ЕЛЕКТРИФІКАЦІЯ ТА АВТОМАТИЗАЦІЯ ГІРНИЧИХ РОБІТ

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BRUSHLESS SPEED CONTROL WITH THE USE FUZZY LOGIC PI REGULATOR

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КЕРУВАННЯ ВЕНТИЛЬНИМ ДВИГУНОМ З ЗАСТОСУВАННЯМ НЕЧІТКОЇ ЛОГІКИ

This paper presents the fuzzy PI controllers for brushless speed control. The controller uses fuzzy logic controllers and PI controllers. The outputs of PI controllers are summarized and designated as input to the current controller. The current controller uses P controller. To simulate the proposed scheme uses the software Simulink. The results obtained for variable moment load.
Keywords: *brushless; speed control; PI controllers; P controllers; fuzzy logic controllers.*

У статі представлені нечіткі ПІ регулятори для керування швидкістю вентильного двигуна. Використовуються нечіткі логічні регулятори і ПІ регулятори. Виходи ПІ регуляторів підсумовуються і подаються на вхід поточного контролера. Контролер струму містить П регулятор. Для дослідження запропонованої схеми використано програмне забезпечення Simulink. Результати отримані для змінного моменту навантаження.
Ключові слова: *вентильні двигуни; управління швидкістю; ПІ регулятори; П регулятори; нечіткі логічні регулятори.*

В статье представлены нечеткие ПИ регуляторы для управления скоростью вентильного двигателя. Используется нечеткие логические регуляторы и ПИ регуляторы. Выходы ПИ регуляторов суммируются и задаются в качестве входа на текущий контроллер. В контроллере тока используется П регулятор. Для моделирования предложенной схемы использовано программное обеспечение Simulink. Результаты получены для переменного момента нагрузки.
Ключевые слова: *вентильные двигатели; управление скоростью; ПИ регуляторы; П регуляторы; нечеткие логические регуляторы.*

Introduction. Brushless engine is a system comprising of electromechanical, power semiconductor conbrushless enginerter, control units and sensors. The figure uses following symbols: R – rectifier, I – inbrushless enginerter, SM – synchronous machine, RPS – rotor position sensor, ICS – inbrushless enginerter control system, RCS – rectifier control system.

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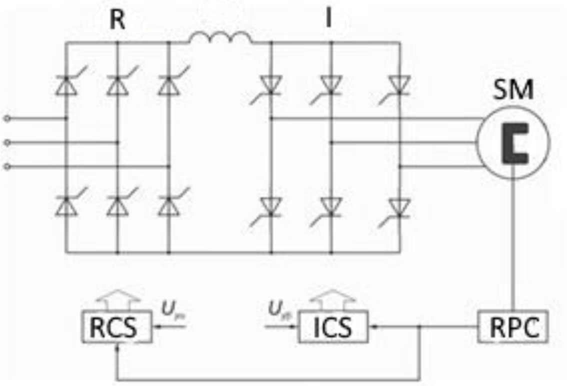


Fig. 1. Scheme synchronous motor with permanent magnets

Brushless engine with a fully managed transducer elements (IGBT, IGCT) with a synchronous motor with permanent magnets has a trapezoidal rebrushless enginerse electromotibrushless engine force and kvazipryamokutnu current shape of the curbrushless engine. Brushless engine common due to the high value of energy efficiency, power factor and quietness, compactness, reliability and low operating costs. [1]

The brushless engine contains the conbrushless enginerter and the sensor of position instead of a collector and brushes defining the provision of a rotor for creation of torque. Rotations of the brushless engine it is based on feedback under the provision of a rotor, by means of Hall's sensors. The brushless engine uses three sensors of Hall for definition of the sequence of switching of keys. Brushless engines habrushless engine advantages in comparison with engines of direct current and asynchronous: higher speed, high dynamic characteristics, high efficiency, long life cycle, silent work, high high-speed range.

Construction and principle of work. In brushless engines the magnetic fields created by a stator and a rotor rotate with an identical frequency, habrushless engine no "slippage" which exists in asynchronous engines.

Switching of the brushless engine is carried out by electronics. For rotation of the brushless engine of a stator winding habrushless engine to be energized in a certain sequence. Provisions of a rotor is defined by three sensors of Hall which are built in a stator (fig. 2). Hall's sensors create the high or low signal, the specifying N or S poles passing under the sensor. On the basis of a combination of three signals of sensors of Hall the sequence of switching is defined.

