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Study of Modern Cutting Materials Used in Mechanical Engineering

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ABSTRACT: The materials used to manufacture the cutting tools used in mechanical engineering were analyzed. Areas of application of materials, their mechanical and technological properties are given.Materials used for cutting tools are analyzed by groups. Heat resistance, physical and mechanical properties at high temperatures are the basis for grouping. Mineraloceramic materials, which are currently widely used in mechanical engineering, are briefly described. and increase the productivity of their use

KEYWORDS:cutting tool, carbon tool and alloy steels, hard alloys, mineraloceramics, ultra hard materials.

I. MODERN CUTTING MATERIALS USED IN MECHANICAL ENGINEERING

The importance of the materials used for the manufacture of cutting tools is one of the decisive factors in increasing the productivity of mechanical engineering, ensuring the accuracy of the manufactured parts.
The use of high-speed steels, hard alloys in cutting tools has shown that in addition to increasing the cutting speed by almost 3-5 times, it is also necessary to carry out improvements on the machine. The increase in cutting speeds requires machine tools to increase sharpness, engine power, and number of revolutions in the first place.
It is known that cutting tools must have a high hardness in order to cut the work cycle, i.e. the shaver to a certain size and thickness. Under the influence of heat generated during cutting, the cutting tool must not lose its stiffness relative to the material of the workpiece. The ability of a cutting tool material to retain its mechanical properties at high temperatures is determined by the concept of heat resistance.
The cutting part of the tool must be able to withstand the high temperatures, large compressive forces and mechanical friction that occur during cutting, wear.
The strength of the cutting tool is one of the main indicators of its resistance to the above factors. Loss of strength results in the cutting tool failing to perform its function.

II. QUICK CUT STEELS

Another requirement for the materials used to make cutting tools is that their technological properties must be good - that is, they must be able to be machined during machining, sharpened during operation, and adapted to a common method and equipment.We will look at the types of materials used to make cutting tools and the direction of development.

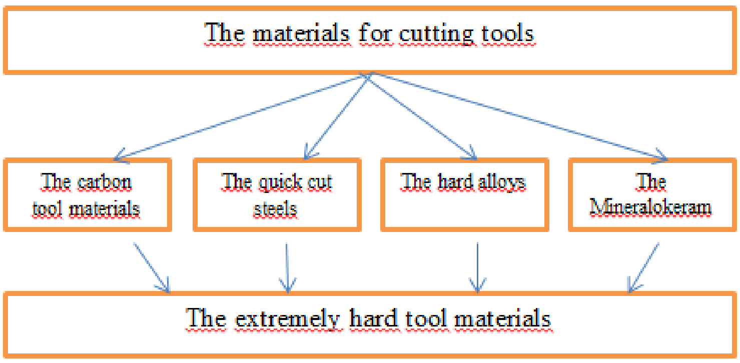

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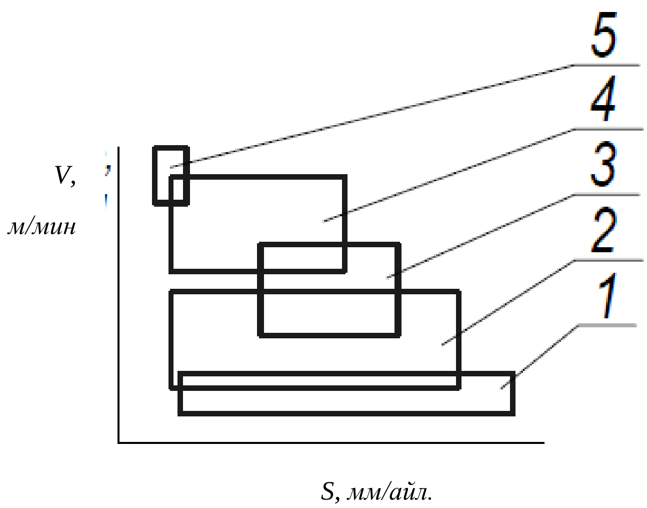
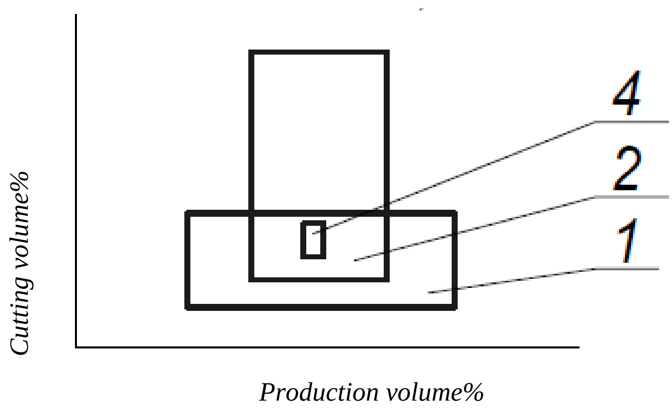
Figure 1. Classification of materials from which cutting tools are made



a)



b)

Figure 2. The use of tool materials within the limits of the cutting speed and the allowable amount of thrust (a) and the volume of production and cutting materials (b): 1 - high-speed steels; 2 – hard alloys; 3-coated hard alloys; 4 – ceramics; 5 - very hard materials**.**

