Classification development for working modules of detail surfaces

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Abstract. The necessity for the development of a system of interrelated classifications of module surfaces was justified. Main distinctive features, based on which the general classification and the classification of module surfaces are developed, were determined. Examples of the development of the general classification and classification of one constructional types of working surface modules were provided.

1. Introduction
To produce machine components, an element base is required, which consists of technological support means required for the manufacturing of details. This base shall include manufacturing procedures, machines, devices, tools and instrumentation. The element base grounds on a product, by which is usually meant a detail. However, the detail as the product is almost unlimited in its variety, and this variety cannot be completely covered. Thus, it was proposed to use not a detail but a detail surface module (SM) as a product, i. e. a combination of surfaces, which are incorporated within the frame of the execution of a certain service function of the detail [1].

Unlike details, SM has a limited nomenclature, which includes twenty-six types of SM divided into three classes: base, working and joining SM. This classification allows developing of the element base of process facilities required for the SM manufacturing.

2. Methods
The classification development shall be started from the determination of a list of distinctive features of each SM class. The analysis shows that the intended service shall be accepted as a first distinctive feature. A second distinctive feature for the classification shall be functions, which SM executes for each option of its intended service. Then, other possible classification distinctive features shall be determined. At first, the general SM classifications shall be developed, for further obtaining of a set of SM construction types; after that, a specific classification for each certain SM construction type shall be developed.

Let us consider working surface modules (WSM), intended for the execution of detail work functions. For example, a tooth gear executes its intended service by means of involute, cycloidal or circular flanks of teeth.

The development of the WSM general classification starts from the determination of possible options based on the first distinctive feature, i. e. WSM intended service. The analysis of different production processes as well as machinery designs shows that WSM are intended for the following
operations: transmission of motion, processing of materials, storage, transfer and mixing of processing media, material grinding, and form transformation.

The second distinctive feature of the WSM classification are functions, which are performed by each group set according to the first distinctive feature. For example, according to the WSM intended service, the first group includes the transmission of motion. This group can perform the following functions: transmission of rotary motion, transmission of translation motion and transmission of compound motion.

The third distinctive feature is a mechanism, which executes the above function and intended service of WSM. These mechanisms include, for example, tooth gearing, camshaft mechanism, screw gearing, etc.

The following distinctive feature of the classification is a type of surface, contributing into the WSM intended service: flat, cylindrical, tapered, thread, profiled, etc.

The last distinctive feature of the WSM classification includes WSM constructions, which perform each function. Each surface type determined according to the previous distinctive feature will make a certain WSM construction. Each WSM construction determined in the general classification will be specified using an alphanumeric code, which present its intended service, performed function, containing mechanism and type of working surface.

3. Results

Let us consider the procedure of the general WSM classification development for the first intended service group, i.e. transmission of motion. In this case, the WSM functions are the following three motion patterns: rotary, translation and compound (rotary and translation) motion. Each of the above motions is performed by a certain mechanism by means of interaction of working surfaces of details, which compose this mechanism. The rotary motion is executed by a tooth gearing, as well as by key and slot joint.

As previously noted, in the tooth gearing, the rotary motion can be transmitted by evolvent or cycloidal working surfaces, as well as by means of circular teeth the specific WSM construction will correspond to each profile of the work surface (Figure 1).

**Figure 1.** Fragment of WSM classification according to the first intended service group
The WSM construction for the rotary motion transmission using the tooth gearing includes a set of tooth flanks of one of three profiles: evolvent, cycloidal or circular. For example, WSM construction for the rotary motion in the tooth gearing with evolvent working surface is shown in Figure 2.

![Figure 2. Two options of WSM22.1.1.1.1 formed by a set of left (A) and right (B) evolvent surfaces](image)

Depending on a direction of rotation of a transmission tooth wheel, two options of the WSM22.1.1.1.1 module are possible. Figure 2 (A) shows the module consisting of a set of eight left evolvent surfaces; Figure 2 (B), correspondingly, shows the module consisting of a set of eight right evolvent surfaces.

After development of the general WSM classification, proceeding to the development of classifications for WSM constructive types is possible. During the development of this classification, a blank material is the first distinctive feature; materials are divided into four large groups: steel, cast iron, nonferrous metals and heat-resistant alloys. The second distinctive feature is a general dimension or dimensional ration, which is specific for this WSM construction. Determine minimum and maximum possible values and divide the obtained range into intervals. The third distinctive feature will be the WSM construction accuracy characterized by a quality class or accuracy degree. The next distinctive feature is surface roughness, which is connected with the accuracy degree.

Let us consider the procedure of the classification development by the example of the constructive type of the WSM22.1.1.1.1 module (Figure 2). The blank material is the first distinctive feature: steel, cast iron, nonferrous metals and heat-resistant alloys.

The main dimensional characteristic of this WSM constructive type and the second distinctive feature will be a tooth module, which shows a diameter value of the initial circle corresponding to one tooth. This parameter is determined before the calculation of main parameters of the tooth wheel. According to GOST 9563-60 [2], seventy-six numerical values of normal modules, from 0.01 mm to 100 mm, are set for evolvent cylindrical tooth wheels.

The third distinctive feature is a number of evolvent surfaces contained in the construction of WSM22.1.1.1.1. to determine the number of the evolvent surfaces, size series of evolvent joints provided by GOST 6033-51 were used [3]. According to the standard, the number of evolvent surfaces can be within the range from 12 to 50, with a two-teeth interval.

The fourth distinctive feature will be the WSM accuracy, which is, according to GOST 1643-81 [4], characterized by twelve degrees of accuracy of tooth wheels and transmissions. For each accuracy degree, three accuracy standards are determined: index accuracy of the tooth wheels and transmission, smoothness of operation the tooth wheels and transmission, and gear tooth contact.
The result of the classification development will include many codes, containing information on materials, dimensional and accuracy characteristics of the WSM22.1.1.1.1 module (Figure 3).

![Figure 3. Classification of constructive type of the WSM22.1.1.1.1 module](image)

Then, the total number of the obtained set of WSM codes is divided into ranges; for each range, a certain processing procedure module will be determined. The SM processing procedure module (PM) is a list of auxiliary and process conversions with cutting modes required for the SW manufacturing. In its turn, the total number of obtained PM is divided into ranges, and each range is executed by corresponding machinery module and tool setup module, and is controlled by an instrumentation module.

Under this approach, during projecting of the detail manufacturing process, at first a detail drawing is decomposed into SMs, and during projecting of a processing technology for detail manufacturing, corresponding PM are selected from element base of process support facilities for SM manufacturing. This allows significant reducing of the labor required for projecting of the detail manufacturing process.

4. Conclusions

Thus, based on the study carried out the following conclusions can be made:
1. To develop the SM classifications, the general distinctive features of SMs shall be determined. These features are divided into three classes: SM intended service performed by SM and options of SM functions for each intended service.

2. The SM classification is ended with the set of SM construction options; each of them is designated by its own alphanumerical code.

3. For each SM constructive type, its own classification shall be developed, which considers possible SM options for material, dimensions and accuracy.

4. The available classifications of the SM constructive types allow developing of an own manufacturing process module for each SM option. This reduces about twice the labor required for projecting of the detail manufacturing process.

References

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