Formation of a batch of parts in the conditions of one-off and small-scale production

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Abstract. The article is devoted to increasing the efficiency of manufacturing a batch of parts by optimizing the sequence of their production. It is shown that the effect of the sequence of manufacturing parts in a batch on efficiency is manifested through the time spent associated with transitions to the manufacture of parts of different names. The criterion for the optimal variant of the sequence of manufacturing parts in a batch is the minimum time spent on changing technology during transitions to the manufacture of parts of different names.

The purpose of forming a batch of parts is to increase the efficiency of their manufacture by reducing the variety of technology and increasing its repeatability.

Under the formation of a batch of parts we mean the grouping of homogeneous parts and manufactured in a given sequence.

In practice, the formation of batches of parts is implemented using standard and group technologies [1-6].

The main task of the typical technology is to reduce the labor intensity of the technological preparation of production.

In this regard, the grouping of parts is made in such a way that structurally similar parts with similar characteristics are included in one group, followed by the definition of a part - a representative [7], under the production of which a typical technological process is being developed, which is used in the development of technological processes for each part in the group.

The grouping of parts by design features is carried out by dividing them into a number of the following classes: shafts - V (smooth, stepped shafts, spindles, axles, pins, etc.); bushings - A (smooth bushings, stepped bushings, liners, sleeves, collets, etc.); discs - D (flat parts of rotation); plates - P (bodies, beds, frames, tables, strips, etc.); eccentric parts - E (eccentrics, crankshafts); levers - R, etc. Details of each class are subdivided into groups, subgroups and types. This classification is the basis for the typification of technological processes [1, 2].

Group technology pursues the goal of increasing the efficiency of operating technology by combining parts into groups containing the same surfaces, manufactured at one workplace.

Thus, the formation into groups is carried out according to the generality of processing workpieces in the corresponding operations. When forming a group, one should take into account the following [3, 4]:

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• The generality of structural elements that form the configuration of the part (threads, chamfers, grooves, cylindrical outer and inner surfaces).
• Accuracy and roughness of surfaces.
• Homogeneity of the workpiece material, which allows the use of the same machining method and common tool for machining all parts of the group.
• The proximity of the dimensions of the workpieces, which allows processing on the same equipment using the same devices (group, readjustable and others).
• Serial production and labor intensity of parts processing.

Thus, typical technology includes structurally similar parts, and group technology includes structurally inhomogeneous parts, but containing groups of identical surfaces.

But in both cases, the parts are different both in design and in characteristics. This leads to a difference in the schemes of basing their workpieces, fixtures, processing methods and processing tools.

In both cases, there remains a reserve for increasing the efficiency of their manufacture, which consists in establishing the optimal sequence for the manufacture of parts in a batch.

The influence of the sequence of parts in a batch on the efficiency of their manufacture affects the time spent on transitions to new technologies in the manufacture of other parts of different names.

For example, when switching to the manufacture of the second part in a batch, it will be necessary to change the machine tool to install the workpiece, and when switching to the manufacture of the third part, you will need the machine tool used in the manufacture of the first part [8].

Hence it follows that it is advisable to produce a third part after the first part, and not the second part.

In practice, the sequence of parts in a batch is usually determined by the type of the structural form of the parts, assuming that the change in technology during transitions to the manufacture of new parts will be minimal.

For example, body parts are made first, then parts such as caps, etc. However, this sequence of parts to be produced may not be optimal. It may be more efficient to manufacture a cap as a second part.

Therefore, depending on the sequence of production of parts of different names in the batch, the efficiency of the batch of parts produced can vary significantly.

And the wider the nomenclature of manufactured parts in a batch, the greater the difference in the production efficiency of a batch of parts, depending on the selected sequence of parts production.

This is mainly due to a change in the labor intensity of work associated with a change in the technology of transition from manufacturing parts of one name for the manufacture of parts of another name.

