Development and analysis of tool design for precision blind holes

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Abstract. Precise blind holes are very often used in machine part designs. As a rule, these holes are processed using CNC machines using various operations, or sequentially with various tools, which is the least cost-effective in contrast to a multi-function CNC machine. Comprehensive processing is a fundamental and crucial factor.

1. General about the processing of precision blind holes, as well as the features of this wood processing

Drilling is the machining of parts to produce blind or through holes. Drilling is carried out using a tool (drill) both manually and on machines.

Drilling is not the basic method of wood processing; it is more common in the manufacture of cabinet furniture, and more specifically for the formation of nests or holes in the product, in order to further connect the parts.

Drilling of wooden products is carried out according to the method of marking the centers of drilling holes - the centering tip of the drill (center, burrow, sting of a spoon drill) must be installed exactly in the center of the drill hole [1-4].

During drilling operations, the following should be considered:
1. First, the drill is attached to the chuck, and then the tip is brought to the intended center of the hole. It is important that the axis of the drill coincides with the axis of the projected hole. In order for the task to be successfully completed, the workpiece to be processed must also be firmly fixed.
2. The drilling process always starts at low speeds. It is necessary that the tool enters the material slightly and not harshly. The drilling process should go smoothly and without creating jerk motion. The drill pressure will gradually increase and as a result the hole will be drilled to the end.
3. When processing wood, it is not necessary to cool the tool with an emulsion, as when processing metal. It is only necessary shut down the tool frequently and durably in order to avoid a rise in temperature and subsequent ignition of the material.
4. When a through hole is being worked on, it is important to monitor the drill exit from the hole. The final process should be gradual, with a decreasing speed. The aim is to reduce the possibility of chip formation.
5. When processing through holes in large-sized products, the drilling operation is carried out from two sides. During processing of the facing material, it is important to be careful and accurate as much as possible.
6. If the drill seizes during processing of the product, it is necessary to set the reverse rotation process and pull the tool out of the hole, and eliminate seizing at the end.
7. During the processing of deep holes, the tool should be removed and cleaned periodically.
8. Holes of large diameters are drilled in two passes. First, with a tool with a smaller diameter to a small depth, and then with a drill of the desired diameter to the design level.
9. During operation, the drill wears out and needs periodic sharpening. Sharpening of drills is carried out on an abrasive stone.

The widespread use of CNC machines, and in the future the creation of automated workshops and manufactures on their basis, puts forward new requirements for both the preparation of production and the development of technological processes for manufacturing parts [3].

2. Development and analysis of the design of the tool for processing precision blind holes

The accuracy of processing affects the degree of conformity of the geometric dimensions of the finished part with the geometric dimensions specified in the drawing [1].

 Obviously, it is impossible to get exactly the same dimensions for several parts, but when choosing a decent tool, achieve maximum manufacturing accuracy can be achieved.

One of the influential and current factors in improving the accuracy of manufacturing parts is the constant modernization of the tool that processes the projected.

This paper considers the Forstner drill as a prototype tool. This tool has two significant advantages over other woodworking tools:

- very clean drilling;
- thanks to the cutting rim, chips are practically not formed.

During the operation of the Forstner drill, the walls of the hole in the product are smooth and the bottom is flat. This factor is very important in the manufacture of candles or hiding the screw heads.

It should also be noted that, unlike traditional drills, the tool in question maintains its direction precisely due to the rim, and not due to the central tip, due to which accuracy and precision are achieved when machining holes that overlap at the end or at the edge [2].

The Forstner drill has a cylindrical guide surface, two main end blades, and two auxiliary blades intersecting the guide surface (figure 1).

![Figure 1. Forstner drill prototype.](image)

The presented prototype includes the following design solutions. The centering element is presented in the form of a centering drill; at the end of this element, a centering drill with a tapered end of the tail is placed. The main cutting part consists of two end blades. Both blades are responsible for machining the part, leaving an allowance for clean blades. In order to reduce the width and volume of the chips, spiral grooves are provided. The lateral part of the surface of the instrument is spiral blades. These blades are a continuation of the main blades. Additional blades also have their own similar chip grooves. The tool shank is made in the form of a standard Morse cone. The geometry of
all blade elements meets all the requirements for metal processing. Metal cutting issues include and summarize data on metal cutting processes, information on the design, material and use of cutting tools, based on the design, kinematics, dynamics and proper use of metal cutting machines [6].

Figure 2 shows a model of the tool.

The developed tool is capable of performing three combined transitions [5]:

- centring;
- face drilling;
- hole calibration.

The efficiency of the tool was calculated using the Compass – 3D software package - the APM FEM strength analysis system. The calculation results are presented in figure 3.

Information about the installed loads is presented in table 1 [7].

| Name title | Selected objects | Load parameters |
|------------|------------------|-----------------|
| Pressure: 1 | Facets: 17       | Value: 250 H    |
| Pressure: 2 | Facets: 17       | Value: 250 H    |
Distributed force: 2 Facets: 17
Force vector:
X = 0; Y = 1; Z = 1
Value: 1.421214 H

Distributed force: 3 Facets: 19
Force vector:
X = 0; Y = -1; Z = 1
Value: 1.421214 H

Figure 4 shows the stress distribution.

Figure 4. Stress distribution.

3. Conclusion
The calculation shows that the rigidity and strength of the tool is provided with:

- a modified tool that enables to produce a larger number of holes [7];
- obtaining the blind hole shape with a flat bottom the first time;
- obtaining high accuracy of the cylindrical part of the hole;
- increased productivity of processing parts.

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References
[1] Aleksandrov N M 1978 German-Russian Dictionary of Mechanical Engineering. Machine tools and metal processing tools (Moscow: KUBUCH) p 290
[2] Ashkinaziy Ya M 2003 Centerless circular grinding machines. Constructions, Processing and Editing (Moscow: Mashinostroenie) p 352
[3] Balla O M 2015 Processing of parts on CNC machines. Equipment. Rigging. Technology (Moscow: Lan) p 368
[4] Baryshev I V 2013 Joiner's works. Wood processing technology (Minsk:Vysheyshsaya shkola)
[5] Vereina L I 2002 *Machining on planing and mortising machines* (Moscow: Mashinostroenie) p 678

[6] Isaev P P 2012 *Metal cutting (metal cutting, cutting tools, metal cutting machines)* (Moscow: Mir) p 659

[7] Levadnyi V S 2003 *Wood processing on machines* (Moscow: Adelant) p 384