Simulation and Optimization of asynchronous AC motor control by Particle Swarm Optimization (PSO) and Emperor Algorithm

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***Abstract*—In the present paper, the simulation and optimization of asynchronous AC motor through its controlling and modeling by convert d-q with Simulink of Matlab Software has been studied. By utilization of classic PI controller and also with phase controller has been optimized which membership function center of it has been optimized by new intelligent algorithms such as Emperor and PSO. The obtained results show that obtaining phase points by new intelligent controllers such as Emperor and PSO ones have better results than classic PID and fuzzy controllers. In fact the results of experiments show that the error of Emperor Algorithm is lower than PSO. Thus the emperor algorithm optimizes membership function centers of phase controllers better than PSO one. Simulation is implemented in Matlab Simulink.**

Keywords-Simulationt and Modelling; AC motor; PSO Algorithm; Emperor Algorithm

I. INTRODUCTION

The inductive motor is utilized more in industries because of solidity, reliability, low weight, mass and labor, higher rate, commutation problems and demand for service and finally low inertia of rotor than DC motor. And its advantage than synchronous motor is that in synchronous, rotor should fed on DC. It demands for starter circuit to reach speed of synchronous. All of these advantage caused the high usage of inductive motor than Dc one and synchronous. The sample of induction motor circuit is seen in figure 1 [1, 2].

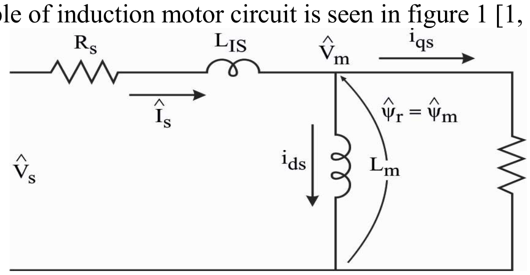

Figure 1. Induction motor equates circuit.

The simulation of 3-phase inductive motor control by 9 inverters which causes to decreased harmonic because of low consumption current and voltage of inductive motor, thus in these method, the produced harmonic is very lower than classic one. In the present paper, we try to control speed of inductive motor optimally. In general some cases has been explained as follows: 1) Discussion on asynchronous AC motor controlling and simulation of rotor motion in AC motor and effect of magnetic resistance and induction coefficient by control (Thus, the practical sample which has been conducted with IC TMS 20F2812 by software model is similar [1]. 2) review of an evaporator MIMO by PID controller [3, 4, 5 ,6] and phase controller coefficient set by PSO algorithm and Emperor one and better results of Emperor algorithm then PSO and Zicler Nicolz method.

II. RELATED WORKED

A. *Inductive motor control by fuzzy controller with PSO algorithm[7, 8, 9, 10]*

Primarily PSO was posed by Kennedy and Eberhart which is one of revolution calculations techniques and population-based optimization method on 1995. The PSO has been inspired by birds or fish group. The scientists found that coordination of birds group behavior has direct relation with maintaining optimal distance between members and neighborhood. The scientists found that members determine their speed based on 2 certain factors in order to find food by simulation of birds search scenario for food and observing their social behaviors: Their mot better previous experience and neighborhood's. This work is similar with behavior of humans in decision–making. In real, the PSO integrates local search techniques' (by experience of member) and general search methods (by experience of neighborhoods) to reach general optimality.

Thus, general formula of PSO algorithm depends on two factors i.e. speed and location change of any member. The speed and location change formula of any member is based on equations (1) and (2) which are as follows []:

$$V_t^d\,(t+1)= V_t^d\,(t)+c_1r_{1,i}^d\,(t)(P_i^d\,(t)- X_i^d\,(t))+ c_2r_{2,i}^d\,(t)(P_t^d\,(t)- X_i^d\,(t)) \quad (1)$$

$$X_i^d\,(t+1)= X_i^d\,(t)+ V_i^d\,(t+1) \quad (2)$$

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This algorithm has been utilized to control of induction motor control by optimization of phase control membership centers. In the following figure, the view of induction motor speed control is observed by PSO algorithm.

