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SYSTEMATIZATION OF MACHINE TOOLS BY FUNCTION

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Abstract. The systematization of machine tools by function is proposed in terms of the set of surface mod-ules that they may produce.The drawbacks of wording the destination machine tools, which makes their choice and automation procedures.Wording proposed in the destination machine tool to include a plurality of modules of surfaces that can be manufactured.The technique of determining the technological capabilities machine tool at module level.The results determine the technological capabilities horizontal boring mill(model LR 620).
Keywords: machine tools, surface, detail, work tool, technological decision, turning of surfaces

1. Introduction

In the design of manufacturing processes for machine parts, the technologist must select the machine tool for each operation. In that case, the initial information includes the surfaces of the parts that must be produced in the operation and the methods used for this purpose. In producing surfaces, the required shape, size, and quality must be ensured. Traditionally, machine tools are selected as follows.

The group of machine tools—lathes, milling machines, drills, etc.—is selected on the basis of the operation and the machining method, at the stage of formulating the manufacturing pathway. In the design of operations, the technologist selects the type and model of the machine tool from this group. The selection of the model is primarily determined by the position of the blank relative to the technological bases and the possibility of producing surfaces with specified size, shape, and precision, in relation to the following criteria: the machine tool's working zone must correspond to the dimensions of the blank; the required manufacturing precision must be ensured; the power, rigidity, and kinematics of the machine tool must ensure the best machining conditions; and the productivity of the machine tool must correspond to the specified production program. In selecting the machine tool, we employ data regarding its function and the list of technical characteristics.

Research shows that the formulation of the machine tool function does not provide complete information, as a rule [1, 2]. This is especially true for universal machine tools and, to a lesser extent, for specialized systems (thread cutting, hobbling, slot milling, and other machines). Let's consider, as an example, the 16A20F3 lathe, which is described as "intended for turning the external and internal surfaces of solids of revolution in one or two passes, in a closed semiautomatic cycle. It may be used for small scale and large scale production." This formulation provides no information regarding the specific shape, position, and precision of the surfaces produced by the machine tool. Analogous deficiencies are found in the descriptions of other machine tools. Typically, such descriptions do not include a complete list of the types of surfaces that may be produced by the given machine tool; along with their character is tics and their positions with respect to the working elements of the machine tool. This hinders the selection of the machine tool, prevents the automation of the process, and in some cases even leads to incorrect choice of the machine tool. The foregoing underlines the need for technological identification of the machine tools—that is, complete and precise description of their purpose. In technological identification, the challenge is that the surfaces manufactured by the machine tool are extremely varied, in terms of shape, position, size, precision, and surface quality. An example of precise technological identification of a machine tool is its operational specification, in which the surfaces to be manufactured are stated, along with all their characteristics. This is not possible for universal machine tools, since they are designed without specifying the parts and surfaces to be manufactured. A promising approach in that case is to design the processes on the basis of modules [3]. The focus then is not on the surface to be produced, but on the module of surfaces of the parts, which characterizes the design of the surfaces corresponding to general functions. The main benefit of this method is that the range of modules of surfaces is finite. This permits satisfactory identification of the machine tools (in terms of their function), in terms of the set of surface modules to be produced.

2. Main part

In this context, we propose the following method of technological identification in terms of surface modules. The initial data is the classification of the surface modules and the characteristics of the machine tool. In accordance with the rated data and the kinematics of the machine tool, possible shaping motions of the working elements and the system of shaping motions for each tool are established [4]. Then, the shapes of the surfaces that may be produced on the machine tool using the system of shaping motions are established. According to the classification of the surface modules, the structures formed by these surfaces are determined. Then, for each surface module, possible ranges of each characteristic are determined, in accordance with the machine tool specification, and hence we may establish the required position of the surface modules relative to the bases used to locate the blank in the machine tool. According to the classification, the list of surface modules manufactured on the machine tool is determined, with allowance for the ranges of their characteristics, and a code is assigned to each surface module in this list.

