Application of Drill with Replaceable Head and Identification of Specific Type of Wear

Milan Matúš, Michal Adamik, Vladimír Kročko, Maroš Korenko, Pavol Findura

Abstract. *This paper describes the basic criteria of tool selection, supplemented by experience from practice. We focus on the construction of a drill body and its influence on tool life, especially the shape of cooling channels. The most important part of the paper focuses on changeable heads and their wear. Finally, we consider and describe the basic type of wear on the cutting edge and ways of preventing the occurrence of wear.*

Keywords: *Drill, wear, machining, cutting edge, durability, reliability.*

INTRODUCTION

Even in prehistoric times people needed to create a hole in materials to give it a new purpose. But since that many technicians have had problems with criteria to select a proper drilling tool and how to reach optimal durability and reliability.

Drilling is a machining technology where it is difficult to observe the whole process and estimate the current level of cutting edge wear because the cutting edge is not visible during machining. Therefore, the operator has to rely on their experience, the sound during machining, shape and flow of chips, spindle load and, if possible, the final quality control of drilled hole.

The selection of drilling tool is based on the following criteria:

- material of workpiece;
- number of workpieces;
- hole parameters such as: hole diameter, tolerance, quality of machining, hole depth;
- machine tool parameters – internal cooling, spindle power, number of axes, etc.

Technologists often ignore the selection of exact type of drilling tool. Therefore, it is important to know the structural properties of these tools, or at least:

- what influences the lifetime of the tool;
- whether is it possible to optimize the cutting edge to reach the desired result.

Probably one of the most widely used types of drilling tools are drills with changeable head. Based on our professional experience, we can compare different structures of these drills.

SELECTION OF DRILL BODY

The selection of drill body is based on the following parameters: the range of drilling and what is the smallest diameter of changeable head.

If it is necessary to clamp the head with a screw, the minimal diameter of drilling is limited by this clamping screw. It should be borne in mind that the smaller the drill head, the smaller the clamping screw. This could be a big risk for further exchange of drill head because frequent exchange can damage the clamping screw and thus destroy the whole body.

In comparison to self-locking clamping, it has its weaknesses in case of damage of self-locking due to imperfect or none cooling.

Cooling is necessary for all types of changeable head drills. Its function is not only to help with chip removal and provide cooling but also to reduce the possibility of chip adhesion on the wall of the drilled hole (Fig. 1).

Fig. 1 Surface of the hole drilled without cooling – steel 11 523

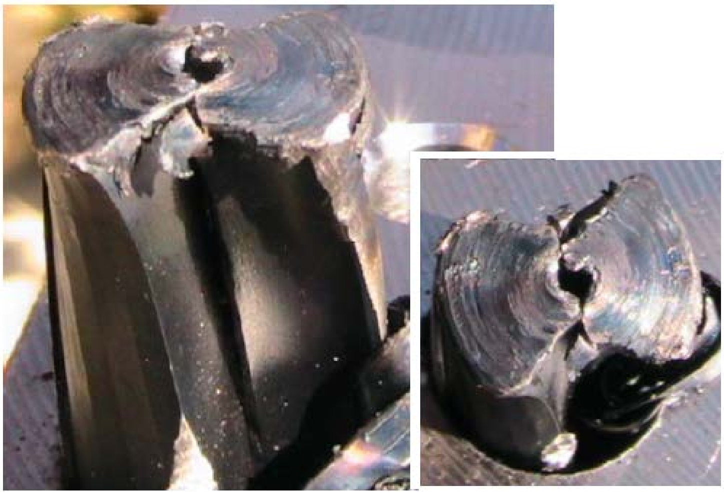

Fig. 2 Longitudinal crack of body caused by the reduced cross-section of the body core

The structure of drill body influences the design of cooling channels. In practice, there are two types of cooling channels [1,2,3,4]:

- Single cooling channel – with a split of the channel at the end of the drill to direct the cooling liquid into the cutting area. The costs for manufacturing this type of cooling channel are relatively low, but on the other hand, there is a risk that the cross-section of the flute for chip removal will be reduced and it will increase the surface quality deterioration. It can reduce the rigidity of the tool, which can result in the crack of the tool along the axis (Fig. 2).
- Double cooling channel – more difficult to manufacture, but it gives an optimal size of flutes for proper chip removal, increases the quality of drilled surface, and extends the life of the drill body.