B. Dynamic modeling and induction motor control[11, 12, 13, 14]

In summary, one of most current equations which are used to simulate of inductive motor is cross model. This model has been written based on the flux which is seen as formules of (3) to (6).

$$\frac{dF_{qs}}{dt} = \omega_b \left\{ v_{qs} - \frac{\omega_e}{\omega_b} F_{ds} + \frac{R_s}{x_{ls}} (F_{mq} + F_{qs}) \right\} \tag{3}$$

$$\frac{dF_{ds}}{dt} = \omega_b \left\{ v_{ds} + \frac{\omega_e}{\omega_b} F_{qs} + \frac{R_s}{x_{ls}} (F_{md} + F_{ds}) \right\} \tag{4}$$

$$\frac{dF_{qr}}{dt} = \omega_b \left\{ v_{qr} - \frac{(\omega_e - \omega_r)}{\omega_b} F_{dr} + \frac{R_r}{x_{lr}} (F_{mq} - F_{qr}) \right\} \tag{5}$$

$$\frac{dF_{dr}}{dt} = \omega_b \left\{ v_{dr} + \frac{(\omega_e - \omega_r)}{\omega_b} F_{dr} + \frac{R_r}{x_{lr}} (F_{md} - F_{dr}) \right\} \tag{6}$$

In general, the circuit of d-q dynamic model with inductive motor is seen in figure 2.

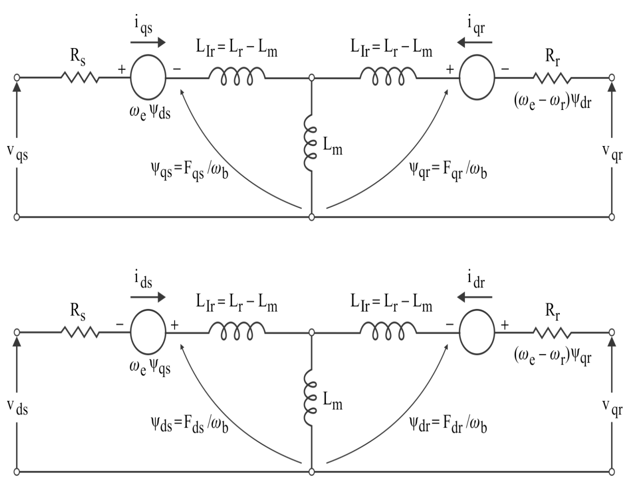

Figure 2. d-q dynamic model circuit with inductive motor.

The input of an inductive motor of squirrel cage is 3-phase voltage, frequencies and load torque. Its output is 3-phases current, electrical torque and rotor speed. The d-q model of inductive motor demands for 3-phase variables conversion to round 2-phase source. The inductive motor model of squirrel cage has two black of convert 3-phase voltage to 2-phase and 3-phase current to 2-phase one in addition to d-q block. Among the works could state is one diagram block of direct controlling by voltage feed source PWM which is seen in the figure 3. In summary, the difference of direct and indirect control relates to how produce single vectors. In direct method, the single vectors is produced by using of flux signals but in indirect one is calculated by rotor speed signal and slip frequency.

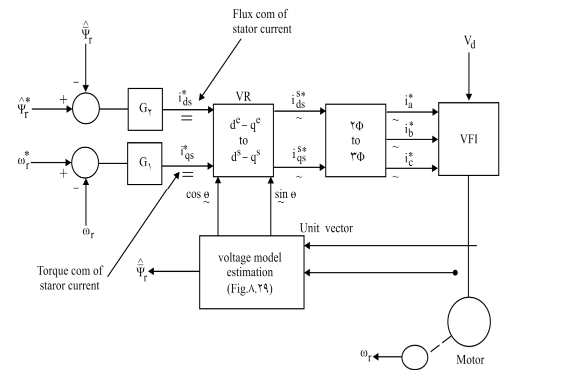

Figure 3. Direct controlling by rotor flux orientation.

