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Cutting Holes in the Walls of Main Pipelines Using Planetary Cutting Heads

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ABSTRACT: This article discusses various grades of modern high-alloy high-speed steels, from which the bulk of various metal-cutting tools are made. The article discusses the analysis of their chemical composition and characteristics of mechanical properties, structural and technological properties. Various processes of hardening treatments for steels of various grades to replace hard alloys are discussed.

KEY WORDS: high-speed steel, chemical thermal treatment (CHT), hardening, tempering, normalization, mechanical properties, hardness, hardening, cutting tool, metal alloy.

I.INTRODUCTION

High-speed steels are alloy steels intended primarily for the manufacture of metal-cutting tools operating at high cutting speeds. British engineers were the first to use high-speed metal to produce tools. Products made from this alloy are used to work with metals of different hardness, which is why the steel is called rapidsteel, which translates as “high-speed”.

This property and the English expression served as the basis for recording the type of high-speed steels and their grades in the form of a designation with the letter “P”. In the marking of high-speed steel, the letter P means that the steel is high-speed, and the number following the letter is the content of the average mass fraction of tungsten in percent; the chemical composition of high-speed steel is given in Table 1. There may be such alloying elements as: M - molybdenum, F - vanadium. The numbers following the letters indicate their average mass fraction in %. Let us give an example of decoding using the example of steel P6M5, P6M5K5 - high-speed tool steel with a tungsten content of 6%, molybdenum 5%, cobalt 5%. Considering the characteristics of high-speed steels, it should be noted that this type of material is specially created for operation with a high friction index that occurs at the moment of cutting [1].

In modern engineering production, cutting still plays a leading role. Since the main way to improve cutting efficiency is to operate at maximum productivity, there is a tendency to further increase cutting speeds, which, in turn, requires increasing the efficiency of the cutting tool. Productivity and tool life largely depend on the properties of the tool material[1,8].

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Chemical composition of high-speed steels with carbide hardening in %.

1-Table

Steel grade	Chemical composition, %					
	C	**W**	**Mo**	**Cr**	**V**	**Others**
Steels of moderate heat resistance (615…620 °С)						
Р18	0,75	18,00	до 1,00	4,00	1,20	–
Р12	0,85	12,00	–	3,70	1,70	–
Р6М5	0,88	6,00	5,00	4,00	1,90	–
10Р6М5МП	0,97	6,00	5,20	4,10	1,90	–
High heat resistance steels (630…650)						
Р12Ф3	1,00	12,70	до 1,00	3,70	2,70	–
Р8М3К6С	1,00	8,00	1,70	3,70	17,00	6,30Co
Р9М4К8	1,05	9,00	4,10	3,30	2,30	8,00Co
Р12М3ФК8	1,30	12,00	3,10	4,00	2,10	8,00Co
Low heat resistance steels (low alloy)						
Р3М3Ф2	0,98	2,80	2,70	4,50		2,90
11Р3АМ3Ф2	1,07	2,90	2,75	4,05	2,40	0,11 N
ЭП973	0,64	–	2,90	6,00	2,80	0,20 N
Р2М5	1,00	2,00	5,10	4,00	1,10	0,65 N
Р2М2Ф3	1,00	2,00	1,70	3,50	3,10	–
11М5Ф	1,06	–	5,50	4,00	1,40	–
РОМ4**	0,85	–	4,40	4,20	1,00	–
РОМ4Ф***	0,90	–	4,20	4,20	1,00	–

The composition of high-speed tool steel significantly increases the hardness of the metal, due to which it can work at increased speed. High-speed steels have high strength, can work successfully at large depths of cut (drills) and at high feed rates (cutters, drills, etc.) Characteristics of high-speed steel:

- Heat resistance. The heat resistance of quick cutters is 600-650 degrees, depending on the composition and processing.
- Hardness. The hardness of quick cutters is HRC 68-70. High-speed steels have even lower hardness compared to conventional carbon steels if the cutting temperature is within normal limits.
- Cutting speed. The first high-speed steel tools allowed a cutting speed of 18 m/min, then tools with a cutting speed of 35 m/min appeared. Currently, cutting speeds of 60 m/s or more exist.
- Wear resistance. This parameter for high-speed steels is 3-5 times higher than for carbon and alloy steels.
- Red resistance. This parameter of any metal characterizes the period of time during which a tool made from it is able to withstand high temperatures without losing its original characteristics. High-speed steels as a material for the manufacture of cutting tools have no equal in this parameter. This parameter for quick cutters is approximately 4 hours.

