Improving the performance of the processing of deep holes by improving the structure of the boring tool

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Abstract. The experimental and industrial testing of the developed design of a new boring mandrel for processing deep stepped bores in the body workpieces of gray cast iron has been performed. The boring mandrel is characterized by high rigidity and fast replacement of cutting plates. The use of the mandrel in the current production of the GAZ Group of enterprises allows three to four time increase in the productivity of boring holes in the large-scale production of cylinders.

Boring of deep stepped holes in workpieces of body parts in the current production are among the most time-consuming. As a rule, this is due to the need to simultaneously ensure a minimum drill run-off of the entire hole and strict tolerances for mismatch of the axes of short cylindrical sections. The problems of ensuring the alignment of short cylindrical sections of the hole become less relevant when their formation is carried out on lathes, but the issues of reducing the drill run-off, on the contrary, become complicated.

The purpose of this work is to develop a new design of a boring mandrel, which, in the context of large-scale production, will ensure boring the holes in the body workpieces of blocks of cylinders of automobile engines made of gray cast iron with the highest possible performance.

Increasing the efficiency of the tool when boring deep holes is possible under the following conditions:
- facilitation of chip removal conditions;
- transportation of cutting fluid (coolant) in the area of direct contact of the cutting plates with the workpiece;
- reducing the weight of the boring mandrel body while maintaining its rigidity;
- creation of the anti-vibration geometry of the entire boring tool.

A significant share of the parts related to the power components of machines, namely blocks of cylinders and camshafts made of various metals have a complex spatial shape with a large number of stepped holes and flat multi-faceted surfaces. As a rule, when processing workpieces of this kind of parts, especially in the preliminary and semi-finishing operations and during the transitions, they alternately use a significant number of tools (Figure 1).
In the context of the large-scale and mass production, one-piece tools of stepped monolithic design find their application much more often.

The analysis of many designs of one-piece tools developed in Russia (USSR) and abroad for boring operations in the large-scale production and approbations of prototypes under industrial conditions allowed offering the following option (Figure 2) for practical implementation during the formation of deep step holes in the block of cylinders of the automobile engine [2].

As follows from the design presented in Figure 2, the decrease in the weight of the one-piece tool is achieved, on the one hand, by forming a central hole for coolant supply and inclined holes for coolant supply to the areas of direct contact of cutting carbide plates with the workpiece, on the other hand, by forming of a mandrel of four rectangular grooves on the body [1]. This shape in the form of a tetrahedral cross-section mandrel with a central hole has four times less weight compared to the one-piece mandrel of a continuous cylindrical section at practically the same rigidity and significantly better placement conditions of the formed chips. Application of the anti-vibration geometry (Figure 3) and different thickness of feathers (Figure 4) in the design of the tool allows reducing the deviation from the geometric shape of the holes (which is especially important in the assembly) and ensuring a uniform roughness (up to Rz10) on all machined holes. To reduce the load on the cutting plates in the design of the mandrel, the use of the maximum possible number of teeth (4 pcs.) on each dimensional diameter is provided.
The application of widely used at enterprises combined tool type BIG KAIZER (see Figure 1) built up of three to five transition stages to obtain the necessary outreach to 500 mm significantly increases the load on the working parts of the equipment due to the high weight that consequently causes an increase in resonant vibrations at the end of the tool.

In this paper, the example of processing of a block of cylinders (Figure 5) shows the prospects for the use of the new design of the one-piece boring mandrel with internal coolant supply for rough boring (developed by HALTEC) that solves these problems [3].

Initially, the goal was to achieve the maximum performance along with satisfactory quality of the processed surfaces and resistance of the cutting plates (SMP/CMP) for boring holes of different diameters [4]. The workpiece used is grey iron casting (SCH24/C424) with an allowance of 0.2 - 2mm on the side of the hole to be bored.

Table 1. Comparative characteristics of the boring tools used in the pilot industrial tests

| Name of components | BIG-KAIZER combination tool | HALTEC monolithic tool |
|--------------------|-----------------------------|------------------------|
| Hole boring D51.5mm. | Basic mandrel HSK-A100 X CKS4 X 160 | 1. Mandrel - holder HSK100 |
|                     | Extension CKB4 X CKB4 X 120 SD | 2. Rough boring |
|                     | Boring head SW 41-54(66) X CK4 | 3. Plate CCMT09T308 K20C |
|                     | Cutter (set) 41/54 SW41 CC09 | |
|                     | Plate CCMT09T308 K20C | |
|                     | Tube for HSK100 coolant supply | |
| Hole boring D52.5mm. | Basic mandrel HSK-A100 X CKS4 X 160 | |
|                     | Boring head SW 41-54(66) X CK4 | |
|                     | Extension CKB4 X CKB4 X 120 SD | |
|                     | Cutter (set) 41/54 SW41 CC09 | |
|                     | Plate CCMT09T308 K20C | |
|                     | Tube for HSK100 coolant supply | |
| Hole boring D53.3mm. | Boring head SW 41-54(66) X CK4 | |
|                     | Cutter (set) 41/54 SW41 CC09 | |
|                     | Plate CCMT09T308 K20C | |
| Hole boring D54.5mm. | Boring head SW 41-54(66) X CK4 | |
|                     | Cutter (set) 41/54 SW41 CC09 | |
|                     | Plate CCMT09T308 K20C | |
|                     | Tube for HSK100 coolant supply | |
| Making chamfer 1x45° | Chamfer D12mm length 100mm | 1. Chamfer D12mm length 100mm |
|                     | Plate CN12 | 2. Plate CN12 |
| Number of components, pcs. | 16 | 2 |
| Number of cutting plates, pcs. | 9 | 20 |
| Weight of the combined structure (total), kg. | 19.3 | 4.5 |
| The load on the machine spindle (medium), % | 20-25 | 10-15 |
| The number of tool changes, pcs. | 5 | 1 |
The technology implemented at the enterprise using the combined tool BIG-KAIZER is associated with frequent change of boring blocks and has a large number of changeovers during the transition from one bore diameter to another. This obviously affects the high time spent on the manufacture of a cylinder block.

Now, the completion of these operations takes $T_{mash} = 12$ sec. (+ frequent tool changes of 6-10sec.). The newly developed tool (Figure 6) allows reducing the machine time up to 4-6 sec., which gives 3 to 4 time increase in productivity [5]. This result is particularly effective during the work on automatic and large-scale production lines.

![Figure 6. Boring tool DX100.052.B40-525 HALTEC.](image)

**References**

[1] Rodin P R 1986, *Metal cutting tools* (Kiev) p 455.
[2] Lazarev D E, Nasad T G 2011 *Cutting tools for improving of quality and productivity of precise holes processing* (Saratov) pp 80 - 83.
[3] Inozemtsev G G 1984, *Designing of metal-cutting tools*, p 272.
[4] Ryzhkin A A, Shuchev K G, Skhirtladze A G 2009, *Textbook* (Rostov n D) p 405
[5] Kozhevnikov D V, Grechishnikov V L, Kirsanov S V, Kokarev V I, Skhirtladze A G 2005, *Cutting tool*, p 528.