The indirect controlling works better on 4 area of speed torque, this system runs better in low and about zero speeds. In this method, there isn't harmonic problem; the main problem of this method is change of machine parameters which causes to disruption in approximation of source slip that leads to disruption of system from controlling situation. The view of indirect controlling remodeling is seen in figure 4.

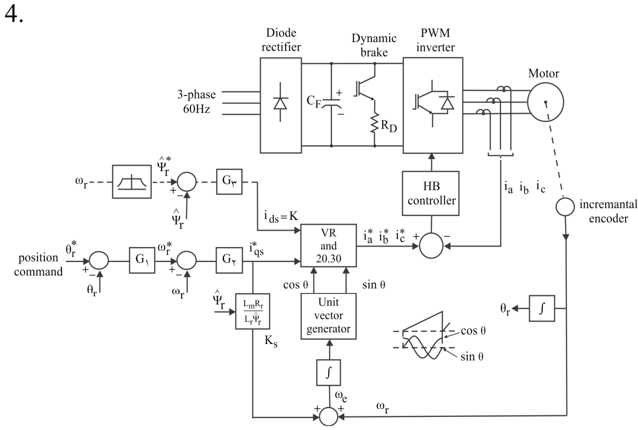

Figure 4. Indirect controlling demodulation.

In both direct and indirect controlling method which an inverter has utilized in controlled current situation, also in controlling, the indirect and direct controlling method has been discussed, because of advantages which the indirect control such as sensors out of motor which isn't bulky and isn't sensitive to temperature, usually in running controlling, the indirect controlling is used comparison of scalar control and control.

In various methods, the scalar control, voltage and/or current with frequency are of inductive motor controller variables. In this state, torque and flux are dependent on voltage or current and frequency. Thus, it has mutual effect an each other and causes to slowness of induction motor response to signal changes of input source. If we use flux control coil, the response of system, under these conditions is fluctuating and it's position time also will increase [15, 16].

But in controlling method, there is possible for separate control of torque and flux and could control inductive motor such as independent simulation motor.

C. The direct and indirect control comparson[15, 16]

In the direct control, the angle Θ_e is calculated as aerial distance flux, but in indirect one, the rotor angle is calculated by measuring alternate values such as slip speed. The direct control method is based on aerial (overhead) distance flux by using of search coils or Hall Effect sensors. But, in indirect controlling, the in hall and/or tachometer sensor is used. In low frequencies, the integral deviation related to search coils, causes problems. The Hall Effect sensors are sensitive to temperature. But encoder sensor doesn't have these problems. The indirect control method works well in lower speeds. Because of suitable characteristics, we demodulated indirect control of inductive motor.

III. Proposed Method

Figure 5 and 6 show Emperor Algorithm flowchart. This algorithm similar to other revolution algorithms, starts with same random primary population which any of the is called country. Some of better population elements is selected as imperialist (equals to elites in genetic algorithm). The reminder of population is considered as colony. The colonialists based on their power attract these colonies with a special trend. The total power of any emperor depends an it's two constituent parts i.e. imperialist (central care) and it's colonies. In mathematics, this dependence has been modeled by description of emperor power as total power of imperialist country along with percentage of mean power of its colonies. By forming primary emperors, the imperialist competition between then is initialized. Any emperor, who couldn't act successfully in colonial competition and add its power, will be eliminated from colonial competition area. Thus, the survival of one emperor will depend on its power in attraction of apparent empires colonies and dominance of them. In conclusion, in imperialist competitions flow, gradually the power of elder emperor will increase and the weakest empires eliminated. The empires in order to increase their power should improve colonies of self [17].

