УДК 621.327.539

INFLUENCE OF VOLTAGE AND CURRENT FREQUENCY DEVIATION ON TECHNOLOGICAL CHARACTERISTICS OF MILK PUMP

V. Savchenko, Ph.D.

The researches of influence of a voltage deviation and current frequency for angular speed and technical characteristics on pumps of milk are carried out. Dependences of productivity, pressure and capacity of pumps from the voltage and current frequency are established.

Pump of milk, electric drive, voltage deviation, current frequency, productivity, pressure, capacity of the milk pump.

Deviations from the standardized values of voltage and current frequency is a violation of the normal course of technological processes, a simple farm production and poor quality products, increased morbidity and death of plants and animals, reducing the life of electrical equipment, increased power losses, etc. [1].

Now the actual deviation Voltage Ukraine exceeds the permissible value. Expectation bias voltage is within 16%, and the range of voltage variation is 15-28% of the nominal [4].

Because bias voltage or current frequency varies the angular speed of the motor, which in turn causes a change technological characteristics of working machines.

The purpose of research - impact of setting bias voltage and frequency of current technological characteristics of breast pumps.

Materials and methods research. The analysis of the angular velocity of electric breast pumps at a deviation of voltage and current frequency was conducted using the theory of electric related electromechanical properties of induction motors, power transmission characteristics of working machines and mechanisms and the use of mathematical modeling.

In experimental studies of stress on the engine changed using transformers, current frequency - the frequency converter firm "Mitsubishi" and thus determine the angular speed, performance, and power head pump milk.

Studies. In dismissing the mechanical characteristics of the motor voltage on the working area described by the equation [2]:

$$M_{\partial} = \beta_{\partial} U_*^2 (\omega_0 - \omega), \tag{1}$$

where M_{∂} - point motor N·m; β_{∂} - mechanical stiffness characteristics of the electric motor, N·m·s; ω_0 - synchronous angular velocity, s^{-1}; ω - angular velocity is given, s^{-1}; $U_*=U/U$ - voltage in relative units.

The mechanical characteristics of the centrifugal milk pump has the form [3]:

$$M_c = M_0 + (M_{сн} - M_0)\left(\frac{\omega}{\omega_н}\right)^2, \tag{2}$$

where *Mc* - static moment resistance of the working machine N • m at a given angular velocity, M_0 - initial time N·m; $M_{сн}$ - static moment resistance, N·m at nominal angular velocity; ω and $\omega_н$ - and given nominal angular velocity, s^{-1}.

In steady state operation

$$\beta_{\partial} U_*^2 (\omega_0 - \omega) = M_0 + (M_{сн} - M_0)\left(\frac{\omega}{\omega_н}\right)^2, \tag{3}$$

or

$$\beta_{\partial} U_*^2 (\omega_0 - \omega_н \omega_*) = M_0 + (M_{сн} - M_0)\omega_*^2, \tag{4}$$

where $\omega_* = \omega/\omega_н$ - angular velocity in relative units.

After transformations we obtain:

$$U_* = \sqrt{\frac{M_0 + (M_{сн} - M_0)\omega_*^2}{\beta_{\partial}(\omega_0 - \omega_н \omega_*)}}. \tag{5}$$

It follows from (5), the angular velocity of the pump milk at bias voltage varies from complex algorithms.

For centrifugal pumps [3] performance

$$Q_* = \omega_*, \tag{6}$$

pressure

$$H_* = \omega_*^2, \tag{7}$$

power

$$P_* = \omega_*^3. \tag{8}$$

While these laws change values for milk pump with bias voltage can be written as:

productivity milk pump -

$$U_* = \sqrt{\frac{M_0 + (M_{сн} - M_0)Q_*^2}{\beta_д(\omega_0 - \omega_н Q_*)}}, \tag{9}$$

pressure -

$$U_* = \sqrt{\frac{M_0 + (M_{сн} - M_0)H_*}{\beta_д(\omega_0 - \omega_н \sqrt{H_*})}}, \tag{10}$$

power -

$$U_* = \sqrt{\frac{M_0 + (M_{сн} - M_0)P_*^{2/3}}{\beta_д(\omega_0 - \omega_н \sqrt[3]{P})}}. \tag{11}$$

Experimental study of changes in performance and power head milk pump 36 МЦ6-12 and НМУ-6 with bias voltage confirmed the adequacy of the analytical formulas (9) - (11). The results are shown in Fig. 1.

