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Individual Compensation of Reactive Component of Consumed Power by Means of Automatic Systems

Sadullaev Nasullo , Schwarzburg Leonid , Urinov Nodir

Doctor of technical sciences, professor, vice-rector on scientific work and innovations, Bukhara Engineering-Technological Institute. Bukhara, Uzbekistan.
Doctor of technical sciences, professor, head of “Engineering ecology and life safety” department, Federal state budgetary educational institution of higher education “STANKIN” Moscow State Technological University, Moscow, Russia.
Doctoral student of “Power machines and technologies” department, Bukhara Engineering-Technological Institute, Bukhara, Uzbekistan.

ABSTRACT: The article covers the optimal method of control of power consumption of machine-building technological processes due to individual compensation of reactive component of consumed power by means of automatic systems.

KEYWORDS: power factor, energy efficiency, compensating devices, non-adjustable capacitor, automatic compensation devices, contactor, individual compensation.

I. INTRODUCTION

In recent years, according to various estimates, the industry of Uzbekistan accounts for about 45% of country’s total energy consumption. Of these, mechanical engineering and metal processing take the second place after the fuel industry in terms of power consumption. Therefore, the issues of reducing energy intensity are important and relevant [3].

The main feature of mechanical engineering and metalworking is that technological operations take a significant place, the implementation of which requires power significantly lower than the rated power of electric motors, for example, such as faceting, finishing process, etc. Besides, the presence of idle running caused by approaching or change of tool, turning of work-piece, etc .should also be noted. All this leads to the fact that the cutting power required for the implementation of the process is significantly lower than the rated power of the electric motor of the machine equipment, resulting in a significant increase in the energy intensity of these processes [1].

II.MATERIALS AND METHODS

Underutilization of machine equipment determines excessive power consumption of mechanical engineering processes implemented on them. This is because the underutilization of the machine motor has a significant effect on the power consumption parameter as the power factor (cosφ). This factor shows the relationship between the active power consumption component that is directly operating and the total power consumed by the machine equipment.

The power factor reaches optimal values in cases where the cutting power leaded to the motor shaft is equal to the rated power of the machine. The power factor decreases sharply in the case when the cutting power is less than the nominal.

The main reason for the need to minimize the energy intensity of mechanical engineering technological processes is the underutilization of the electric motor, which is characteristic of mechanical engineering equipment that implements these processes. This is due to the power required for the implementation of the engineering process and determined by the cutting forces, in most cases significantly less than the rated power of the machine.

One of the methods for reducing energy intensity during the implementation of engineering processes is the method of compensating the reactive component of the power consumed during their implementation. It is advisable to

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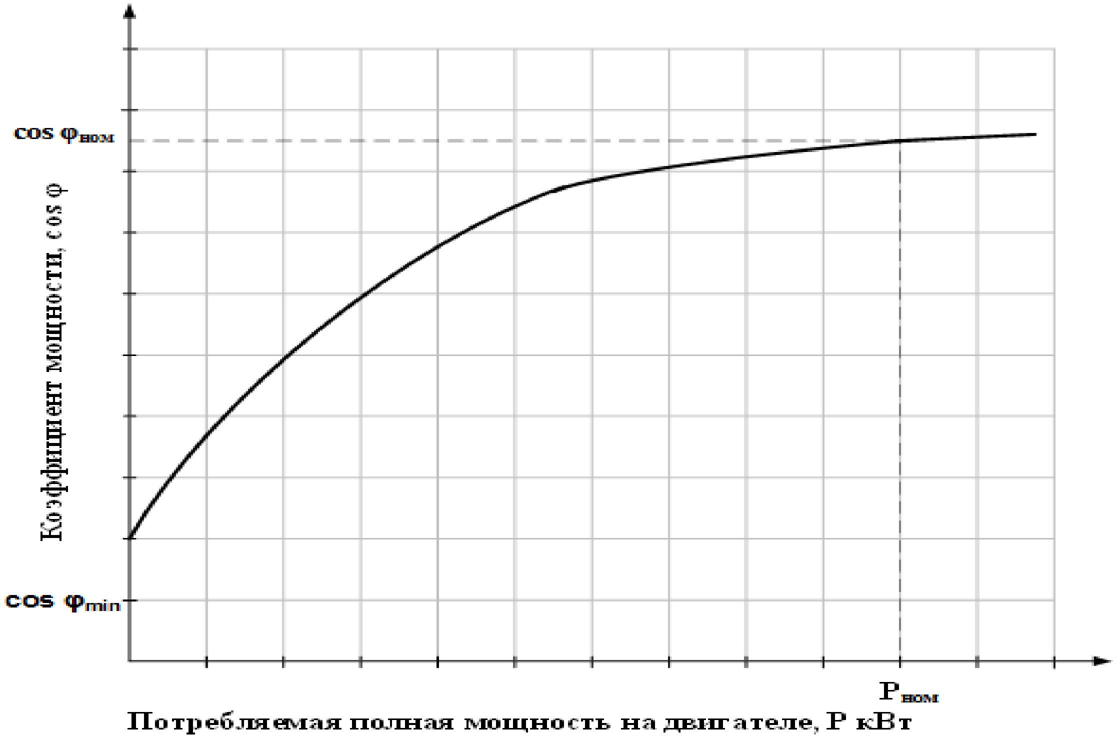
implement this method by means of automation, which allows not only taking into account the real parameters of the technological process and equipment, but also to increase the efficiency of compensation and, as a result, reduce the energy consumption of technological processes and increase the competitiveness of manufactured products.