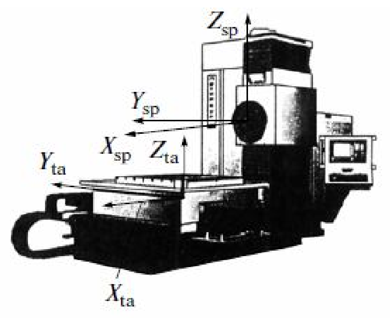


Fig. 1. LR620 horizontal boring mill

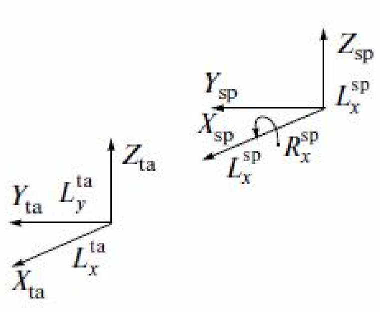


Fig. 2. LR620 horizontal boring mill shaping motions

As an example, let's consider the application of this method to the identification of an LR640F4 horizontal drilling machine (Fig. 1-2), with the following specifications:

Dimensions of the turntable working surface, mm	1250 ? 1250
Capacity of table, kg	6000
Diameter of drill spindle, mm	100
Spindle taper	50
Maximum displacement, mm:	
of table along X axis	1250
of table along Z axis	1000
of clamp along Y axis	1000
of spindle along W axis	710
Speed, rpm:	
spindle	1–1600
faceplate	1–160
Working supply along X, Y, Z, W axes, mm/min	1–8000
Speed of fast adjustment along X, Y, Z, W axes, mm/min	9000
Power of primary drive, kW least	22
Maximum torque at drill spindle, N m	1765
Maximum supply force along X, Y, Z, W axes, N	11 000
Dimensions (length ? width ? height), mm	7600 ? 3750 ? 3300
Mass, kg	1920

As follows from the ratings, the machine tool is intended for the following operations: the milling of planes, slots, and projections; drilling, reaming, centering, and countersinking of holes; boring out holes; thread cutting by taps; turning of surfaces; and the manufacture of end channels and recesses by means of a built in faceplate and programmed motion of the radial support. In formulating the function of the machine tool, we do not specify the complete list of surfaces that may be obtained or the precise range of values of the characteristics. In other words, we do not know the position of the surfaces in the machine tool, their shape and size, and the precision in terms of the size, shape, and roughness.

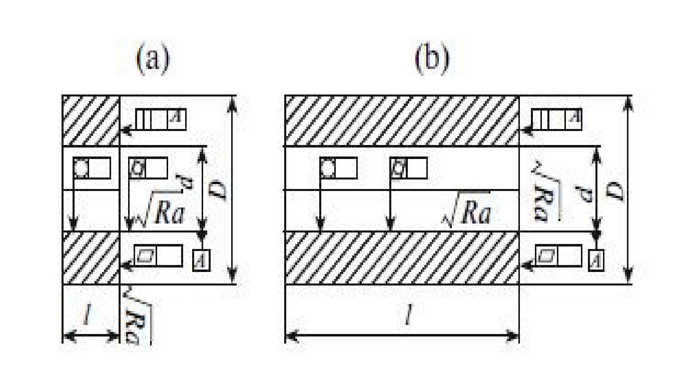
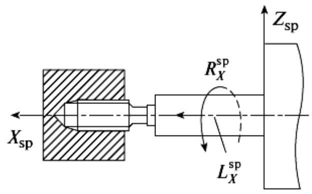


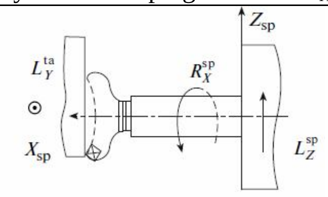
Fig. 3. B311.1 surface modules with l/d ≤ 0.5 (a) and l/d ≥ 2.5 (b): D = 8–1000 mm; d = 6–100 mm; l = 3–250 mm; ITd = 6–11; ITl = 9–12; Ra = 2.5–50 mm.

To determine the set of surface modules for the machine tool, we must first establish all the surfaces that may be manufactured using the machine tool.