These works are associated with a change in certain elements of the manufacturing technology of parts.

So, the problem arises of lining up parts of different names in a row to minimize the labor intensity of work associated with the transition from the manufacture of a part of one name to the manufacture of a part of another name.

In connection with the foregoing, as a criterion for determining the sequence of manufacturing parts of different names in a batch, one should take not the constructive similarity of parts, but the minimum laboriousness of work associated with transitions to changes in the technology of manufacturing parts of another name.

When determining the sequence of manufacturing parts in a batch, the initial data should be drawings of parts in the batch, the machine tool park of the enterprise, technological equipment and technological processes for manufacturing parts of each name, and the laboriousness of changing technology elements associated with transitions to the production of parts of other names.
In table 1, as an example, an operational map of grinding the surface of a shaft is given, according to which the elements of the manufacturing technology of parts that can change during the transition from the manufacture of a part of one name to the manufacture of parts of another name include:

- change of devices for workpiece installation;
- changing the processing tool;
- changing the control and measuring device;
- changing the processing mode;
- setting the machine for the accuracy of the part.

Table 1. Operational chart of shaft surface grinding.

| №  | Transition                   | Cutting tool                  | Measuring tool                | Estimated size, mm | Processing mode |
|----|------------------------------|-------------------------------|-------------------------------|--------------------|-----------------|
|    |                              |                               |                               | Diameter, mm       | S, mm/rev       | n, rev/min     | V, m/min         |
| 1  | Install the shaft in the center |                               |                               | 35                 | 0.2            | 0.2           | 380 35           |
| 2  | Sand surface 1               | Grinding wheel PL500×50×305   | Indicator bracket D=50mm      | 30                 | 0.25           | 0.2           | 380 35           |
| 3  | Sand surface 2               | 24A10PS2 35m/s 1kl A GOST2424-75 |                               | 6                  |                |               |                  |
| 4  | Remove part                  |                               |                               |                    |                |               |                  |

Each of the listed technology elements is characterized by the corresponding time consumption (see table 2).

Table 2. Elements of technology that change during the transition to the manufacture of a new part.

| №  | Technology element                          | Time (t) |
|----|--------------------------------------------|----------|
| 1  | Machine change                             | T_s      |
| 2  | Change of machine tool                      | T_p      |
| 3  | Changing the processing tool                | T_i      |
| 4  | Change of control and measuring device      | T_n      |
| 5  | Changing the processing mode                | T_r      |
| 6  | Adjustment for machining accuracy           | T_b      |

When determining the best sequence for manufacturing parts in a batch, there will be a sequence in which the total laboriousness of changing the above elements of technology in the manufacture of the entire batch will be minimal.

During transitions to the manufacture of parts of different names, various combinations of changing technology elements are possible. For example, in one case, you will have to change the machine tool, assign other processing modes, and in the other case, change the machine tool and part of the processing tools [9].

The task of determining the optimal sequence for the manufacture of parts of different names in a batch includes the following steps:

- determination of all possible options for the sequence of manufacturing parts of different names in the batch;
calculation of the amount of time spent on changing the manufacturing technology of parts during transitions to the manufacture of parts of different names;

determination of the sequence for manufacturing parts of different names, which has a minimum amount of time spent on changes in technology during transitions to the manufacture of parts of different names.

The problem of determining the optimal variant of the sequence of manufacturing parts of different names of a batch of parts is solved by enumerating options.

- the reserve for increasing the efficiency of manufacturing a batch of parts is the optimal sequence of manufacturing parts of different names;
- the sequence of manufacturing parts of different names in a batch determines the time spent associated with changes in technology during transitions to the production of parts of different names;
- as a criterion for the optimal sequence of manufacturing parts in a batch, it is necessary to take the minimum time spent on changing the technology during transitions to the manufacture of parts of different names;
- the optimal variant of the sequence of manufacturing parts in a batch is determined by enumerating all possible variants of the sequence of parts.

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