The decrease in power factor during underutilization of the electric motor of machine-tool equipment is caused by the presence of the reactive component of the power consumption, which is typical for consumers with inductive resistance, such as asynchronous motors, transformers, electric furnaces, lighting systems, etc. Since the reactive component does not perform useful work and increases transmission losses electric energy to the consumer, its reduction will reduce the energy intensity of mechanical engineering technological processes (pic 1). [8]



Power factor	Total power consumption on the motor

Fig.1 Diagram of power factor dependence on motor load

The most important direction of automation of the technological processes is the automation of energy consumption control in the implementation of these processes. Low energy efficiency of technological processes is due to a number of their characteristic features.

Currently, there are several approaches to automated compensation of the reactive components. They differ in both the level of compensation and, for example, the type of compensation devices.

Compensating devices are divided into permanent (non-adjustable) and automatic [4].

Permanent compensators are one or more capacitors to provide the constant level of compensation. This type of compensators can be used on terminals of inductive devices (motors or transformers), on switchboards supplying a number of small motors and inductive equipment for which separate compensation is economically unfavorable, or on consumers with a enough constant load and allow reducing reactive currents and voltage drop in the transmission and transformation of electrical energy.

Non-adjustable capacitors can be controlled manually: by means of switch or load switch; semi-automatically: by means of the contactor or directly connection to load and commutation with it.

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Automatic compensation devices provide control of energy consumption at consumers with a relatively high level of change in the active and reactive components of power consumption. They provide automatic control of power factor compensation and maintaining a given level of power factor within narrow limits. Such devices can be used on the splints of the main switchboard or on the terminals of a heavily loaded cable.

Automatic compensation, as a rule, is carried out using automatically adjustable capacitor units, which is divided into a number of sections, each of which is controlled by a contactor. Switching on the contactor includes a section corresponding to it in parallel with other sections that are already working. This allows to stepwise increase or decrease the capacity of the unit by turning on and off the control contactors.

The control is carried out by a relay that controls the power factor of controlled circuits, which serves to turn on and off the corresponding contactors to provide power factor values in a given range (within the tolerance specified by the value of each compensation battery). For the normal functioning of this system, the current transformer for the control relay must be connected on one phase of the input cable supplying the control circuits

III. RESULTS AND DISCUSSION

In devices for automatic compensation of the reactive component of power consumption, both standard contactors and static contactors (thyristors) can be used. The use of the latter is advisable in controlling the energy intensity of equipment with a fast cycle or high sensitivity to perturbations arising at transient processes. The advantages of thyristors include instantaneous response to a change in power factor (up to 40 ms), an unlimited number of responses, elimination of transient processes in the network when capacitors are turned on, and silent operation [5].

According to selection of place of installation of compensating devices central, section-by-section and individual compensation are distinguished.

With central compensation of the reactive component of power consumption (Fig. 2), the compensating device is connected to the collecting splints of the main switchboard or distribution substation of the enterprise. With this connection, the aggregate of the reactive component of the power consumption of the entire enterprise is compensated. This allows reducing the required total power consumption, based on which, as a rule, a fixed fee is established. The load on the power transformer is also reduced, which, in turn, allows to connect additional consumers to it.

However, this method has a number of disadvantages. With this compensation mode, the reactive current continues to flow across all cable conductors from the main switchboard to its final consumers. For this reason, the centralized compensation mode does not allow to reduce the section of cables of the power network of the enterprise, and as result, reduce losses in them.