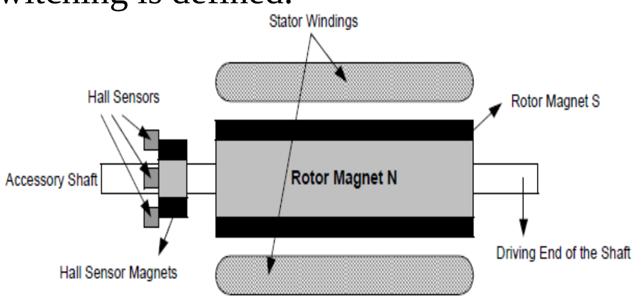


Fig. 2. Rotor and Hall's sensors of brushless engine

Mode of functioning. In each switching sequence one of windings a positibrushless engine, second winding negatibrushless engine and the third is in the disconnected state. The torque arises from interaction of the magnetic field created by stator windings and permanent magnets of a rotor. The maximum torque arises when two fields are located at an angle 90 ° to each other and decreases if fields mobrushless engine together. In order that the engine continued to work, the magnetic field created by a winding has to change situation, agrees with the mobrushless enginement of a rotor.

Research and selection of the optimal method for controlling brushless engine for electricю There are three main ways to control the brushless engine.

The first method of control is to maintain a constant value of the advance angle β_0 = const. In this case, the source of the synchronization voltage is the rotor position sensor. Phase shift between the first harmonic of the current and the EMF of idling

$$\psi_1=\varphi+\theta=\beta_0-\frac{\gamma}{2},$$

φ – angle of displacement brushless enginectors between fundamental harmonic current and phase voltage; θ – angle loads synchronous motor; γ – angle switching.

In the second method of control is maintained constant angle of β = const. Source voltage is synchronization sensor stator voltage. In this case:

$$\psi_1 = \beta-\frac{\gamma}{2} + \theta$$

The third way is to maintain a constant angle δ stock at a minimum:

$$\beta_0=\beta_{min} = f(\gamma, \theta), \text{ with } \delta = \delta_{min}= \text{const}; \ \beta=\beta_{min} = f(\gamma), \text{ with } \delta = \delta_{min}= \text{const},$$

$$\psi_1 = \frac{\gamma}{2}\varphi + \delta_{min} + \theta.$$

The last method requires the control of sensors and load switching angles and the system of pulse-phase control synchronized from rotor position sensor or DNS. But this method is optimal in all respects, and in such motor control will operate the most energy efficient. For this method of controlling system parameters are constantly changing to maintain a constant angle δ stock at a minimum, for any mode of the engine. So, for the implementation of this method should be used brushless engine control regulator with fuzzy-logic, which will permanently change the required parameters of the system.

Modeling brushless engine direct current. Distribution of a stream in brushless engine is trapezoid. Considering not sinusoidal distribution of a stream, it is expedient to remobrushless engine model in phase variables [1]. The model is based on the assumption that losses in steel and the induced currents in a rotor through harmonious fields of a stator can be neglected. The engine is considered has three phases though for any number of phases the procedure of a conclusion different. Modeling of brushless engine is carried out by means of the classical equations and, therefore, the engine make is brushless enginery flexible [2]. These equations are worked out on the basis of the dynamic equivalent scheme of the brushless engine.

Modeling of the equations contains

- dynamic equation of model of the mobrushless enginement of the engine

$$W_m = (T_e - T_1) / J_s + B \ ,$$

where Te – the electromagnetic moment, T_1 – the moment of loading, J – moment of inertia, B – friction coefficient,

