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METAL-WORKING EQUIPMENT
LECTURE 3

Lecturer – Dmitry M. Kozar

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TECHNICAL SPECIFICATIONS OF MACHINE TOOL

Each machine tool is a complex technical system which described by a large number of characteristics that can be divided into four groups: geometric precision, speed and power.

The geometric characteristics of machine tool include: the size of workspace (the maximum values of movements of working bodies of machine tool); main connecting dimensions; overall dimensions of machine tool. Workspace means a space which houses a processed workpiece. The sizes of workspace determined by the value of the largest displacement of movable bodies. Connection sizes of machine tool – the sizes of surfaces by the which are connected workpieces or tools.

The accuracy characteristics of machine tool include accuracy of positioning and movement of the working bodies of machine tool; the accuracy of spindle rotation (radial and axial run-out of the front end of spindle); the accuracy of the mutual arrangement of the working bodies of machine tool (perpendicularity of guide carriage and sleigh, and so on); the accuracy of the mutual arrangement of individual components parts (misalignment of the guide frame or rack and so on).

TECHNICAL SPECIFICATIONS OF MACHINE TOOL

The speed characteristics of machine tool provide optimum machining mode by the use of mechanisms of regulation of cutting speed and feed.

The power characteristics of machine tool are determined by the power of main drive, feed drive, idling and torque.

The accuracy characteristics are characterized by a movement error of the unit of machine tool to a given position on one or more coordinates. A large number of systematic and random errors affect positioning accuracy. Positional stability is determined by the area of the scattering (dispersion) of the provisions of the unit of machine tool in its movement to the specified position from the same direction. Error of movement characterize the systematic component in a fixed direction. The dead zone is called the difference of error of position of the node when feeding it to a given point from different sides. Positioning accuracy is an important characteristic quality of all machine tools with numerical control. If you know the characteristics of the positioning accuracy for this particular machine tool, it can be clarified when developing the control program.

TECHNICAL SPECIFICATIONS OF MACHINE TOOL

Vibration resistance of machine tool (dynamic quality) determines its ability to counteract vibrations that reduce the accuracy and performance of the machine tool.

The most dangerous vibrations of the tool relative to the workpiece. Forced vibrations occur in elastic system of the machine due to unbalance of the rotating parts of the drive and the rotors of electric motors and due to periodic errors in the gears and external periodic perturbations. Especially dangerous if the forced oscillations are resonant oscillations. That occur when the frequency of the external influences coincides with the natural frequency of one of the elastic links of the machine. Self-excited oscillations or vibrations associated with the nature of the processes of cutting and friction in the movable joints. When the loss of stability arise oscillations, which are supported by an external power source from the drive machine.

The main ways of increasing vibration resistance of machine tools: elimination of the sources of periodic disturbances; the selection of the parameters of the elastic system to ensure sustainability; enhancing the damping properties; the application of systems of automatic control of the level of fluctuations.

TECHNICAL SPECIFICATIONS OF MACHINE TOOL

Heat resistant of machine tool characterizes its resistance to rise to unacceptable temperature deformations under the action of those or other sources of heat. The main heat sources include cutting process, engines, mobile connections, especially when significant speed relative motion.

The flexibility of machine tools – the ability of the machine to the rapid readjustment in the manufacture of other (new) details. The more often a change of machined parts and the greater the number of different parts requires treatment, the greater flexibility must have a machine or an appropriate set of machining equipment. Flexibility is characterized by two indicators – universality and ability to readjustment.

Universality of machine tools is determined by the number of different parts to be processed on this machine, i.e. the nomenclature of the handled details.

TECHNICAL SPECIFICATIONS OF MACHINE TOOL

Ability to readjustment of machine tools is determined by the loss of time and funds for the changeover of machine tools, during the transition from one batch to another batch of workpieces. Thus, the ability to readjustment is an indicator of the flexibility of the equipment depends on the number of batches of parts to be processed on this equipment during the year.

For each type of machine tools there are quite certain the cost of readjustment. With the increase in the number of parts in the batch the total costs of conversion are reduced, but increase storage costs of parts that did not go further, and create a work in progress. Thus, for each type of machine tool with his ability to readjustment there exists an optimal size of the batch of workpieces. Less than the optimal batch size, the more flexibility has the machinery. The application of computer technology to control machine tools, manipulators and installation of NC equipment has greatly enhanced the flexibility of equipment with a high degree of automation.

TECHNICAL SPECIFICATIONS OF MACHINE TOOL

The accuracy of the machine tool determines the accuracy of processed products. The nature and source of all the errors of the machine tool are conventionally divided into several groups.

The geometric accuracy of the machine tool depends on connection errors and affect the accuracy of relative position of units of the machine tool in the absence of external influences. The geometrical accuracy depends mainly on the accuracy of manufacturing of basic parts, their connections and build quality of the machine tool. On the errors in the location of the major components of the machine there are standards. The machine tool according to these standards is checked during manufacture and periodically during its operation. Standards valid for machine tool geometric errors depend on the required accuracy of manufacturing parts.