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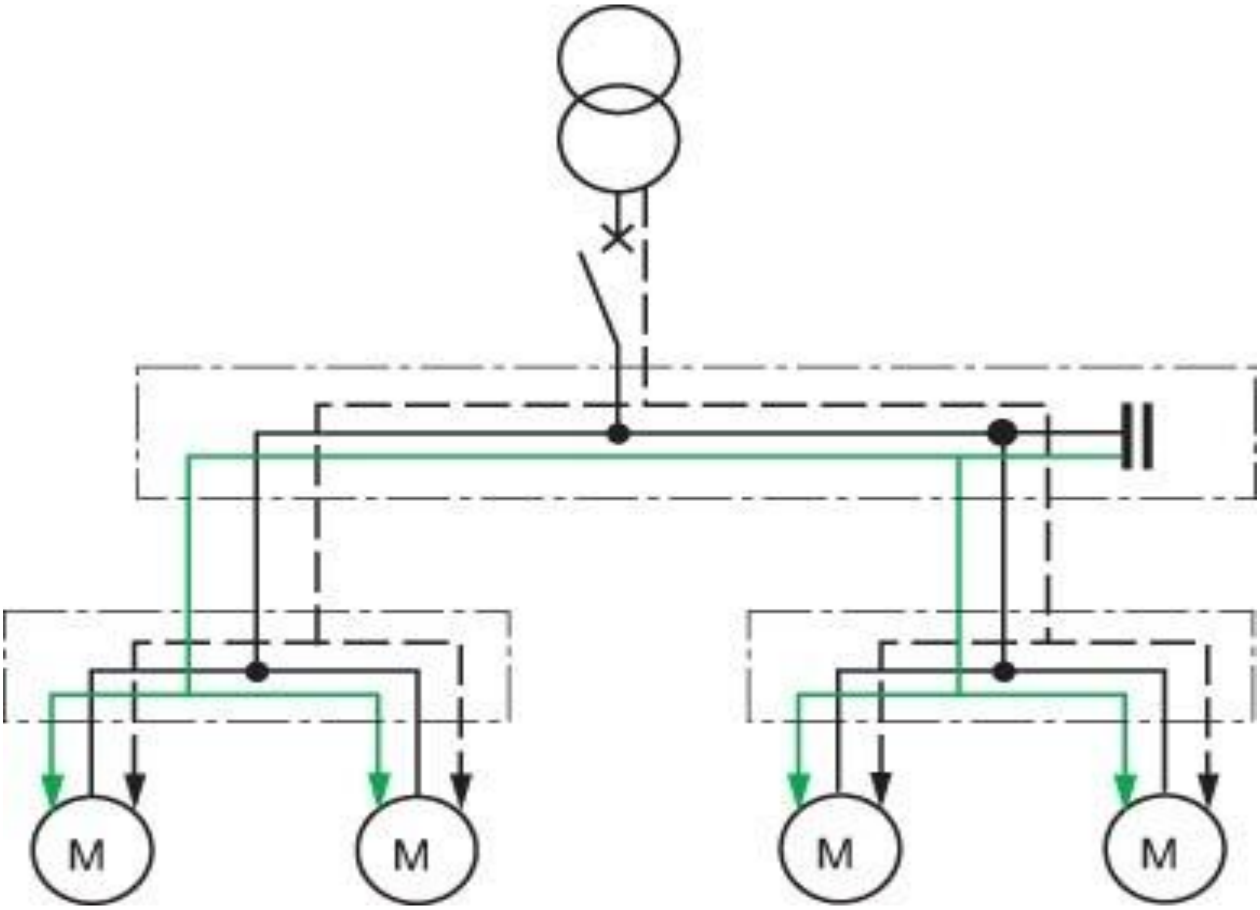

Fig. 2. Scheme of centralized compensation of the reactive component of power consumption

This approach is advisable to apply in industries with a constant and steady load. This is because with a variable load, the efficiency of the compensating installation will decrease, and in some cases, it may vice-versa increase the reactive component of the power consumption. The latter is caused by the so-called re-compensation effect, which occurs when connecting compensating devices of greater power than necessary.

In cases where sectional compensation is applied, the blocks of compensating devices are connected to the workshop switchboards and automatic machines (Fig. 3).

The greater locality of this approach allows more effectively control the energy intensity of technological processes, in particular by reducing losses in the transfer of energy from a common distributor to a local one. However, for the same reasons as centralized compensation, sectional compensation is inexpedient to apply in the presence of a large number of consumers with different load conditions.

Individual compensation implies local compensation of the reactive component of power consumption directly at the consumer. Compensating devices in this case are connected directly to the electric motor of machine-tool equipment.

With the correct selection of the range of compensating devices, this approach allows to control the energy intensity of machine-building technological processes with maximum efficiency and significantly increase their energy efficiency [2].

