POZNAN UNIVERSITY OF TECHNOLOGY ACADEMIC JOURNALS
No 72 Electrical Engineering 2012

Mohammed H. MOHAMMED*

OPTIMIZATION THE DYNAMICAL PARAMETERS OF THREE PHASE INDUCTION MOTOR USING GENETIC ALGORITHM

This paper deals with the optimization of the induction motor design with respect to torque as a dynamical parameter. Most studies on the design of an induction motor using optimization techniques are concerned with the minimization of the motor cost and describe the optimization technique that was employed, giving the results of a single (or several) optimal design(s).Procedure includes the relationship between torque of motor and other effects as they occur in an optimal design. The optimization method that was used in this paper is Differential Evolution as genetic algorithm. Optimal results are in picture as curves or in tabula.

1. OPTIMIZATION METHOD

1.1. Summary technical description

Differential Evolution (DE). is one of the best type genetic algorithms for solving problems with the real valued variables. In DE, each variable's value is represented by a real number. The best features of DE are its simple structure, ease of use, speed and robustness. May be defined as a design tool of great utility that is immediately accessible for practical applications. Moreover can be used in several science and engineering applications to discover effective solutions to nearly intractable problems without appealing to expert knowledge or complex design algorithms. If a system is amenable to being rationally evaluated, DE can provide the means for extracting the best possible performance from it. Differential Evolution uses mutation as a search mechanism and selection to direct the search toward the prospective regions in the feasible region. Genetic Algorithms generate a sequence of populations by using selection mechanisms. While Genetic Algorithms use crossover and mutation as search mechanisms. The principal difference between Genetic Algorithms and Differential Evolution is that Genetic Algorithms rely on crossover, a mechanism of probabilistic and useful exchange of

---

* Brno University of Technology.

information among solutions to locate better solutions, while evolutionary strategies use mutation as the primary search mechanism.

1.2 Parameters of tested motor

Made by: SIEMENS Electric motor
induction motor type:1LA7083-2AA
P_n = 1100W, n_n = 2845 ot. /min, p_p = 1, f_n = 50 Hz, M_n = 3,6905 Nm,
J_m = 0, 0085kgm^2,
U_{sn} = 400 V efective value – star conection,
I_{sn} = 2,4A efective value of current,
R_s = 12.578 Ω stator resestance per phase,
R_r =12.578 Ω rotor resestance per phase,
L_h = 0,4513 H main inductance,
$L_{s\sigma}$ = 0,02783 H leakage inductance of stator,
$L_{r\sigma}$ = 0,02783 Hleakage inductance of stator.

1.3. Equivalent circuit of motor

Approximate equivalent circuit of deep par three phase induction motor without core loss resistance is shown below in Fig. 1.

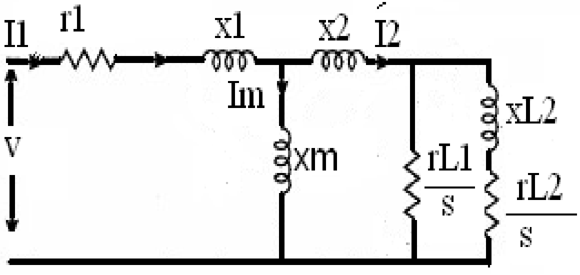

Fig. 1. Equivalent circuit of tesed motor

The equivalent circuits as in Fig. 1 can be represented the steady state behavior of a three-phase induction motor (Rc) is ignored: core loss resistance, where:
R1 : stator resistance,
X1 : stator leakage reactance,
Xm : magnetizing reactance,
rL1 : rotor resistance referred to stator,
rL2: paralel rotor resistance referred to stator,
X2 : rotor leakage reactance referred to stator,
XL2 : paralel rotor leakage reactance referred to stator,
s: slip.