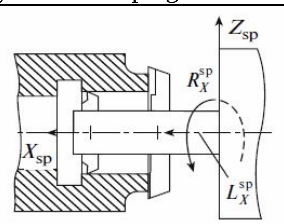
Table 1
Systems of shaping motions and surfaces produced



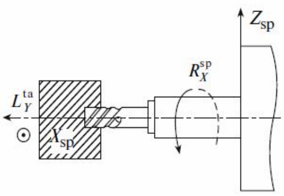
Thread cutting
System of shaping motions: R_X^{sp} L_X^{sp}



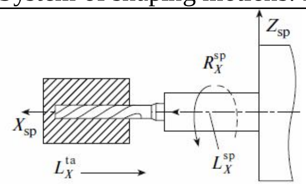
Contour milling of plane
System of shaping motions: R_X^{sp} L_Z^{sp} L_Y^{ta}



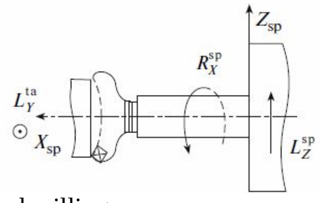
Reaming holes and slotting ends
System of shaping motions: R_X^{sp} L_X^{sp}



Slot milling
System of shaping motions: R_X^{sp} L_Y^{ta}



Hole milling
System of shaping motions 1: R_X^{sp} L_X^{sp},
System of shaping motions 2: R_X^{sp} L_X^{ta}



End milling
System of shaping motions 1: R_X^{sp} L_Y^{ta},
System of shaping motions 2: R_X^{sp} L_Z^{sp}

Table 1 presents the systems of shaping motions that may be implemented on the machine tool according to the ratings (disregarding the turntable and faceplate) and the surfaces that may be obtained for particular tools: mandrels with cutters for boring holes; bits for drilling, reaming, and centering; taps; mills for the production of planes, slots, and projections; and man drills with cutters for turning external cylindrical surfaces and cutting channels and recesses at the ends. On the basis of Table 1 and the classification of surface modules, we may determine the surface modules that may be formed by the manufactured surfaces, as well as their possible positions relative to the coordinate system of the machine tool spindle group. One such surface module is module B311.1, formed by surfaces corresponding to the end and a hole. Depending on the ratio of the hole length l to its diameter d, it may take two forms (Fig. 3). To establish the codes of module B311.1, we need to construct their classification, in terms of the dimension d, ratio l/d, and surface precision and roughness (Fig. 4). Each characteristic has a particular range of ances and fit in the shaft–hole joint. The precision of the surface module attained on the machine tool may be characterized by a range of quality scores. We assume approximately that the maximum possible score for the machine tool is 6. If we regard scores of 6–11 as economically expedient, we determine the set B311.1 of surface modules that may be manufactured on a horizontal boring mill. We select ranges of values of the machine tool characteristics and, on that basis, determine versions of surface module B311.1 that may be manufactured on the LR620F4 machine tool (denoted by thick lines in figure 3). According to the classification, the set of structural codes for the B311.1 module has the structure [1, 2].[1–12].[1–12].[1, 2]. In turn, the subset of structures of the B311.1 module manufactured on a horizontal boring mill is [1, 2].[2–10].[4–9].[1, 2].

Table 2
Types of surface modules manufactured on machine tool

Machining method motions	System of shaping	Tool	Type of surface modules
Reaming	R_X^{sp}, L_X^{sp}	Reaming cutters	B311,R121, S121
Milling	$R_X{}^{sp}$, $L_{Yt}{}^{a}$	Face and end milling	B11, B12, B311, R111, R112, S111, S112
Contour milling of planes	R_X^{sp}, L_Y^{ta}, L_Z^{sp}	End mill	B11,B12, R111,R112, S111,S112
Boring, boring out, and countersinking of holes	R_X^{sp}, L_X^{sp} R_X^{sp}, L_X^{ta}	Bits, countersinks	B311,R121, S121
Thread cutting by taps	R_X^{sp}, L_X^{sp}	Taps	B211, B221
Slotting ends	R_X^{sp}, L_X^{sp}	Slotting cutters	B311,R111, S111