Special attention should be paid to hot hardness, since it is this indicator that primarily distinguishes high-speed steel from other alloys. This is the hardness maintained when hot. As is known, any tool used to perform cutting processing is intensely heated during such processing. As a result of heating, conventional tool steels are subjected to tempering, which ultimately leads to a decrease in the hardness of the tool. This does not happen if high-speed steel was used for manufacturing, which is capable of maintaining its hardness even when the tool is heated to 600 degrees. Typically, high-speed steels, which are often called high-speed steels, have even lower hardness compared to conventional carbon steels if the cutting temperature is within normal limits, that is, within 200 degrees.

When considering the use of wear-resistant metal, attention should be paid to the fact that the specific composition of the metal determines its performance qualities. A tool made from such metal can withstand long-term use. The scope of application is quite wide. Let us consider the scope of application of high-speed steels depending on the grade [1,2,8,9].

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To make drills, countersinks and other cutting products harder, resistant to rust and wear, they are additionally processed using chemical-thermal treatment methods. When products are heated in a certain liquid or gaseous environment, the necessary substances penetrate into the atomic crystal lattice of iron.

Nitriding – the surface is saturated with nitrogen in a gaseous environment (80% nitrogen and 20% ammonia or 100% ammonia). In 10-40 minutes at a temperature of 500-600°C, the surface shell is strengthened.

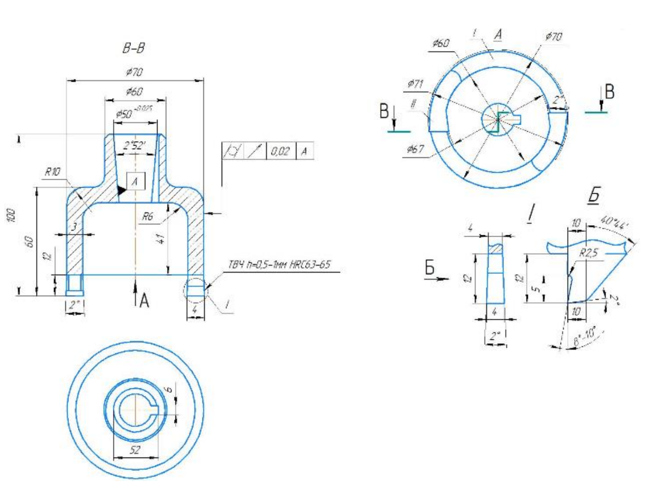
Cyanidationis – the saturation of a surface with zinc in a gas or liquid medium. Can take place at high and medium temperatures, lasts from 5 to 45 minutes. The high-temperature process takes place at 800-900°C, the low-temperature process at 500-600 degrees. Saturation of the tool surface with zinc gives it excellent wear.

Sulfidation – saturation of products with sulfur for 2-3 hours. The material is heated in sulfur-nitrogen salts at a temperature of 550-600°C. The process also improves the wear resistance of cutting edges.

To obtain maximum hardness and heat resistance after chemical treatment and hardening from 1220 °C, it is recommended to temper at 600 °C, which intensifies the process of dispersion hardening of steel. After heat treatment of steel according to the selected mode, the working hardness of the layer increases to 67-69 HRC, heat resistance (for 60 HRC) is equal to 675 °C, and impact strength KC = 0,20 МДж/m^2. It has been established that in order to increase impact strength, it is recommended that the first tempering be carried out at 560 °C, and the second and third at 600 °C. After tempering in this mode, the impact strength of steel increases to 0,26 МДж/m^2 [5,10].

It has been established that a tool made of steel type R6M5 subjected to chemical treatment is not inferior in hardness and wear resistance to a tool made of two-carbide hard alloys of the VK type, while reducing the specific costs of the material by 1.2 times and the costs of auxiliary materials by 15-20% [1,2,7,8]. This allows us to recommend the developed technologies for manufacturing cutting tools for piece and small-scale mechanical engineering enterprises, the watch industry, the industry for the production of medical instruments, the electronics industry and other industries. Hard-to-deform complex alloy high-speed hot-rolled steel P6M5 (0.9% C; 6.0% W; 5.3% Mo; 1.95% V; 4.0% Cr) in the delivered condition (after annealing) is the main one among normal high-speed steels heat resistance and is widely used for the production of high-speed cutting tools.

