The Cheremkhovo K. Marx Engineering Plant, which manufactures deep-bore pumps, is now engaged in a modernization scheme involving the reorganization of the machining of the pump head parts and is installing a group production line* of machining 3 different impellers. The line has been developed at the MNIPTImash in Kemerovo. In developing this line the problem was to improve the machining accuracy in order to reduce cost and provide for interchangeability.

Figure 1 shows examples of six impeller groups selected on the basis of their machining, inspection, transportation, planning, assembly, and operation features. The impellers are solids of rotation of the stepped disk type, having a central bore. The impeller flow channels are the functional surfaces. The diameter of the impellers is 112-380 mm and their width is 34-140 mm. The blanks used (made to 3-2nd class of accuracy) are cast from iron, steel, or polystyrene. Net weight of impellers is 0.14-9.5 kg, the machining accuracy of 2-3rd class, and the maximum surface finish of 6-8th class. According to the part size, the unbalance should not exceed 1.5-100 g.cm, and the eccentricity of working surfaces should not be over 0.025-0.075 mm.

The machining processes and tools used at present at the Plant fail to produce the necessary coaxiality of the working surfaces and also the required balance. The reason is an incorrect balancing during the first turning operation and bad blanks. Observations showed that during the machining of unbalanced blanks and the removal of the nonuniform machining allowance, a disproportional copying of errors takes place caused by the cutting force, centrifugal force, inertia, and gyroscopic effect, i.e., by the moments of forces generated by the displacement of the axes of the parts being machined. This displacement is due to an inadequate rigidity of the system machine tool – fixture – tool – part.

* O. F. Borodokina, I. P. Bessarabov, and A. T. Shiskin took part in the development of the manufacturing process.

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Upon recommendations [1] it has been decided to adopt the functional surface of the impeller, i.e., the flow channels, as the reference surface for the first turning operation. For this purpose, a pneumatic chuck (Fig. 2) was developed for use with all impellers of the group.

In order to eliminate the effect of the inadequate smoothness of the blank (casting) on the quality of mounting, the blank is now rough-machined in a fixture (Fig. 3). The rocking clamp of this group fixture is placed into the turret head of the 1P365 lathe using an adapter bushing. A floating mushroom device is used for centering the impeller. When the turret head has been operated, the rocking clamp moves against the part pressing at it by pins 2 against three supporting pins 7 with knurled ends; these pins are fixed in the body. The body is secured to the adapter face plate and thereby to the machine spindle.

The adjustable fixture, shown in Fig. 4, has been designed for machining tapered surfaces; it is mounted in the turret head of the 1P365 machine. The required taper angle is set by rotating the body about axis 6 and advancing the rod, connected to the body, by shaft 5 held in position by a pin. The cutting tool is mounted on the tool slide by means of bolts. Tool feed to the part is by turret head. The cross feed of the tool is effected by a pusher mounted on the cross slide tool holder. During its motion the pusher travels against the slide and moves it in the transverse direction along the guide plane of the body which, in turn, is connected to the slide by a "dove tail." While moving along the body the slide compresses the spring mounted on shaft 4. On completion of machining the turret head is retracted and the slide returns to its starting position.

According to the machining method used, the heavy part of the impeller causing the unbalance is determined by balancing on knife edges and the excess metal is removed on a 1A62 lathe. To shorten this operation an original balancing device has been designed for use with all impellers of the group; with this device the balancing of the part to equilibrium can be effected without removing it from the machine.

The manufacturing process provides for the use of the existing machine tools. The Institute also compiled technical specifications for the modifications of some machines: MK-62 copying lathe, 1425 turret lathe with an adjustable group machining device, and the MS979 balancing machine for static balancing under dynamic conditions.

Pin-type transportation and storage equipment is used to prevent damage to parts. In simultaneous machining in some cases the transportation between operations is in multichannel chutes. A day schedule is used in the operation of the line. The design provides for the use of modern control equipment.