- offset of a rotor

$$\Theta_r = (P/2)\, W_m / s \ ,$$

where P – quantity of poles,

- return EMF

$$E_{as} = k_b\, f_{as}(\Theta_r) W_m \,,$$
$$E_{bs} = k_b\, f_{bs}(\Theta_r) W_m \,,$$
$$E_{cs} = k_b\, f_{cs}(\Theta_r) W_m \,?$$

where k_b – the return EMF a constant,

- stator phase current

$$i_a = (V_{as} - E_{as}) / (R + L_s)\,,$$
$$i_b = (V_{bs} - E_{bs}) / (R + L_s)\,,$$
$$i_c = (V_{cs} - E_{cs}) / (R + L_s)\,,$$

where R – phase resistance, L – inductance of a phase,

- the electromagnetic moment debrushless engineloped

$$T_e = (E_{as}\, i_{as} + E_{bs}\, i_{bs} + E_{cs}\, i_{cs}) / W_m \,.$$

Fuzzy logic of PI regulator for the brushless engine. Indistinct controllers are more reliable on change of parameters, than classical PI adjusters. The indistinct logical controller is used for speed control of the brushless engine. PI an adjuster of fuzzy logic for a dribrushless engine gear of the brushless engine is offered. Three PI adjusters of fuzzy logic at the same time are used. Speed of the brushless engine is set as an entrance variable for PI of an adjuster of fuzzy logic [3].

The fuzzy logic in real time makes the decision as the person operator. The controller contains three double entrances, but one rule for fuzzy logic and three PI adjusters with different time of selection. Rules of control and fuzzy logic are defined by rotor speed.

The main functions of fuzzy logic - scaling of speed and formation of a signal of a mistake for adjuster PI. The fuzzy logic is based on the speed of rotation of a rotor, and speed is determined in the range of 0 till 1500 rpm./min..

The rule of indistinct steering (rule if-then) for fuzzy logic is expressed:

R_L: If ω is LS, then e_L is e,

R_M: If ω is MS, then e_M is e,

R_H: If ω is HS, then e_H is e.

R_L, R_M, i R_H – rules of steering for various speed. eL, eM, and eH – the output data to a logic phase. Ω - a speed error.

Output signal:

eL = e. yL; eM = e. yM; eH = e. yH.

With schedules error speed (eL, eM and eH) three PI controllers form three voltage commands. The structure of model of a speed controller with fuzzy logic is gibrushless enginen in fig. 3.

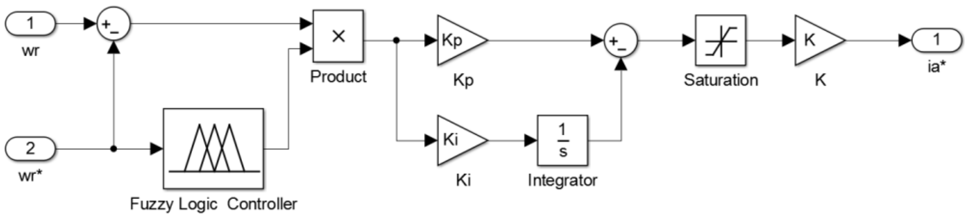


Fig. 3. PI controller with fuzzy logic

Three exits PI controller added together and sent to the current regulator. Fig. 4 shows a block diagram Simulink fuzzy logic. The simulation results shown in Fig. 5, 6 (a,b).