As follows from the above relationships, the bias voltage performance, pressure and power of breast pumps replaced by sophisticated algorithms.

If you change the frequencies on the mechanical characteristics of the engine operating region described by the equation:

$$M_д = \beta_д\left(\frac{2\pi f}{p} - \omega\right), \tag{12}$$

where *f* - frequency current, Hz, *p* - number of pole pairs.

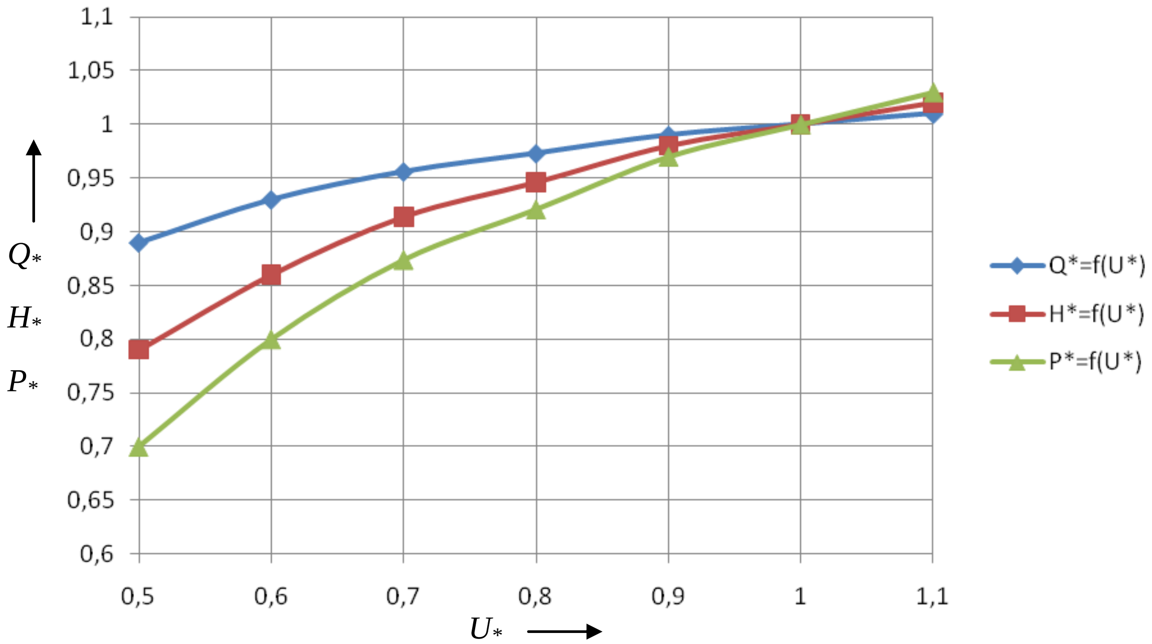

Figure 1. Dependence of productivity (*Q*), pressure (*H*) and power (*P*) milk pump from voltage in relative units

In steady state operation

$$\beta_{\partial}\left(\frac{2\pi f}{p}-\omega\right)=M_0+(M_{сн}-M_0)\left(\frac{\omega}{\omega_н}\right)^2, \tag{13}$$

or

$$\beta_{\partial}\left(\frac{2\pi f}{p}-\omega_н\omega_*\right)=M_0+(M_{сн}-M_0)\omega_*^2. \tag{14}$$

Synchronous angular velocity at rated frequency current holder $f_н$ is defined by the expression:

$$\omega_{0н}=\frac{2\pi f_н}{p}. \tag{15}$$

Then equation (14) can be written as:

$$\beta_{\partial}(\omega_{0н}f_*-\omega_н\omega_*)=M_0+(M_{сн}-M_0)\omega_*^2, \tag{16}$$

whence we obtain

$$f_*=\frac{M_0+(M_{сн}-M_0)\omega_*^2+\beta_{\partial}\omega_н\omega_*}{\beta_{\partial}\omega_{0н}}. \tag{17}$$

If we neglect the initial point $M_0=0$ and taking into account that for engines with stiff mechanical characteristics $\omega_н \approx \omega_{0н}$, we can write:

$$f_* = \omega_* . \quad (18)$$

Then for performance, pressure, power milk pumps at switching frequencies just following relationship:

$$Q_* = f_* , \quad (19)$$

$$H_* = f_*^2 , \quad (20)$$

$$P_* = f_*^3 . \quad (21)$$

Results of experimental studies of productivity, pressure and power of 36 breast pumps 36 МЦ6-12 and НМУ-6 by changing the frequencies shown in Fig. 2.