Table 1. The results of measurements of motor parameters

Lp	Speed	Torque	Slip	Current	PF	Efficincy	Voltage
	Rpm	N.m		A		%	V
1	2399	7,848	0,2003333	6,047	0,9385	0,505434	398,49
2	2580,4	7,3575	0,1398667	5,078	0,9341	0,608979	398,79
3	2655,6	6,867	0,1148	4,598	0,9294	0,649261	398,57
4	2702,6	6,3765	0,09913333	4,208	0,9249	0,672523	399,46
5	2743,3	5,886	0,08556667	3,822	0,919	0,698466	399,35
6	2773,6	5,3955	0,07546667	3,502	0,9119	0,712557	398,79
7	2803,7	4,905	0,06543333	3,205	0,9016	0,722409	399,64
8	2831,7	4,4145	0,05 61	2,911	0,8874	0,733035	400,47
9	2854,7	3,924	0,04843333	2,638	0,8705	0,739491	400,11
10	2876,4	3,4335	0,04 12	2,386	0,8467	0,741167	400,11
11	2897,2	2,943	0,03426667	2,161	0,8162	0,733319	399,88
12	2916,4	2,4525	0,02 7866	1,936	0,7722	0,725499	400,03
13	2932,9	1,962	0,02236667	1,752	0,7129	0,697932	400,42
14	2953,2	1,4715	1,56	1,571	0,6159	0,679519	400,72
15	2967,8	0,981	0,01073333	1,453	0,5111	0,593041	400,97
16	2996,5	0,0981	0,0116667	1,333	0,2286	0,145891	401

1.4 Parameters optimazition from motor test using equivalent circuit

The parameters of equivalent circuit obr(1) can be estimated by using the measured data of motor test coupled with genetic algorithm(DE). The idea for estimating the equivalent circuit parameters proceeds as follows. From test of motor, only 4 sets of data of motor input voltage, current, power factor (or torque if possible) and speed, which need not be close to no-load or full-load values, are directly measured while the motor is in service. The stator winding resistance $R1$ which is obtained from resistance measurements is also included. However, it remains inconvenient to measure the shaft torque in the field.For this reason, the motor input power factor data is then proposed in this technique. Then these test data sets are determined in the optimization process. After optimization process, the parameters of equivalent circuit can be obtained and finally, the operating. The objektive function of motor can be represented by the values of power factor, current and efficincy all values(meatured and calculated).

$$F_{obj} = \sum_{i=1}^{m} \left| \left(\frac{I_{(eval)}}{I_{meas}} - 1\right)^2 \right| + \sum_{i=1}^{m} \left| \left(\frac{\cos\varphi_{(eval)}}{\cos\varphi_{meas}} - 1\right)^2 + \sum_{i=1}^{m} \right\| \left(\frac{\eta_{(eval)}}{\eta_{meas}} - 1\right)^2 \right| \qquad (1)$$

where $I_{(eval)}$, $\cos\varphi_{(eval)}$, $\eta_{(eval)}$ are the calculated values, m – number of measurement.

For optimaziton motor torque did repeated above cycle only objektive function as follows.

$$F_{obj} = \sum_{i=1}^{m} \left| \left(\frac{M_{(eval)}}{M_{meas}} - 1 \right)^2 \right| \tag{2}$$

From test of motor , only 3sets of data of motor input voltage, torque and speed slip are obtained from measurements is also included.The results of optimazition equivalent circuit parameters of motor are reperesented in Table 2 and as curves shown bellow:

Table 2. Best parameter set returned by function differential evolution:

Lp.	r1	rL1	rL2	x1	x2	xL2	Xm
	Ω	Ω	Ω	Ω	Ω	Ω	Ω
1.	13.330	16.53	5.38	1	25.81	1	176

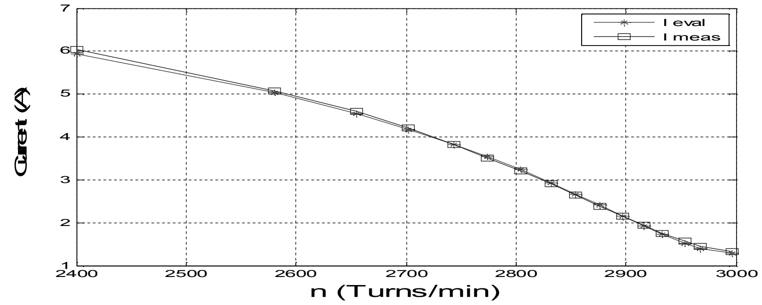

Fig. 2. Input current

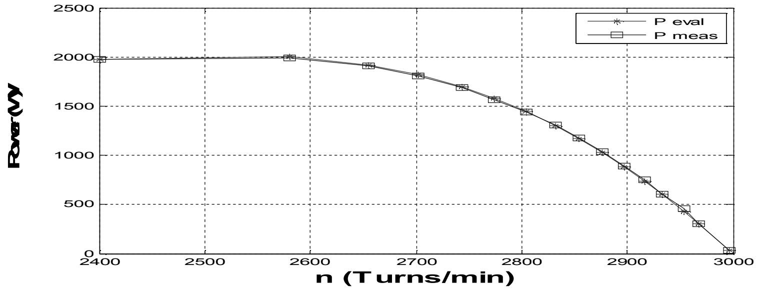

Fig. 3. Output power

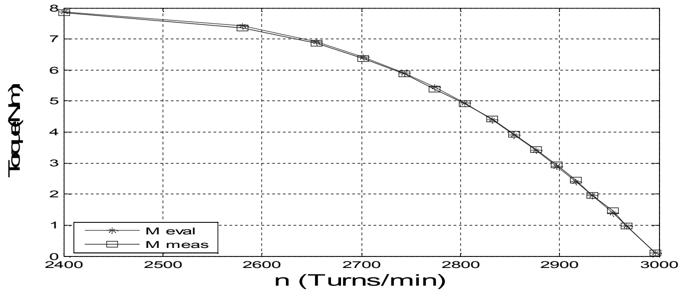

Fig. 4. Output torque

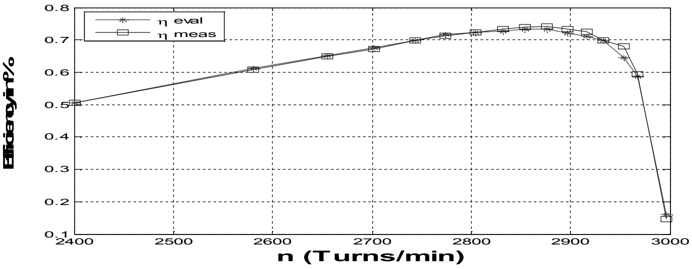

Fig. 5. Efficiency motor

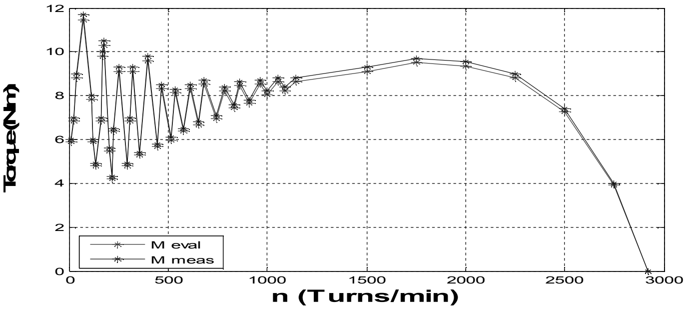

Fig. 6. Complete characteristic including run-up motor torque

2. CONCLUSIONS

This paper has presented, appliction of (genetic algorithms) (DE) used in electrical machine optimization and also the important results of a part of the research work carried out has been presented. Optimization techniques coupled GA will result in best results in the design.

REFERENCES

[1] IEEE Standard Test Procedure for Polyphase Induction Motor and Generators, IEEE Standard 112-1996, New York, May 1997.

[2] J. S. Hsu, J. D. Kueck, M. Olszewski, D. A. Casada, P. J. Otaduy, and L.M. Tolbert, "Comparison of induction motor field efficiency evaluation methods," IEEE Transactions on Industry Appli., vol. 34, issue:1, pp.117-125, Jan./Feb. 1998.

[3] F. Alonge, F D'Ippolito, G. Ferrante and F.M. Raimondi, "Parameter identification of induction motor model using genetic algorithms", IEE Proc.,Control Theory Appl., vol. 145, no. 6, pp. 587-593, Nov. 1998.

[4] T. Phumiphak, and C. Chat-uthai,Estimation of Induction Motor Parameters Based on Field Test Coupled with Genetic Algorithm. Dec. 2002.

[5] Vasan Arunachalam,Optimization Using Differential Evolution, The University Of Western Ontario, London, Ontario, CanadaISSN: (print) 1913-3200; (online) 1913-3219; ISBN: (print) 978-0-7714-2689-6; (online) 978-0-7714-2690-2;July 2008.

[6] RNDr. Jaroslav, Mgr. ,Genetic algorithms and their application in practice, 2005.