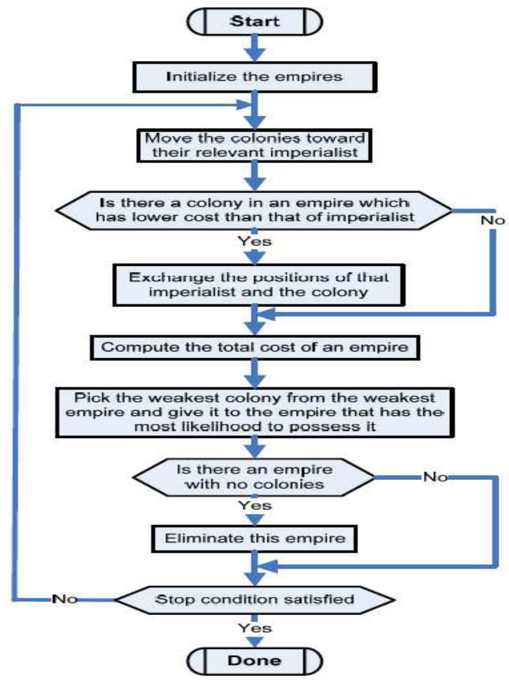

Figure 5. Emperor algorithm flowchart (sequence).

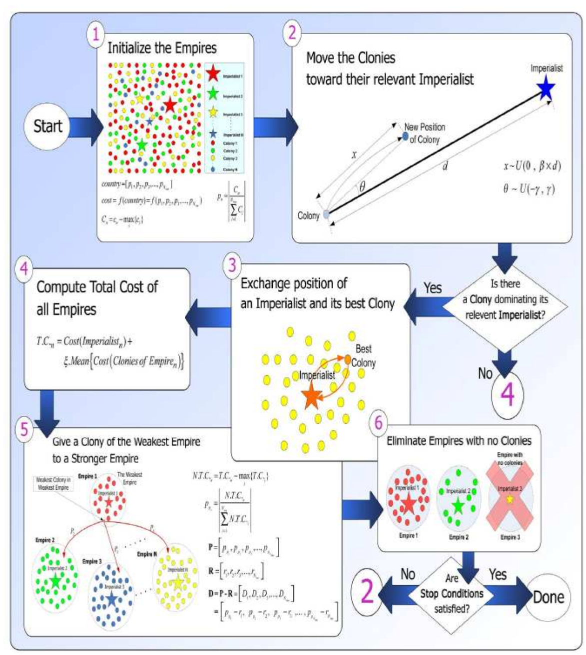

Figure 6. Emperor algorithm flowchart .

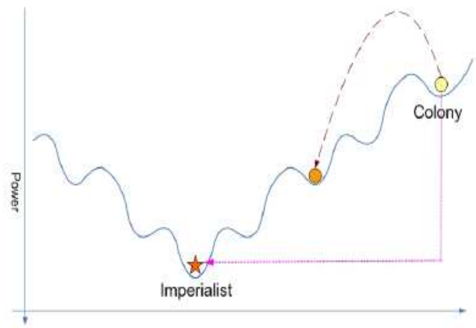

Figure 7. Attraction policy impasition by colonialists on colonies.

With time, the colonies will approach to empires from respect of power and we would observe a convergence. The final limit of colonial competition is while we have a single empire in the world, or the colonies which are very similar with imperialist country. The general view of algorithm has been showed in the following figure graphically. Based on this figure, the algorithm with random primary population and forming primary empires is initialized and repeated in attraction policy and imperialist competition. In order to better understand and learning of emperor algorithm, you could refer to papers. In this paper, the inductive motor control is conducted by fuzzy controller. The optimization of fuzzy and de-fuzzy membership function centers of gravity is run to minimize error by Emperor Algorithm.

IV. Simulation and Results

First stimulation of induction motor is demodulation in Matlab Simulink by related equation to inductive motor figure 8.

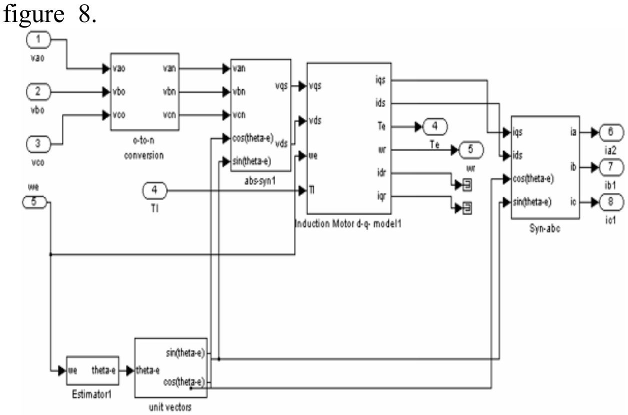

Figure 8. Induction motor modulation with simulink.