It has been practically proven that any cutting tool, if made of steel type P6M5 and others subjected to nitrocarburization, is not inferior in hardness and wear resistance to hard alloys of the type "BK4, BK6, T15K10 and T5K10", therefore, with a reduction in unit costs, the material costs are equal to R6M5 and other high-speed steels 1,2 times [3,4,7]. This will allow us to give recommendations for the enterprise to produce a special cutting tool (planetary cutting head) from high-speed steel for inserting holes into existing main pipelines in order to connect new testing pipeline lines up to 2.5 MPa to them (especially for the purpose of using water supply and heating networks Fig. 1).



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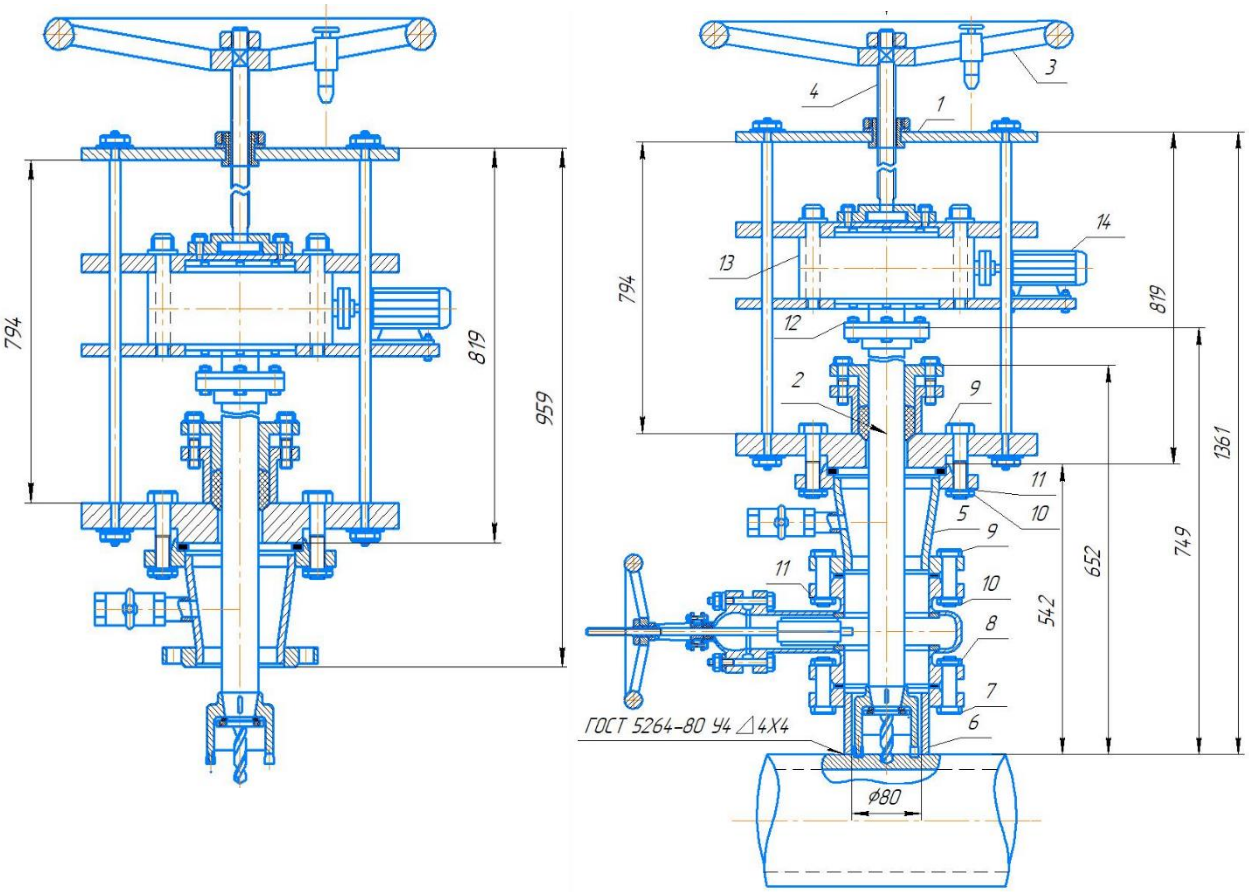