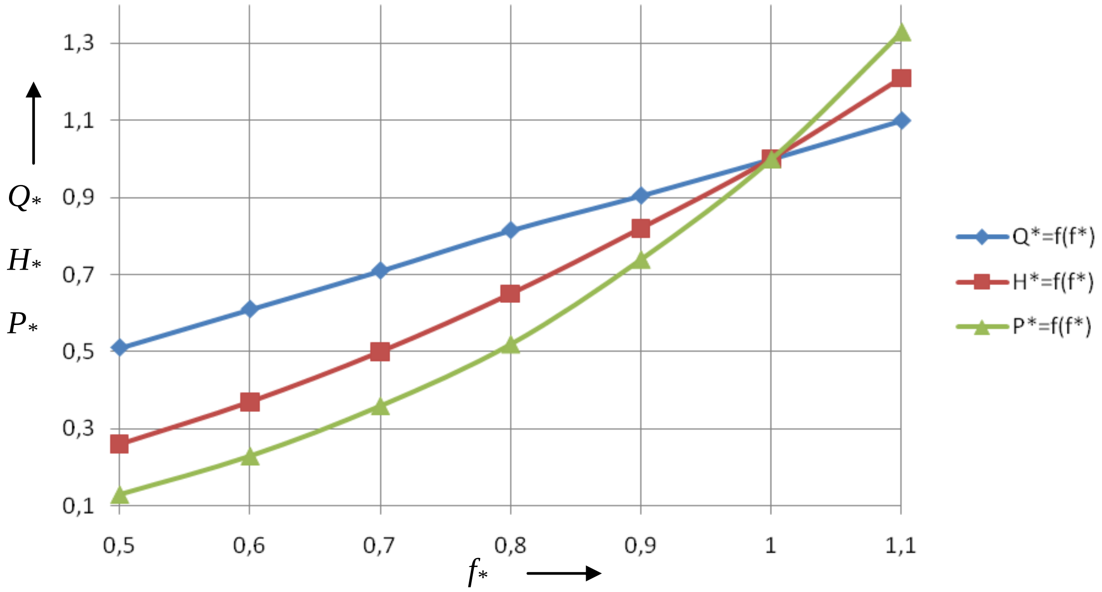

Figure. 2. Dependence of productivity (*Q*), pressure (*H*)and power (*P*) milk pumps from the current frequency in relative units

Studies have shown that when the frequencies of dairy performance of centrifugal pumps depends linearly on the current frequency, pressure - the square of the frequencies, power - from the cube frequencies.

Conclusions

In dismissing the voltage output, pressure and power of milk pumps replaced by sophisticated algorithms. By reducing the voltage to 20% of their capacity is reduced to 3% pressure - up to 5%, power - up to 8%.

When changing frequencies milk pump performance varies in direct proportion to the frequency of current pressure - squared frequencies, power - cube frequencies. At lower frequencies of 2% of their capacity reduced by 2%, pressure - 4%, power - 6%.

References

1. Вплив якості електроенергії на функціонування споживачів у сільському господарстві / Д.Г. Войтюк, В.П. Лисенко, І.І. Мартиненко [та ін.] // Електрифікація та автоматизація сільського господарства. – 2004. – №1(6). – С. 3–12.
2. Електропривод / [Лавріненко Ю.М., Марченко О.С., Савченко П.І. та ін.]; за ред. Ю.М. Лавріненка. – К.: Ліра-К, 2009. – 504 с.
3. Електропривод сільськогосподарських машин, агрегатів та потокових ліній / [Жулай Є.Л., Зайцев Б.В., Лавріненко Ю.М та ін.]; за ред. Є.Л. Жулая. – К.: Вища освіта, 2001. – 288 с.
4. Перова М.Б. Качество сельского электроснабжения: комплексный подход / Перова М.Б. – Вологда: Вологодский гос. техн. ун–т, 1999. – 72 с.