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Modeling of the cutting head for treating holes in the railway

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Abstract

Research of porting operations made by new metal-cutting instrument – a sectional tool head with asymmetrical hard alloyed plates of different width – of holes in railway rails. The tool head has an enhanced durability, productivity, precision and decrease the form deviation and the roughness of surface proceeded. In the article the principle of work and the design are described, and the engineer analysis of the proposed instrument is conducted via APM WinMachine. The application of modern software allow to design instruments with quality, reliability and competitiveness and to make functional decisions based on a comprehensive engineer analysis which enhances quality of design decisions, reduce the time for instrumental production tooling and research the diversity of cutting modes and parameters of the instrument on a model, and indicate the design weaknesses without a full-scale test.

Keywords: Turning; hole; Cutting head; Discrepancy

1. Introduction

The processing of holes occupies a huge place in the total volume of machining, since most parts and mechanisms have round holes, both fastening and landing, to which high demands are placed on the accuracy of size, shape and location is one of the topical problems of machine building.

The holes are machined with metal-cutting tools: drills, countersinks, scrapers, broaches, boring cutters, blocks

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and boring heads. Depending on the requirements for the accuracy of the holes, the appropriate tools are used. Drilling and reaming are preliminary operations, the rest - finishing operations [1-3].

Standard drills having spiral or straight flute grooves, as well as perforated drills used to drill holes in a continuous material, have a number of drawbacks associated with the construction of the cutting part and the profile of the cross section.

The process of drilling with existing drills takes place under severe cutting conditions: chip removal and supply of cutting fluid are difficult because of the considerable friction of the chips on the surface of the drill grooves and the drill itself on the treated surface. The back angle is not a constant value - it increases as you approach the center. Very unfavorable is the value of the front angle at the transverse edge. At standard spiral drills, the front angle on the transverse edge is up to minus 57-60. Therefore, on the transverse edge, which takes up to 80% of the axial force, there is a crushing, squeezing and scraping of the metal instead of cutting.

Numerous ways of forming the cutting part and the transverse edge do not fully eliminate forces acting on the transverse edge, the front angle on the transverse edge decreases, but still remains negative. These working conditions of the transverse edge significantly worsen the processing conditions, the quality of the machined hole and do not give a radical solution to the issue of improving the quality of processing, productivity, and improving the tool life. High heat generation during drilling and abrasive effect lead to a reduction in cutting speed and increased wear of drills.

Improvement of cutting conditions during drilling led to the development of directions: improvement of the cutting part of existing drills; the development of a new, modified structure of drills that have a different cross-sectional shape and the development of special cutting tools that have a fundamentally new design.

For the machining of precise cylindrical holes on the machines of the drilling, turning, boring groups, a finishing axial tool is used - incisors, which are one of the tools for the machining of precise holes.

When designing new designs of a metal-cutting tool, they try to improve their geometric parameters and structural elements, and also use materials with increased cutting properties and new materials [4-12].

2. Principle of operation and description of the precast head construction

All the cutting head is a new high-performance metal cutting tool for turning solid holes, the cutting part of which is made in the form of incisors, the arrangement and design of which allow replacing the drilling with end turning using all the advantages of turning before drilling.

The tool has increased stiffness, does not have a transverse edge, the cutting work is evenly distributed along the length of the blades, the specific pressure and temperature in the cutting zone decrease, which increases the durability and improves the quality of processing by performing smoothing elements on the body allowing to reduce deviations from roundness of the hole and roughness, and the accuracy of processing is much higher due to the absence of destabilizing effect of the transverse edge.

Analysis of the design of the incisor head showed that the use of hard alloy plates with their fastening to the body with screws simplify the design and manufacturing technology.

The design of a combined cutting head with fastening of incisors made of hard alloy to the body with screws is developed, which will make it possible to replace as a result of wear and increase the life due to re-sharpening and increase the tool life.

In the precut head the carbide inserts are located one – to the center, the other - to the periphery. Because of this, the torque on the left and right parts of a different size, which leads to vibration and imbalance, and, consequently, the quality and precision of processing decreases.

To balance the torque, a combined tool head with asymmetrically arranged carbide inserts of different widths, fixed with screws on the body [11].

The cutting part is made in the form of hard-alloy plates of different widths, which contributes to the stability and quality of hole machining, provided that the equilibrium torques are balanced due to free end turning under cutting conditions inherent in turning, which are much lighter than when drilling under unfavorable geometry, scraping and extrusion by the transverse edge of the material instead of cutting, elevated temperatures, cutting forces and increased wear of the tool, as well as due to the convenience and ease of manufacture.