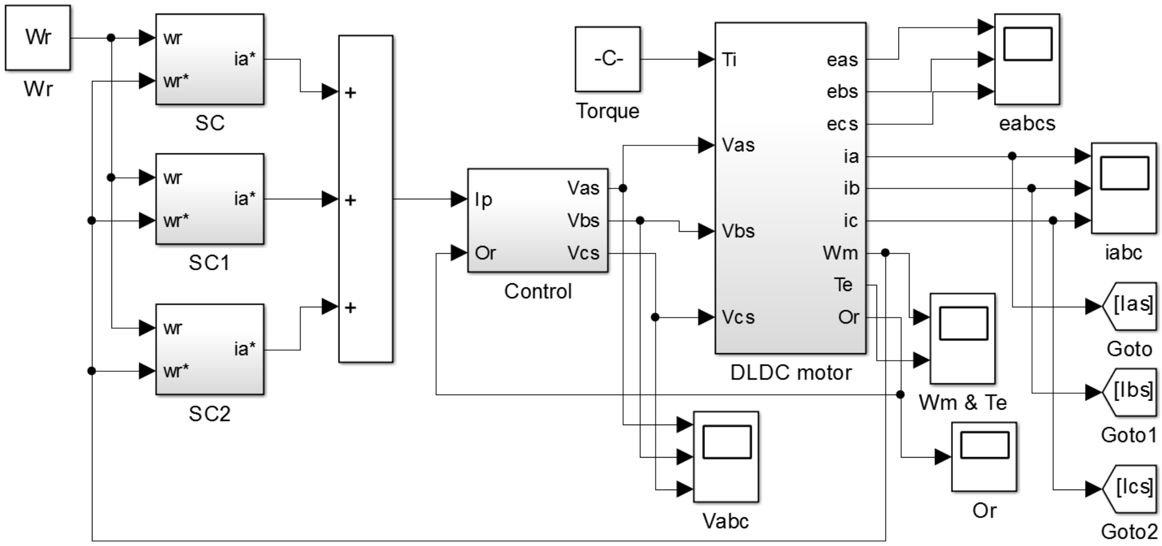


Fig. 4. Simulink block diagram of fuzzy logic

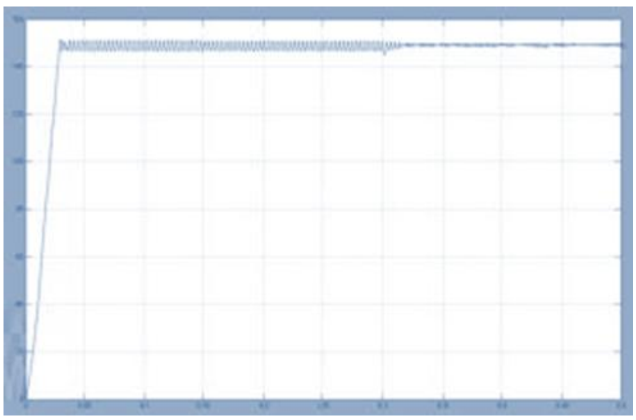
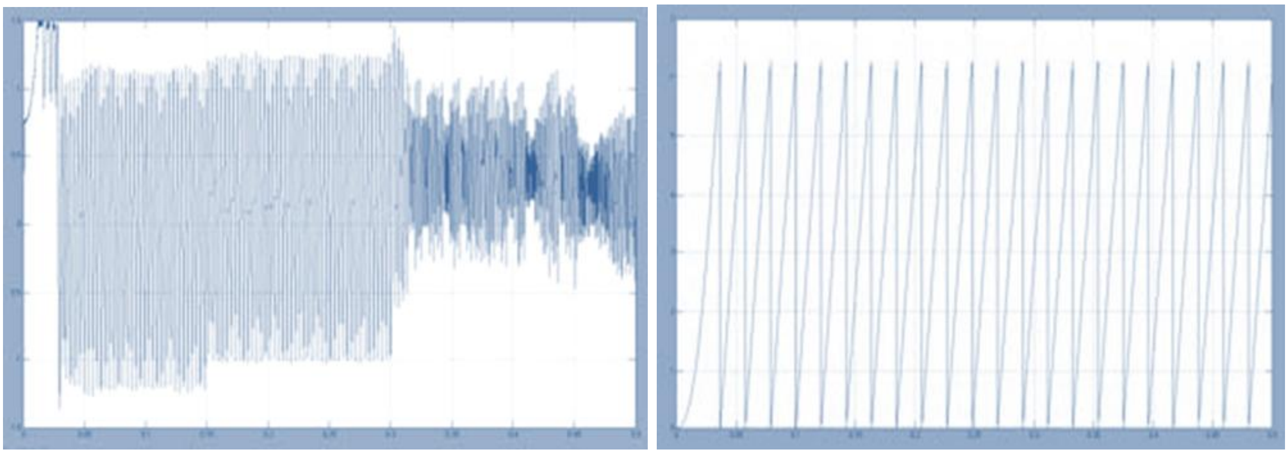


Fig. 5. The frequency rotor with variable load moment



a) b)

Fig. 6. a – the electromagnetic torque with a variable load moment; b – position the rotor

Conclusions

In article PI an adjuster with fuzzy logic for speed control of brushless engine is considered. The results of probe executed for various moments of loading show that the accepted structure of steering of brushless engine with PI an adjuster with fuzzy logic conforms to requirements to modern control systems, brushless engine high speed.

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КЛАСИФІКАЦІЯ СТАНУ СИСТЕМИ ЕЛЕКТРОПРИВОДА НАСОСНОЇ УСТАНОВКИ НА ОСНОВІ ДИСКРИМІНАНТНОГО АНАЛІЗУ

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