Figure 9 shows complete demodulation of inductive motor the equations of motor are calculated in 4 stages in the first stage the flux of stator and rotor is calculated that could use in motor flux control loop. Then d-g the flux mutual is calculated and by using of calculated data the currents of rotor and stator and finally electrical torque and by using of electrical torque and imposed load the speed of rotor is calculated.

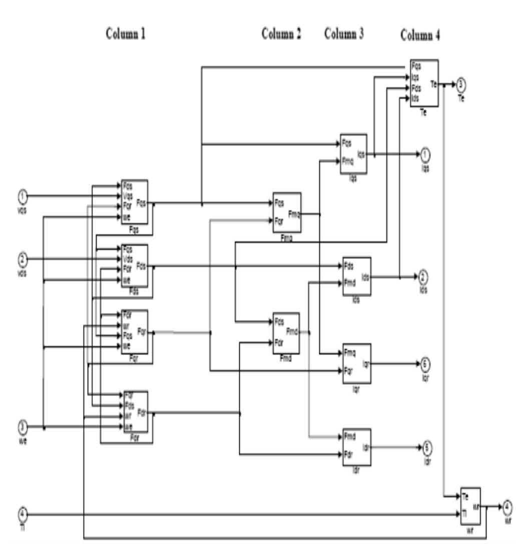

Figure 9. Complete demodulationof in duction motor.

We take feedback from rotors speed in order to solve previous equations and use output of this block in order to utilize in controlling to calculate Θ_e and in fuzzy control to measure error and error changes. And also we use torque and speed to calculate electrical calculation modulation parameters of PI controller in control. In order to modulate KP and KI coefficients in controllers which is used in controlling situation, firstly by selection of very low value of integrator coefficient, we promote rise with time. Then if error is permanent with increased integral coefficient, we alleviate permanent error. But if error isn't permanent in the neat step as increasing perturbation rate which is load torque, the source rate will drop in this step as increasing boot rate of integral, we promote permanent error.

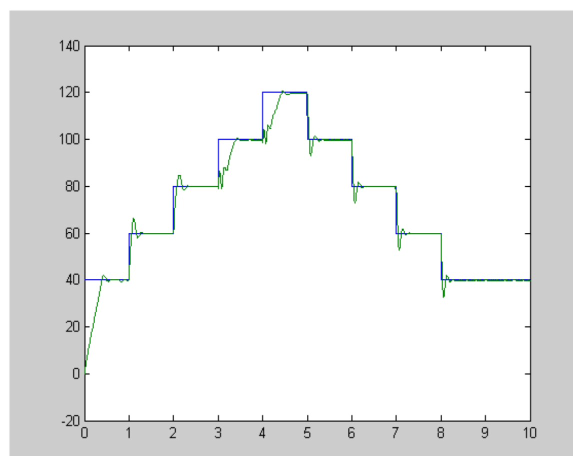

Figure 10. Rate output of PI controller with load exertion.

We observe in the figure that it has error in normal situation and with exertion of bad error increased and motor destabilizes and the form of current interrupts. For this reason, we control its fuzzy controller. As is clear in the figure, there is some perturbation while rate change (figure 11).