The materials used for cutting tools show their increasing cutting and other properties as shown in Figure 2.
Cutters used by hand and machine tools are made of carbon tool steels. These steels have sufficient hardness, strength and are resistant to corrosion. However, when the temperature reaches 250o C, their hardness decreases sharply. Therefore, cutting tools such as small-sized drills, screwdrivers, drills, egov are made of steels such as U9, U10A, U13A. The use of fast-cooling fluids in the cutting of these steels leads to deformation of the tools and the appearance of cracks during annealing. Deformations and cracks cause the polished part to heat up and make it difficult to carry out the polishing process.
The use of low-alloy steels for cutting tools makes it possible to avoid difficulties in machining carbon tool steels. Low alloy steels have good hardening properties and do not heat up during grinding.
The hardening layer of low-alloy 11XF, XV4 steels used in the production of cutting tools is low, the hardening layer of X, XVG, XVSG steels is large.

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Low-alloy steels have much higher performance than carbon tool steels, but their hardness also decreases when the temperature rises to 260oC.
High-strength steels are resistant to corrosion, high heat resistance and strength.
Tungsten in steel provides heat resistance, while chromium provides good hardening, good thermal conductivity in molybdenum up to 5%, cobalt increases hardness.
Depending on the size of the workpiece, cutters made of high-speed steels are divided into groups with normal and high cutting ability.
The first group includes steels of grades R18, R12, R9, R6M5, the group with high cutting ability includes steels such as R6M5F3, R10F5K5, R9K5. The cutting ability of high-strength steels is associated with heat treatment - annealing at a temperature of 1260 - 1300o C and two-three times release.
Tungsten steels R9, R12, R18 are widely used in mechanical engineering. High-precision cutting tools are made of well-polished R18 steel and are used for cutting steels with a strength of 900 - 1000MPa.
Steels of the tungsten-molybdenum group R6M5, R10M5 are used to make all types of cutting tools. The hardness of cutting tools is NRC 64–65 units.
The tungsten group includes R18F, R12F3 steels and is used for making clean and semi-finished cutters, milling cutters, drills and other tools.
R9K5, R9K10 steels with added cobalt retain their mechanical properties up to 630o due to their good thermal conductivity.
The addition of cobalt to tungsten-molybdenum-steel steels increases their hardness to NRC 66–69. This group includes steels of grades R12M3F2K8, R6M5F2K8.
Another type of high-speed steel used in mechanical engineering, dispersion hardening or intermetal reinforcing high-speed steels are widely used. These steels have a carbon content of 0.1–0.3% S, a hardness of NRC68–69 units, a heat resistance of up to 725o C, and a corrosion resistance of cutting tools that increase their strength by 30–50% when the temperature rises to 500 ° C. Making tools from powder-coated steels is made in two stages. In an inert gas (argon, nitrogen), the molten metal is pulverized by spraying.
The powder is cold pressed at a pressure of 40,000 MPa. It is then processed (pressed) in a vacuum container at a temperature of 1150–1200o C and a pressure of 14000 MPa. R18M3K6S, R6M4K8 cutting tools are made of steels of this group.
About 200 brands of high-speed steels are produced in the UK, and cutting tools are also made in Germany, France, Japan and the United States.

III. HARD ALLOYS

Hard alloys are obtained in two different ways - casting and baking. The main ones used are hard alloys obtained by baking.
Cobalt-based alloys contain 75-97% of carbides, while nickel-based alloys contain 61-79%. Since the heat resistance of hard alloys is 800-900oS, the cutting speed can be increased by 2-10 times compared to high-speed steels.
The main disadvantage of hard alloys is their brittleness, low strength in bending and elongation. However, their compressive strength is 4000-6000 MPa. This leads to a sharp increase in productivity, if the cutting tool is able to work on compression. In industry, hard alloys are divided into three types: tungsten - VK - single carbide, titanium-tungsten - TK - two carbides and titanium-tantalum tungsten - TTK - three carbides.
VK-3, VK-4 alloys are resistant to high hardness and abrasion, but very low strength. Alloys of the TK group have a higher hardness, heat resistance, abrasion resistance than alloys of the VK type, but they have a higher brittleness and lower strength.
Hard alloys such as T15K6, T30K4, T5K10 are widely used for cutting tools. TTK type alloys have higher strength than others due to the addition of tantalum carbide (TaS). Alloys of TT7K12, TT8K6, TT20K9 brands belong to the third type.
New types of hard alloys use titanium carbide or titanium carbonitride instead of tungsten carbide, and nickel, iron, molybdenum as binders. These alloys are virtually devoid of the above defects.
Hard alloys are produced in the form of sharpened and non-sharpened plates and welded to the cutter. The surface of the plates is coated with titanium nitride to increase their abrasion resistance. This will extend the life of the cutting tool. With a coating thickness of 2–10 μm, the cutting tool increases the operating time by 2–5 times.