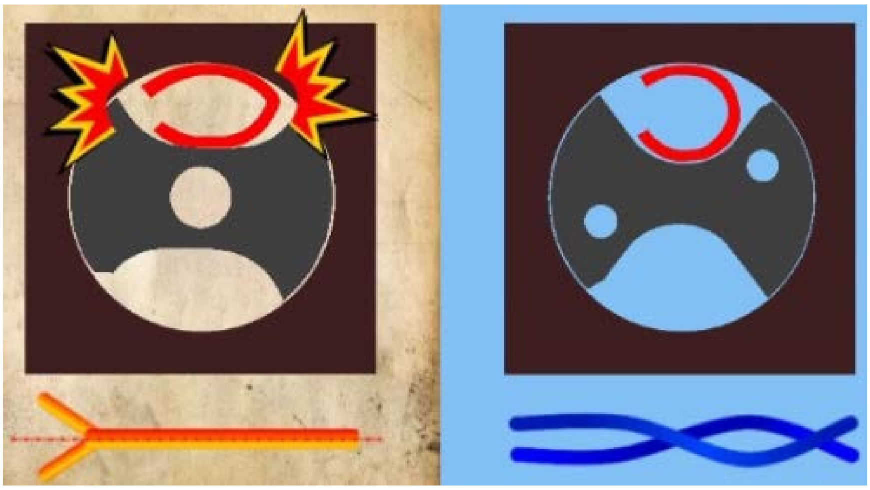

Fig. 3 Comparison of single (left) and double (right) cooling channel design and its impact on flute cross-section size [5]

In machining short holes with short drills having a length up to 3×diameter (3×D), there is no requirement on the bending stiffness of the drill. For 5×D, it is necessary that the drill body has to be made from better materials and reinforced along the entire length. In standard drills, reinforced is only a part where the head is clamped to protect the contact surfaces from deformation by the pressure of clamping screw and from chips. Chips must be securely transported out of the drilled hole and thus they affect not only the hole but also the drill body.

The most frequently asked question is how many exchanges of heads will the body last. The common types of these drills have a lifetime of 10–15 exchanges. The TaeguTec company has developed a drill, the body of which meets all the necessary requirements for reliability, durability and the range of diameters and lengths of drilling. The body itself is reinforced along the whole length to prevent it from bending during drilling over 5×D. The whole functional part that is in contact with the machined material is TiN coated to reduce the adhesion of chips and to increase the abrasive resistance of the body to chips. In order to facilitate the chip flow, flutes are polished [6,7,8,9].

Thanks to upgrade in a bayonet lock, increase in the size of the contact area, and improvement of the body material, the lifetime has increased up to 50 changes of the drill head. In laboratory tests, we have reached up to 120 repeated locking and unlocking of the drill head, where the ability of constant clamping force was measured.

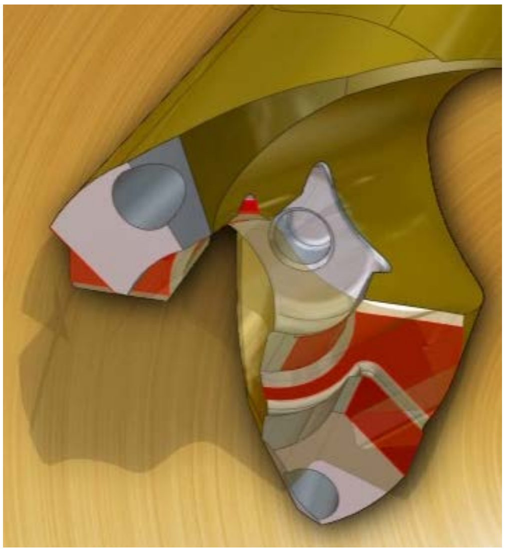

Fig. 4 New contact surfaces on drill body [5]