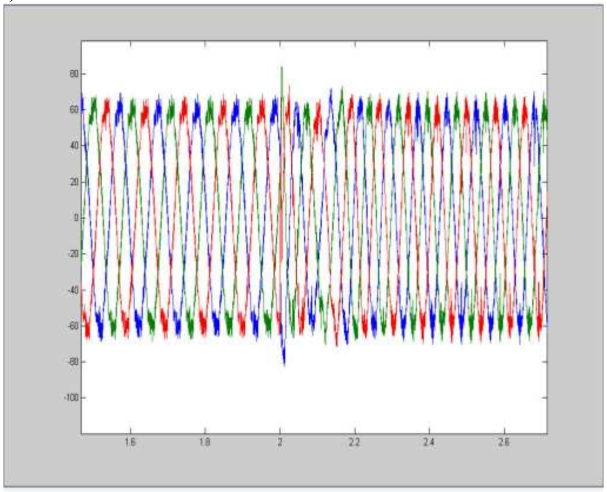

Figure 11. Output current.

A. *Phase controller*

The fuzzy control has two error input and error derivation which the first input has five rounds that the first and last one as is clear in the figure as tramp and the 3 medial round are of triangular type (Figures 12 and 13). The membership function consists of very low, low, median, much and very much.

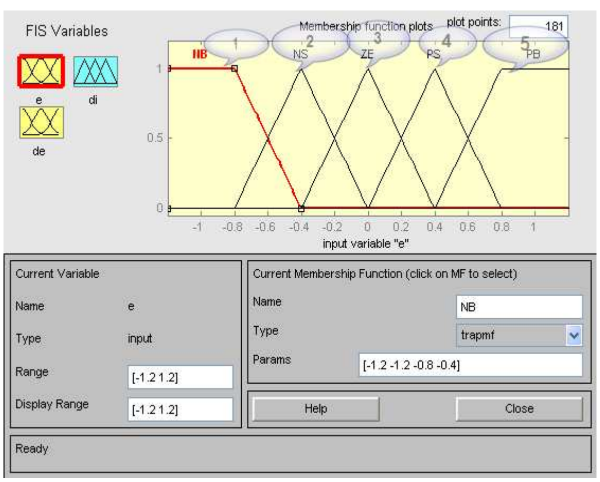

Figure 12. Fuzzy first input.

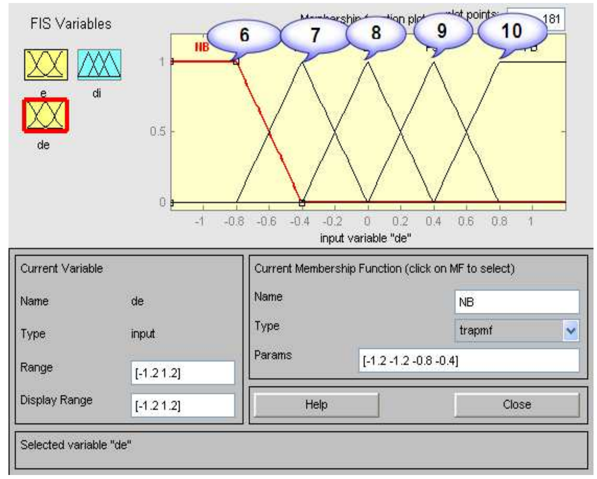

Figure 13. Fuzzy second input.

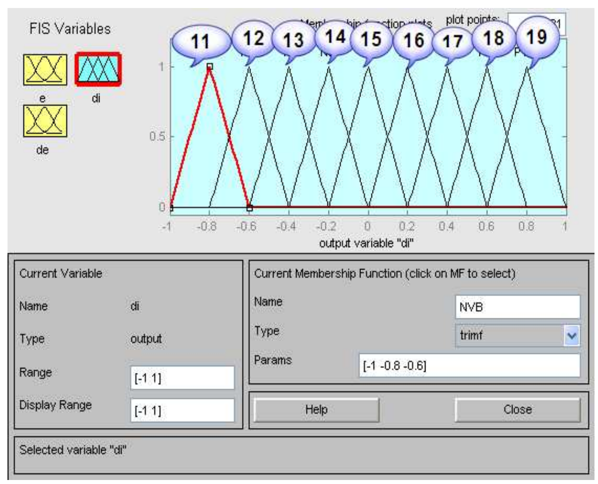

Figure 14. Fuzzy ouput.

de-fuzzy maker has membership function i.e. very very low , very very low, low, lower medium, medium, upper medium , much, very much and very very much (Figure 14).