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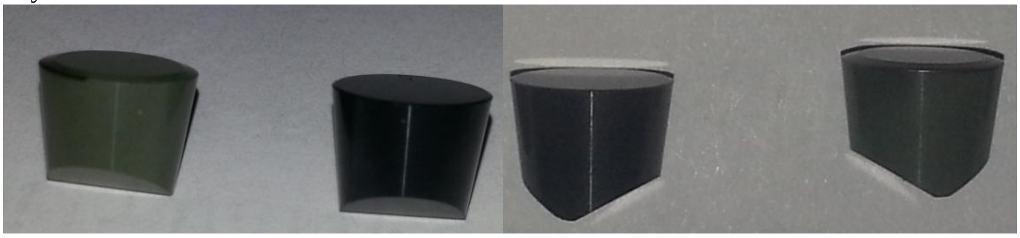
IV.MINERALOCERAMICS

Cutting tools made of mineraloceramics are obtained on the basis of Al2O3 and in some cases are added to metals such as tungsten, titanium, molybdenum, tantalum, chromium or their carbides.
Cutting tools made of mineraloceramics have a hardness of NRA 90-94 and a heat resistance of 1200o C. Low wear, the service life is much longer than cutting tools made of hard alloys. The main disadvantage is that it is very brittle, the impact viscosity an = 0.5 - 1.2 N · m / 〖cm〗 ^ 2.

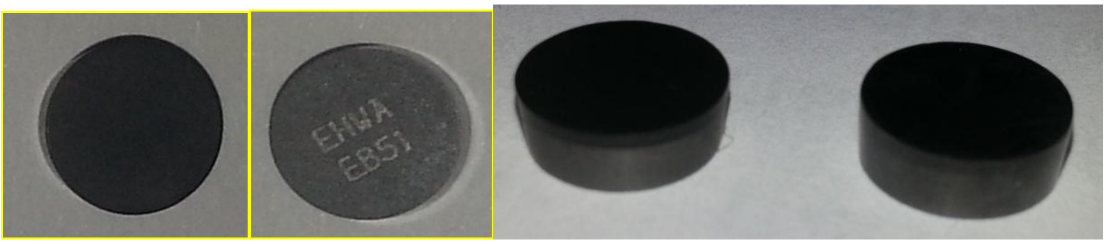


a)b)

Figure 3.The high heat resistance allows to increase the cutting speed several times, to process refined steels, cast iron. Figure 3 shows a cutting tool TsM-332 made of ultra-fine electrocorundum (particle size 1-2 microns) in the form of a plate.Oxide-carbide ceramics are made by adding the above metals or their complex carbides to Al2 O3. Heat resistance decreases due to alloying, and bending strength increases by 450–700 MPa. Mineral ceramics of V-3 and VOK brands are widely used in industry.

V. EXTREMELY HARD MATERIALS

In machine building, natural diamonds, artificial polycrystalline diamonds and cubic boron nitride are mainly used as ultra-hard materials for the production of cutting tools.
Cutting tools made of natural and artificial polycrystals are distinguished from other materials by their high hardness. These materials with a hardness of NV 10000 kgk / mm2 are widely used in machinery due to their small linear expansion coefficient, good thermal conductivity, abrasion resistance. However, the low bending strength of diamonds, brittleness and melting of iron at high temperatures - 750–800oS - do not ensure the use of diamonds at high cutting speeds, when cutting steels. In cutting, natural crystals in the form of crystals are mounted on the metal body of the cutter.
Cutting tools made of artificial diamonds are widely used in the processing of copper, aluminum, magnesium and their alloys, babbitt and precious metals. Cutting tools made of artificial diamonds ASB (ballas) and ASPK (carbonado) can provide a cutting speed of 1000-1200 m / min when cutting the above materials.



a) б)

Figure 4. Boron's cubic nitride.Cube-shaped boron nitride (KNB) is close to diamond in hardness, heat resistance up to 1500o C. KNB polycrystals and composite materials based on them are widely used in mechanical engineering.

The cutting part obtained from composite materials elbor, belbor, hexanite, etc. is obtained mainly by synthesis in a cylindrical form. The diameter of the cylindrical grains attached to the cutting tools is 4 ... 8 mm, height 3 ... 6 mm.
Cutters using composite materials in the processing of steels and cast irons of different hardness can provide Ra-0.08 microns in the quality of 5 –... 6 – accuracy and surface roughness.
Silinite-R tool material is made of new ultra-hard materials on the basis of silicon, heat resistance up to 1600o C. The use of silinite-R as a cutting tool allows not to use the grinding operation on refined steels.

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VI. CONCLUSION

The use of new construction materials in mechanical engineering, the increasing penetration of digitally controlled machines and machining centers at high speeds are dramatically changing the requirements for cutting tools. Globally, the use of high-speed steels in mechanical engineering has almost halved from 60-70% to 35%. At the same time, the use of ultra-hard materials increased from 1% to 10%. It is observed that carbon tools are widely used instead of high-speed steels, ceramics reinforced with silicon nitride.
In the near future, the coating of cutting tools with artificial polycrystalline diamonds obtained by chemical methods - evaporation and sintering - the widespread use of ultra-hard materials will create new opportunities in mechanical engineering.

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