When the cutting head is operated, each cutter removes the chip layer as follows: with two incisors, the inner cutter forms an opening cylinder of approximately 0.5 the diameter of the hole, depending on the adopted ratio of the width of the incisors. The external cutter cuts off the shavings at the annular portion of the hole being machined, remaining after the passage of the inner cutter. The absence of a transverse edge significantly improves the cutting conditions and improves the quality of the processing. Guide elements on the body of the head allow to improve the quality of the surface of the hole. Greater tool rigidity and smoothing increase the accuracy and quality of the hole surface.

The material of the cutter assembly: cases – Steel 45 in accordance with GOST 4543-2016, and hard alloy plates – hard alloy T30K4 in accordance with GOST 3882-74.

The efficiency and quality of hole machining is ensured by free face turning under the condition of equilibrium of the twisting end moments of the outer and inner plates.

In order to balance the twisting end moments of the outer and inner plates, the width of the inner plate should be 1.22 times greater than the outer plate.

3. Tool design using CAD / CAE systems

At present, the problem of combining in the design process two mutually exclusive trends is topical: saving material, on the one hand, and ensuring the required strength characteristics of structures, on the other hand. All this can be achieved through the use of computer technology. Today, it is impossible to create high-quality, reliable and competitive equipment without a comprehensive engineering analysis of the projected facilities with the help of modern software and the adoption on its basis of competent design solutions. Engineering analysis is understood, first of all, to study the stress-strain state of models of designed structures, to obtain their dynamic characteristics and stability characteristics under constant and variable external loading regimes.

The most effective approximate method for solving such a class of problems is the finite element method (FEM). MCE is implemented in such well-known and widely distributed software products that provide strength analysis of model designs, such as ANSYS, NASTRAN, COSMOS and some others. These are very powerful software tools, but they are also not cheap, besides having an English-speaking interface. In addition, the editors of the models of these packages are very complex and require a long preparation of the user. The domestic module of finite element analysis APM FEM, which is part of the CAD / CAE system of APM Compass 3D, is in some ways an alternative to these software products [13, 14].

On the basis of the above, for comprehensive engineering analysis, we perform the strength calculation of the combined cutting head to accept the 3D APM FEM Compass.

Initial data for analysis: head housing material - Steel 45, carbide plate T30K4. The working diameter is 60 mm, s = 1.4 mm / rev; n = 160 rpm, t = 0.5 mm. Load parameters for four plates: Px = 656 N; Py = 1144 N; Pz = 1836 N; T = 754 0C, the material being processed is steel 45. We fix it on the shank of the case.

The process of preparation for strength analysis consists of several stages: the creation of a 3D model; assigning material parameters to the component parts; simulation of operating loads; setting of supports (fastening); definition of coincident surfaces of parts. The system automatically simulates the CE network and assigns parameters.

Then the calculations are performed: static, thermal or fatigue, depending on the specific conditions.

Analysis of the results of the strength calculation showed that the use of a combined cutting head with carbide inserts of different widths gives smaller elastic depressions than with the same ones, which increases the accuracy and quality of machined holes in machine parts.

The use of a combined cutting head with carbide inserts of different widths gives a smaller displacement compared to the same plates, and, consequently, a deviation in the longitudinal and cross sections is 1.2 times, i.e. the accuracy and quality of the machined holes increases. In addition, the load on carbide inserts is reduced by 1.2 times and the strength is increased by 1.1 times, which increases the tool's durability and its service life.

4. Results and discussion

Computer simulation and based on the distribution of operating cutting forces on carbide inserts have established their balancing and leads to the equality of moments, uniform rotation during machining, reduction of vibration and vibrations, and, consequently, a decrease in the error and an increase in the accuracy and roughness of hole machining.

During the design, structural and geometric parameters are established, working drawings are developed and prototypes are produced - a chisel head assembly with hard-alloy plates of different widths.

After carrying out experimental studies of the holes, the parameters and dimensions will be refined and corrected.

5. Conclusion

The combined cutting head with asymmetrically arranged hard alloy plates of different widths increases the durability, efficiency and quality of hole machining, provided that the equilibrium of the torquing torques and the cutting conditions inherent in turning are much easier than when drilling under unfavorable geometry, scraping and extrusion with the transverse edge of the material instead of cutting, high temperatures, cutting forces and increased tool wear.

The use of the Compass 3D APM FEM system for the strength calculation of metal cutting tools can improve design productivity and investigate its multi-variance.

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