Based on the above, it can be concluded that the most optimal method of controlling power consumption of mechanical engineering technological processes is individual compensation of the reactive component of power consumption by means of automatic systems. This conclusion is explained by the peculiarities of the implementation of mechanical engineering technological processes, which are characterized by a wide range of changes in the load on the motor during the implementation of these processes, as well as the possibility to ensure their maximum energy efficiency in this approach.

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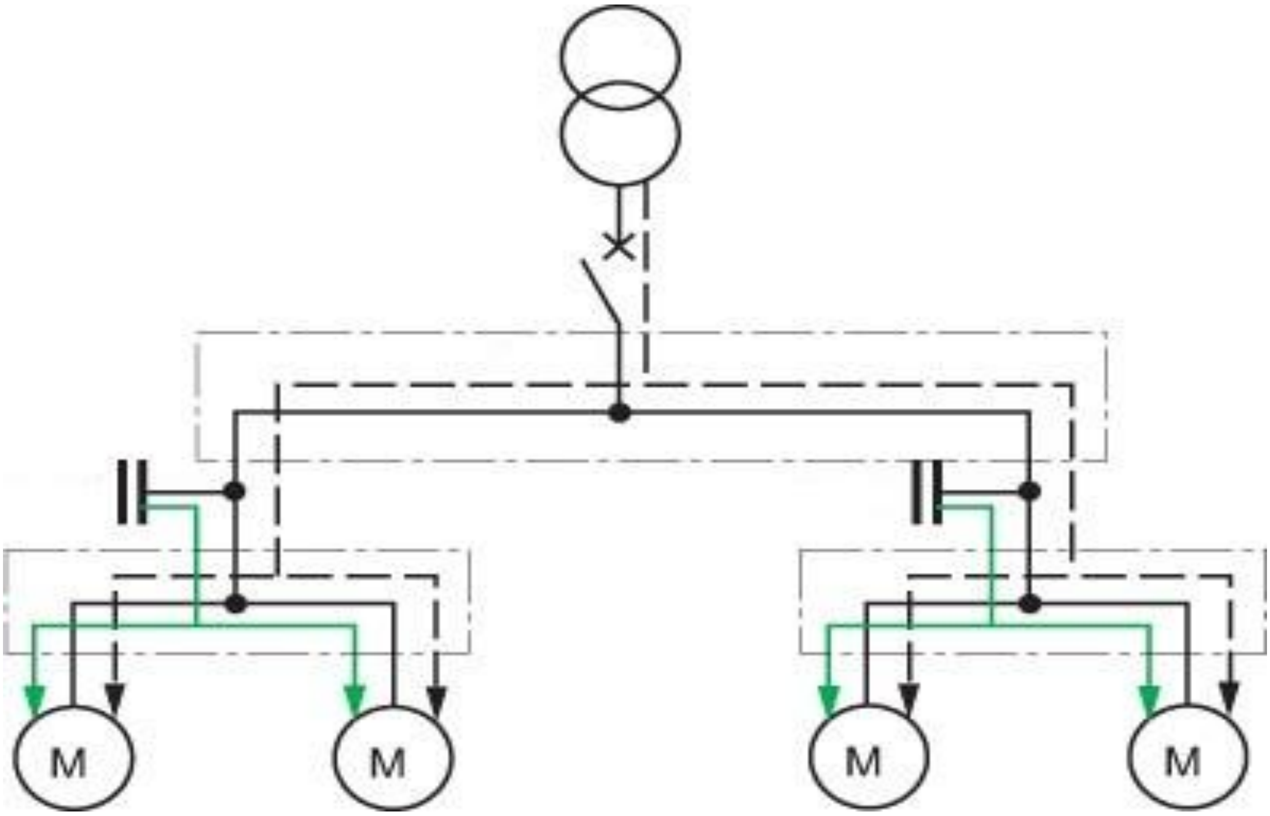

Fig. 3. Scheme of sectional compensation of the reactive component of power consumption

IV. CONCLUSION

Based on the above, the following tasks were set:

1. To analyze the existing methods and means of energy intensity control of mechanical engineering technological processes.
2. To analyze the possibilities of automation of energy intensity control of mechanical engineering technological processes.
3. To establish the relationship between the parameters of mechanical engineering technological processes of edge cutting machining, the rated power of the electrical equipment of the machine and the energy consumed during the implementation of these processes.
4. Based on established relationships, to develop algorithms for automating the energy intensity control of mechanical engineering technological processes.
5. To investigate the possibility of implementing the developed algorithms for automation of energy intensity control of mechanical engineering technological processes with different parameters of technological transitions and different types of processing.

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