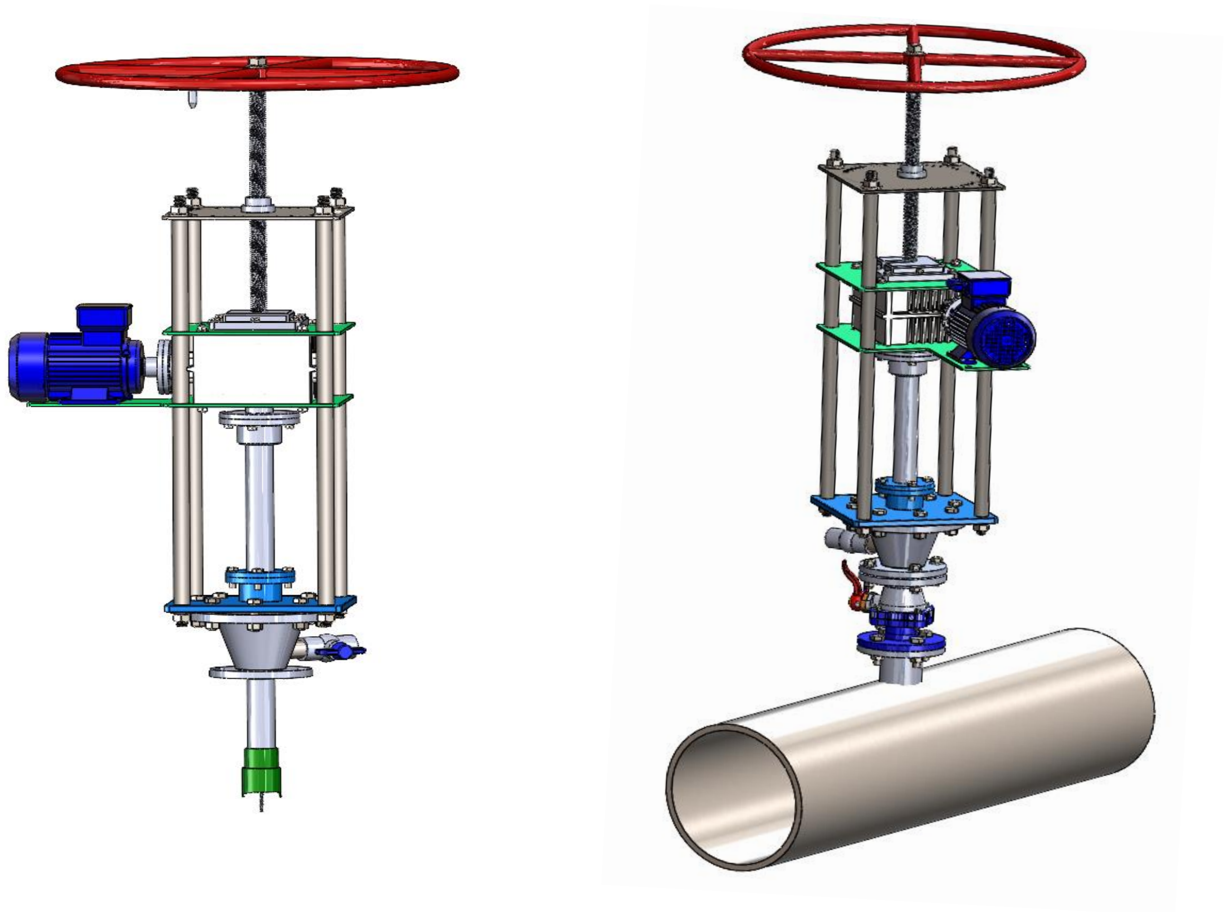

Fig-1. The proposed cutting head and the proposed device for cold cutting of holes on the surface of main pipelines, pressure up to 2,5 MPa.

After performing the listed technologies, the cutting part of the equipment must undergo sharpening and grinding. Steel grade P18 is used for the production of parts that must have increased performance. Due to the internal structure with fine grains, the alloy shows excellent wear resistance. This brand also differs from others in that during heat treatment of products made from high-speed steels, overheating does not occur. It is impossible to produce high-precision tools from steel grade P18, since the workpieces cannot be processed and ground well. The material with the designation of high-speed steel P12, the properties of which are similar to metal P18, has good qualities in terms of strength and ductility, in the deposited state.

II. EXPECTED RESULTS:

- it has been practically proven that it is possible to replace cutting heads manufactured in foreign production with the installation of hard alloys on which are manufactured and designed with a local designer.

- the local designed cutting head is inferior in all respects to its foreign counterpart.

- local designed cutting head is convenient for cutting holes especially on pipelines for all industries, this will provide opportunities to save time and money for all industries of the Republic of Uzbekistan.

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