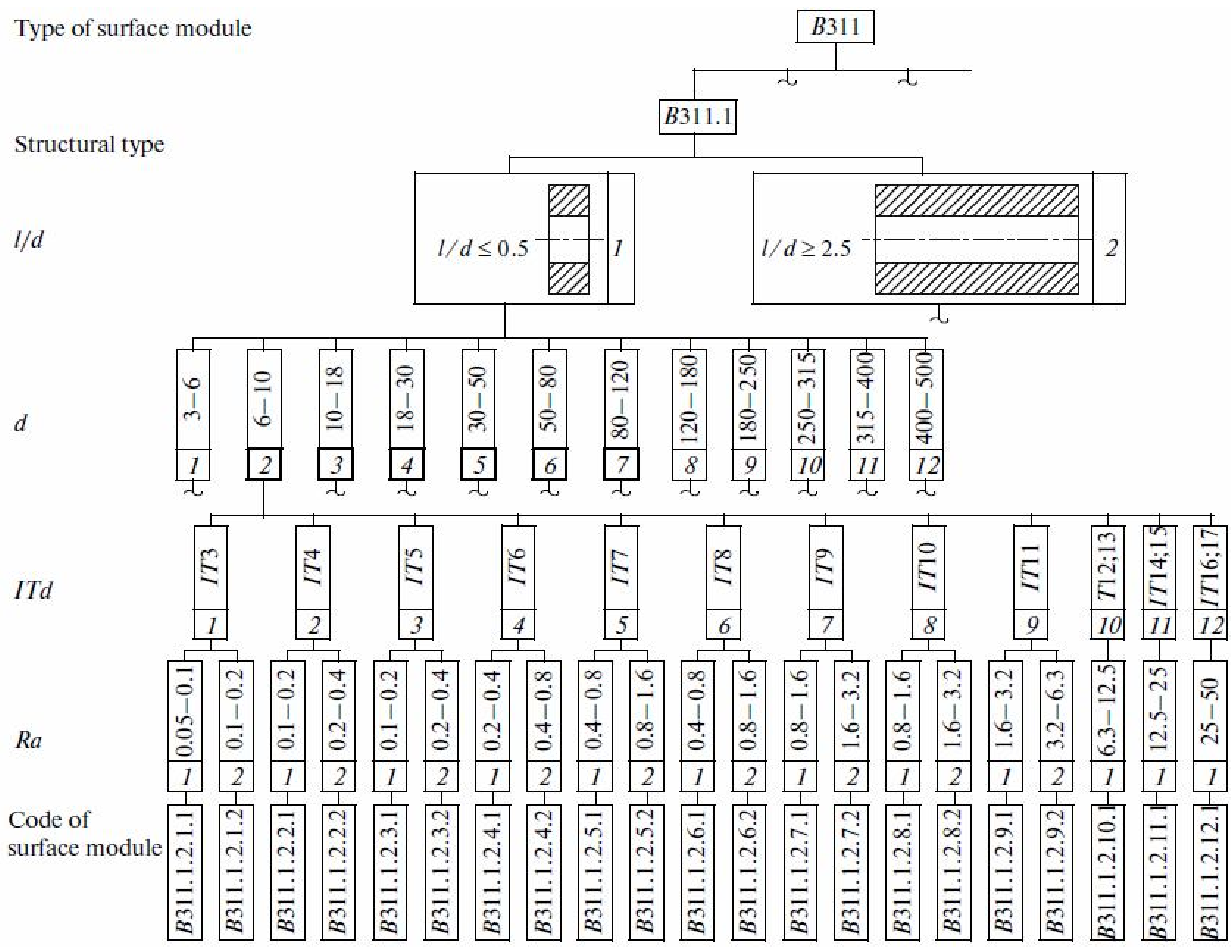


Fig . 4. Classification of B311.1 module

For example, for the B311.1 module, d = 60 mm, l = 20 mm; the precision of the hole diameter corresponds to a score of 7, and Ra = 1 ?m. Its code is 1.6.5.1.Knowing the code, we determine, on the basis of its structure, he subset of B311.1 modules that may be manufactured on the LR620F4 machine tool. Analogously, we determine the set of other surface modules that may be produced on the LR620F4 machine tool (Table 2). These data should be formulated as an appendix to the machine tool rating.

3. Conclusion

With access to such information, the designer of technological operations may determine the machine tools available at the plant from the relevant database, determine the possible range of models, and, on the basis of additional data, select the required machine tool.

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