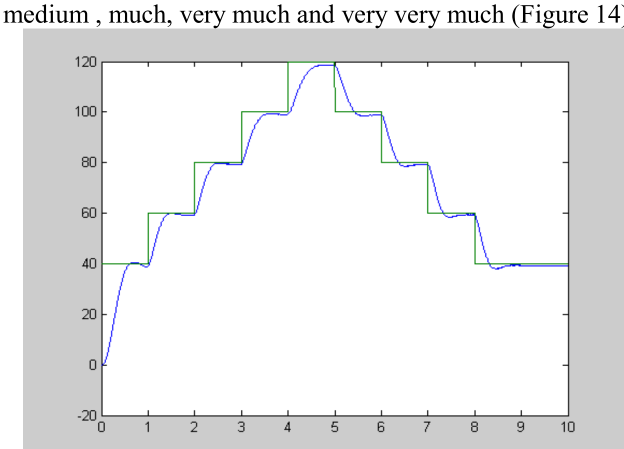

Figure 15. Phase output.

Now by this controller, we impose a step input to induction motor. As is clear in the figure, the overshot error condition is reduced but still has error to reach ideal rate and permanent errors. Following running of PSO algorithm and obtaining optimal points and exertion to fuzzy maker and de-fuzzy maker membership centers, the output response of motor rate is showed in figure 16.

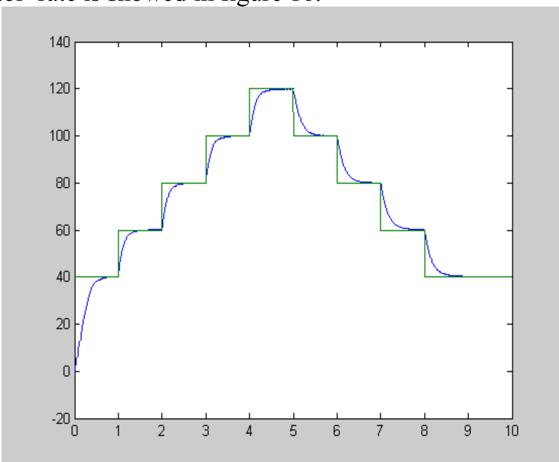

Figure 16. Output response of motor rate with PSO algorithm.

As is clear in the figure, the rate to reach ideal error is lower than phase situation and the permanent error also has been corrected little and error decreases optimally.

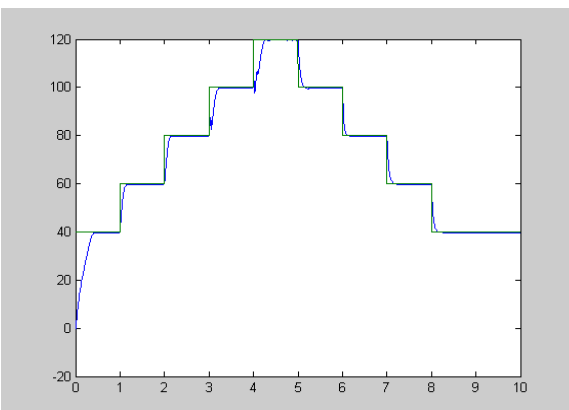

Figure 17. Rate output with exertion.

After running emperor algorithm and obtaining optimal points and exertion to phase-maker and de-fuzzy maker membership centers, the output response of motor rate with load is shown as figure 17. Thus, the rate to reach optimal error is draped and permanent error also has been decreased. In result, by comparison of two figures, we find that, effect of emperor algorithm on phase controller has better performance to control inductive motor in control of rate.

V. CONCLUSIONS

In this paper we conclude that motor control with emperor algorithm has lower error than PID control and PSO algorithm. The convergence time of emperor algorithm is lower than PSO one but convergence of PSO algorithm is conducted very fast. But emperor algorithm prevents falling in local minimum. But there is possibility of falling in PSO algorithm in local minimum.

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