TECHNICAL SPECIFICATIONS OF MACHINE TOOL

Kinematic precision is needed for the machine tools, in which complex movements require coordination of several simple. Violation of coordinated movements, violates the correctness of a given tool path relative to the workpiece, and thus distorts the form of the workpiece. Of particular importance is the kinematic accuracy for gear cutting, thread-cutting and other machines for contouring machining.

Rigidity of machine tools characterized by their ability to resist the appearance of elastic displacement under constant or slowly time-varying force effects. Rigidity – the ratio of the force to the corresponding elastic strain in the same direction.

The reciprocal of rigidity is called ductility. The ductility of a complex system from a set of elastic elements operating in series, is equal to the sum of the ductility of these elements.

TECHNICAL & ECONOMICAL INDEXES OF MACHINE TOOL

For comparative evaluation of the technical level of machines and sets of machining equipment, as well as selecting them for a particular production task are used a set of indicators of the quality of machine tools.

The main technical and economic indicators include: efficiency, productivity, reliability and the flexibility of the machine tools.

The efficiency of machine tools is a complex (integral) index that best reflects the main purpose of machinery is to increase productivity and, consequently, to reduce labor costs in processing the details.

The effectiveness of machine tool is estimated according to the formula:

$$A = \frac{M}{\sum C}$$

where M – annual production of the components; $\sum C$– the sum of the annual cost of their production.

TECHNICAL & ECONOMICAL INDEXES OF MACHINE TOOL

The performance of the machine tool is characterized by several indicators, which compare different types of machines:

- cutting capacity determines the amount of material removed from the workpiece at a time. This indicator is used for assessing the capabilities of machines for pre-sizing, or to compare different technological methods of machining;
- performance shaping is used in the comparative assessment of the nature of different equipment, it is determined by the formula:

$$Q_{PS} = \frac{V_c t_c}{L_\tau}$$

  where V_c – cutting speed along generatrix lines; L – the full path of the tool along generatrix lines; t_c – time cutting; τ – cycle time;
- the performance of the machine tool in a given period of time is determined by the number of manufactured products. Constructive and regime parameters are factors determining the level of the theoretical (nominal) capacity, and technological and operational options – factors determining the level of design and actual performance.

TECHNICAL & ECONOMICAL INDEXES OF MACHINE TOOL

The performance of machine tools can also be divided into nominal, estimated and actual.

The nominal capacity of the machine is considered the maximum number of products Q_N produced per unit time in continuous operation. Is calculated by the formula:

$$Q_N = \frac{3600 \cdot m}{\tau_N}$$

where m – the number of products per cycle; τ_N – nominal cycle time by limiting operations, sec, $\tau_N = t_{AC} + t_{AU}$; t_{AC} – the actual processing time, sec; t_{AU} – auxiliary time – combined time handling movements, sec.

Actual performance of machine tool Q_F determined by the number of products produced per unit of time taking into account the loss of time to perform all the auxiliary operations (planning, maintenance, repair), elimination of failures and downtime due to poor organization of production, installation, configuration, training and information programming. Determined upon.

Estimated performance is contained in its documentation, and the actual adjuster is set in operation. And analyzing actual and estimated performance can be identified organizational and technical measures for reduction of equipment downtime. Calculated by the formula:

$$Q_N = \frac{3600 \cdot m}{\tau_N} \cdot \mu_P$$

where μ_P – estimated utilization rate of equipment.

The reliability of the technological equipment is characterized by a number of indicators: probability of failure, failure rate, parameter of flow failures, etc. These parameters by their physical nature are random, so for quantitative assessment is widely used mathematical apparatus of probability theory and statistics.

TECHNICAL & ECONOMICAL INDEXES OF MACHINE TOOL

The reliability of the machine tool is the property of the machine tool to ensure the uninterrupted delivery of suitable goods in a specified quantity during a specified period of service and conditions of use, maintenance, repairs, storage and transportation.

The operability of the machine tool call failure. When failure products are either not given, or is defective.

Reliability of the machine tool – the property of the machine continuously keep working for some time.

TECHNICAL & ECONOMICAL INDEXES OF MACHINE TOOL

Wear of movable joints in the machine tool (rails, spindle supports, gear screw-nut, etc.) is a major cause of limitations of durability by the criterion of preservation of the initial accuracy.

Maintainability – adaptability of the machine to the prevention and detection of causes of failure, damage and to maintain and restore a healthy state by carrying out maintenance and repairs. This criterion is especially important for machines with a high degree of automation and automatic machine tools, because it determines the cost of the elimination of failures and the associated downtime of expensive equipment.

Technical resource – the time between the start of operation or its renewal after medium and major repairs before shifting the limiting condition. To determine the longevity of individual elements (components and mechanisms of the machine) use the average resource (expectation).

Diagnosis of machine tool is an effective means of improving the reliability of machines and machine systems. This exercise aimed gathering current information about the state of the machine and its critical parts and components.

To gather information use the converters, giving the signal by machine disturbances or on the basis of specially excited by periodic impacts. Search and diagnosis of errors, malfunctions, hazardous deviations from normal operation is carried out by various methods. When using the functional model of the machine and its individual units (the feed drive, the carrier system) is divided into a finite number of functional blocks from a controlled output parameter. A set of output parameters related to the integrated system, is the basis of the model of the site or the entire machine.