Fig. 5 Shape of cutting edge [5]

SELECTION OF DRILL HEAD

In order for the whole process to be successful, it is essential to have a reliable cutting edge of the changeable drilling head. It is provided by the material of the head, which is carbide with coating, and by the geometry of the cutting edge. To ensure the process of drilling, the cutting edge of the head is in the shape of a wave – thus achieving an easy and smooth cut, lower cutting forces, and the elimination of burrs at the output from the hole [10].

To achieve the desired success in machining various types of materials, it is essential to have a certain range of geometries, useful in these sorts of drilled materials: P – steel, M – stainless steel, K – cast iron, N – non-ferrous materials. However, there is not information that one geometry cannot be applied to other materials. All of that depends on circumstances such as stability and low cutting forces where the geometry of P can be used. When there is a request for stronger cutting edge because of inclusions and grain agglomerates in the machined material, the geometry M can be used. However, when there is a demand to increase the radial stability and stiffness of cutting edge that forms the hole diameter, or when there is a problem with burr formation, the geometry K can be used. Cutting parameters do not have to be modified to influence the cycle time.

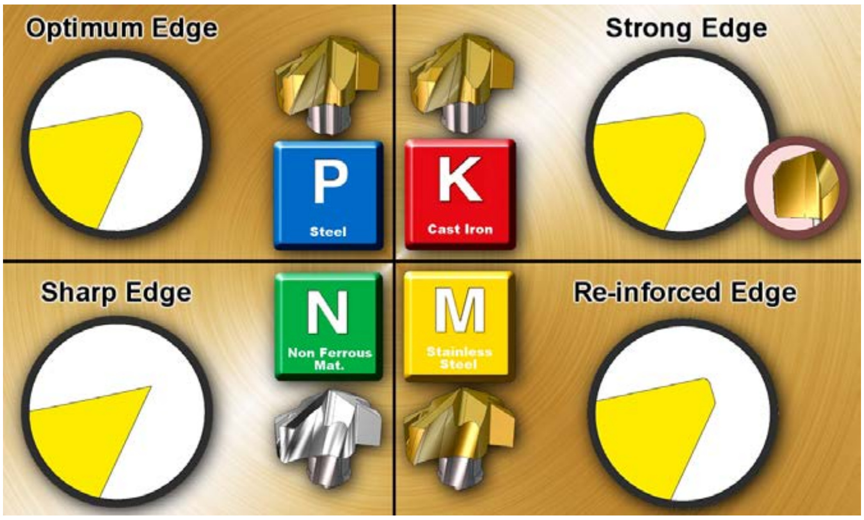

Fig. 6 Geometry of cutting edge [5]

WEAR OF CUTTING EDGE

In practice, we often meet with wear described as edge chipping, or alternatively as plastic deformation [8,11,12,13]. Fig. 7 (left) illustrates the wear of the flank surface. It needs to be compared with chipping on the cutting edge (Fig. 7 right).

Fig. 7 Wear of the cutting edge – chipping of the edge (left) and flank wear (right)

In the first case (wear on flank surface), it is instability during drilling, or it can be caused by the built-up edge. During the process of cutting, the particles of machined material stick to the cutting edge and when the built-up reaches its critical size, it tears off with some amount of cutting edge material. At first sight, it can be classified as chipping. It can be simply proven without doing some major interventions. It is important to understand when the built-up edge is forming – during machining of materials that create a long chip, which are soft and tough, with a tendency to sticking of chips to the surface, there is a high possibility of built-up edge formation. If we cannot change the geometry of the drill head for sharper one, we need to focus on cutting conditions. The assumption is that the spreading rate of cooling liquid and the concentration of emulsion are properly set. Then, we have to focus on cutting speed and feed. Increased built-up edge formation is influenced by cutting speed. The risk of built-up edge formation increases with increasing peripheral cutting speed; however, after crossing certain peripheral speed, this risk will decline. During drilling, we have a whole range of peripheral cutting speeds, from 0 at the central axis to the maximum value at the largest diameter of the drill.

