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Overview of Electric Drive Systems of Domestic Woodworking Machines

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Domestic woodworking machines are an important part of home workshops. Domestic machines are distinguished by industrial several important features: 1) domestic machines usually have low power; 2) these machines usually require lower regulation of mechanical quantities; 3) at home workshops there are usually no three-phase 400 V grids, which means that the machines are designed to be powered from a 230 V single-phase grids.

All of these features led to the use of those electric drive systems that are currently used in domestic woodworking machines. The most common currently unregulated electric drive is based on single-phase capacitor asynchronous motors. In machines, where speed control is not required, the transmission of torque from the electric motor to the working body is carried out through mechanical transmission with a constant gear ratio (gear, chain and belt drives). There are also direct drive circuits.

In the case when, under the conditions of the technological process, it is necessary to regulate the speed of the working mechanism, transmission mechanisms with variable gear ratio (gear boxes, belt drives with a set of pulleys, belt variators) are used. The main disadvantage of such drive circuits is the inability to control smoothly the speed of the actuator, as well as the impossibility of using an automatic control system (ACS). The advantages of these schemes are ease of implementation, reliability, low cost and maintainability [1].

In the case when the machine requires the regulation of the speed of the main movement, an adjustable electric drive is used based on the "frequency converter - asynchronous motor" system [2]. These systems are the most common on machine tools with computer numerical control (CNC). In such systems, a gear unit with a constant gear ratio is used, and the speed is controlled by varying the frequency of the supply voltage in the frequency converter. Using a frequency converter allows to adjust smoothly the speed of an electric motor (usually, the frequency change step is no more than 0.1 Hz, which corresponds to adjusting the speed of the electric motor in increments of 6 rpm or less, depending on the number of motor poles). The main disadvantage of this scheme is the high cost of the electric drive system due to the presence of a frequency converter.

Another promising type of an engine for using in domestic machines can be called motors with excitation from permanent magnets. Electric drives based on such engines include, in addition to the engine itself, also a semiconductor energy converter and a rotor position sensor. They are divided into the permanent magnet synchronous motor drive system (PMSM), where the position of the resulting vector of the magnetizing armature force F_a relative to the rotor position is controlled continuously, and the system brushless DC motor (BLDC), where the position of the F_a is discretely controlled [3]. At present, such motors are excited by magnets based on neodymium – iron – boron alloys (Nd – Fe – B) and ferrites. In woodworking machines, the most advantageous is the use of the BLDC system, since scalar control is used to control the electrical variables in the BLDC. The main advantages of such a system are the absence of losses in the rotor and a greater allowable torque of the electric motor. The main disadvantage is the high cost.

Precision woodworking machines also find limited use of the feed drive based on stepper motors. Stepper motors are a good solution in systems with high positioning accuracy requirements. A stepper motor is a brushless DC electric motor which position can be set to move and hold at one of these steps without any position sensor for feedback. The stepper motor is known by its property to convert a train of input pulses (typically square wave pulses) into a precisely defined increment in the shaft position. Each pulse moves the shaft through a fixed angle.

Stepper motors have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron [1]. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of those rotations is called a "step". In that way, the motor can be turned by a precise angle. Advantages of stepper motor are precise positioning, low cost for control achieved, high torque at startup and low speeds, simplicity of construction, low maintenance etc. The main disadvantages are susceptibility to resonance, difficulty of working at high speeds, low power density.

References:

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