compared to authors previous work [2], in this case when the efficiency is adopted as objective function of the optimisation the increase of the efficiency is achieved by increasing the motor output power without increasing the motor power consumption, for the same value of the power factor for rated operational point which is important for the energy savings. The small modifications in the motor construction contributed in the increase of the motor output power, as well as improved motor efficiency.

3 FE method results

The magnetic field distribution in the motor cross section for all motor models for rated operation point, as well as for no load and locked rotor is obtained by using FEM approach. In Fig.6 the magnetic field distribution is presented for rated operational point for BM and M3.

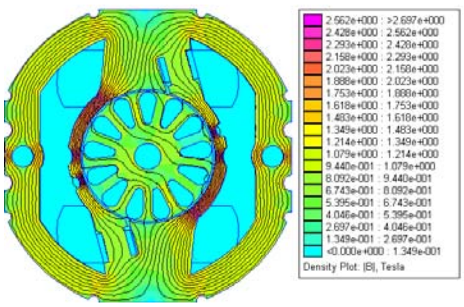


Fig.6.Magnetic flux distribution for BM

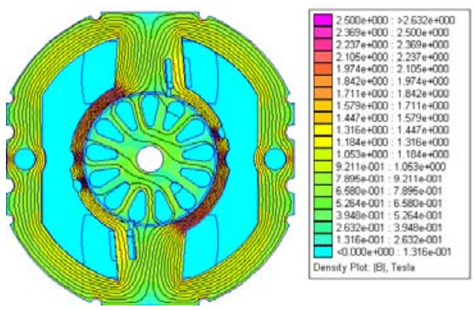


Fig.7.Magnetic flux distribution for M3

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[2] V. Sarac, G. Cvetkovski, ”Different Motor Models Based on Parameter Variation Using Method of Genetic Algorithms”, *Journal Przeglad Electrotechniczn* , **87**, NR 3/2011, pp.