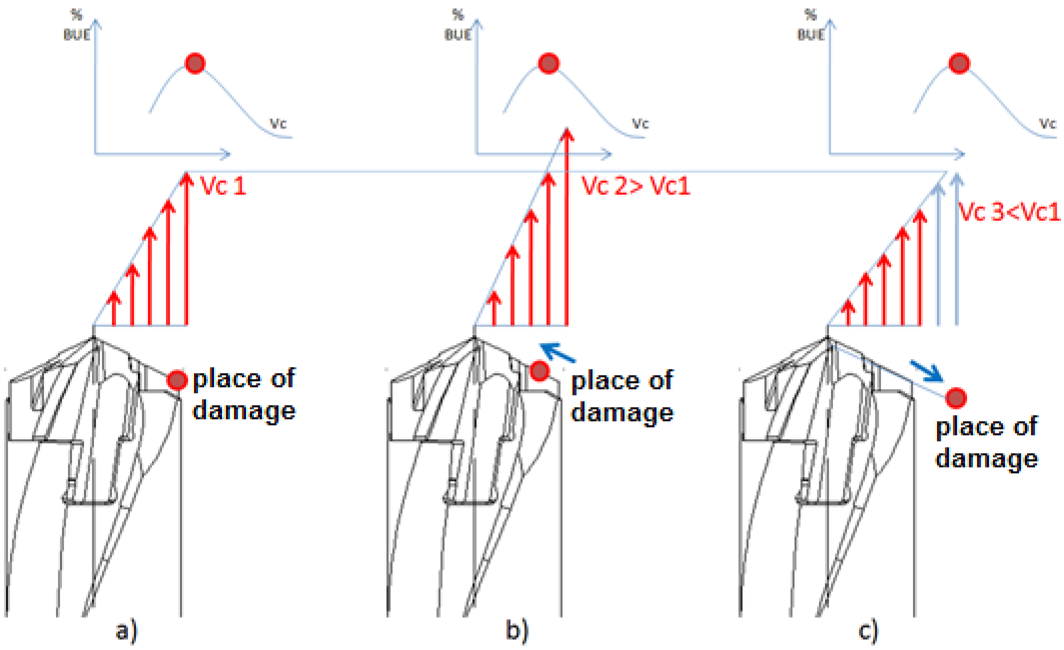

Fig. 8 Position of chipping by built-up edge depending on cutting speed

Explanation of Fig. 8:

a) at cutting speed v_{c1}, the highest formation of the built-up edge is at the periphery of the cutting edge;

b) when the cutting speed increases to v_{c2}, the built-up edge will be formed on the part of the cutting edge where cutting speed is equal to v_{c1};

c) changing the cutting speed to v_{c3}, in this case it means the decline of cutting speed, the position (theoretical diameter) where the built-up should be formed will be off the cutting edge. This solution can help to increase the lifetime and reliability of the cutting edge.

SUMMARY

In this paper, we have described the basic rules of proper selection of drill with changeable head. We need to keep in mind that the structure of the drill body affects the cost of machining because it has an effect on the lifetime of the tool. Also the proper selection of changeable head is important and it needs to be carefully considered to fulfil the machining requirements and conditions. The common type of wear and its possible wrong identification was presented on a simple example. By a small change of one of the cutting parameters – cutting speed, we can simply avoid the formation of built-up edge and damage to the cutting edge.

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CONTACTS

Milan Matúš, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xmatusm@uniag.sk

Michal Adamik, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xadamikm@uniag.sk

Vladimír Kročko, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: vladimir.krocko@uniag.sk

Maroš Korenko, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: maros.korenko@uniag.sk

Pavol Findura, Department of Machines and Production Systems, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: pavol.findura@uniag.sk