# Technology for Obtaining Tangential Holes in the Shell of the Combustion Chamber of a Liquid Propellant Rocket Engine

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**Abstract.** Method of obtaining tangential holes in the shell of a combustion chamber of liquid-propellant rocket engine is presented in this article. Advantages and disadvantages of technologies for making small diameter holes are consired. The developed technology and tooling made it possible to obtain small diameter holes designed to swirl the coolant flow in the veil belt of the combustion chamber shell. As a result, material and labor costs were reduced in the manufacture of engine components.

## Introduction

Liquid-propellant rocket engines have been widely used as marching engines for launch vehicles. Liquids and liquefied gases are often used as fuel components. Liquid-propellant rocket engines can be divided by the following characteristic features: type of fuel, design features, fuel supply system, purpose. Combustion chamber is the main unit of the rocket engine. It subjected to high thermal loads during operation. One of important tasks in the design is organizing the cooling of the chamber. [1].

Methods of combusting chamber cooling: external and internal. Engine elements are cooled due to the flow of the heating surface by the cooler from outside during external cooling. Liquid flowing through the cooling path is heated. Heated liquid enters mixed head after cooling of chamber walls. Component requires low values of viscosity, corrosion activity and freezing temperature. Values of heat capacity, boiling point and component decomposition should be maximum. The cooler may be fuel or oxidizer. Internal cooling is characterized by supply of cooler to internal cavity of combustion chamber, while creating a wall layer of gas. Combustion chamber inner shell is cooled by gas reduced temperature. General view of combustion chamber shell of liquid-propellant rocket engines shown in figure 1. Fuel is used in internal cooling. Component shall have increased thermal capacity, boiling point and dissociation.

Coolant can be supplied to the chamber through peripheral nozzles located along outer diameter of the chamber head. Veil belt is used for effective cooling of internal wall of the combustion chamber. This is a series of tangential holes of small diameter made in inner

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wall of the chamber. These holes are circular or circular slot shape. Usually veil belts are performed in front of the most heat stressed areas of the chamber of liquid-propellant rocket engine. General view of veil belt of the combustion chamber shell shown in figure 2.

**Fig. 1.** General view of combustion chamber shell of liquid-propellant rocket engines.

a) b)

**Fig. 2.** General view of veil belt of the combustion chamber shell: a) with tangential holes, b) with slot channels.

Volumetric control methods are used to determine serviceability of combustion chamber. Accuracy of small diameter channels manufacturing is controlled by spillage. The volume of liquid passing through the detail measured for a certain period of time. Detail is

installed in stand with displacement water supply system. Nitrogen or compressed air is used as displacement agent. Service water is used as working fluid. Water is supplied from tanks where gas of displacement is supplied under the pressure. Service water under pressure is supplied to the internal cavity of detail. Water jets form veil passing through tangential holes and provide cooling of combustion chamber. Organoleptic control method is used to check uniformity of liquid distribution in circumference.

## Main part

Obtaining tangential holes of small diameter in the veil belt of the combustion chamber shell is an actual problem. Arrangement of tangential holes shown in figure 3.

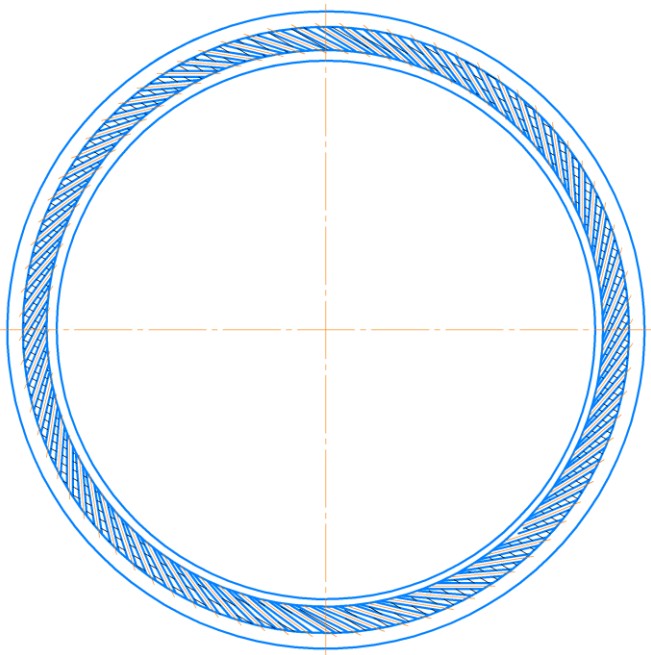

**Fig. 3.** Arrangement of tangential holes in the veil belt.

Main process parameters provided when receiving tangential holes:
- high accuracy of the obtained holes (до 0,1mm);
- uniformity of flow section of holes;
- surface quality.

Laser processing is often used to obtain small diameter holes in the production of liquid-propellant rocket engines. The advantage of using a laser is obtaining holes with diameter of from micrometers to several millimeters with high performance. The material is removed in the form of a mixture of molten and evaporated particles during laser drilling. Laser processing makes it possible to make holes of any geometric shape in blanks from hard-to-process materials. This method is widely used in the manufacture of gas turbine engines. Surface Quality Assessment Parameters: roughness and presence of microcracks. Defects when using this processing type:
- scattering at the entrance to the hole;
- presence of melting zones and thermal influence due to thermal stresses and crystallization of the material;

- taper.

Using laser drilling to obtain tangential holes of small diameter in shells of combustion chambers is impossible due to defects adversely affect to quality of the spill.

Electroerosion push broach is possible. Wire electrodes-tools are supplied through the conductor to ensure accuracy of the manufactured holes. Electroerosion treatment is performed by electrode-tool in working medium. Workpiece is acted on by electric pulses during processing. Manufacturing by this method is not technological. It makes it difficult to obtain the necessary accuracy and increases the cost of processing due to the large wear of the tool. The wear value of brass electrodes is 25-30 percent of the metal volume removed from the workpiece.

The electron beam method of processing is widely used in mechanical engineering. This treatment is the effect of a concentrated beam on the workpiece [2]. The material is expanded and gas is formed during processing. Quantity of holes depends on the beam intensity and pulse duration [3]. Quality of holes depends on the amount of liquid phase formed in the hole and time of its crystallization. Shape of metal may differ by the time of solidification of the molten metal due to vapour pressure forces arising during treatment and hydrodynamic processes at release of part of material in liquid phase [4]. Small diameter holes with uneven flow section obtained by beam method shown in figure 4.

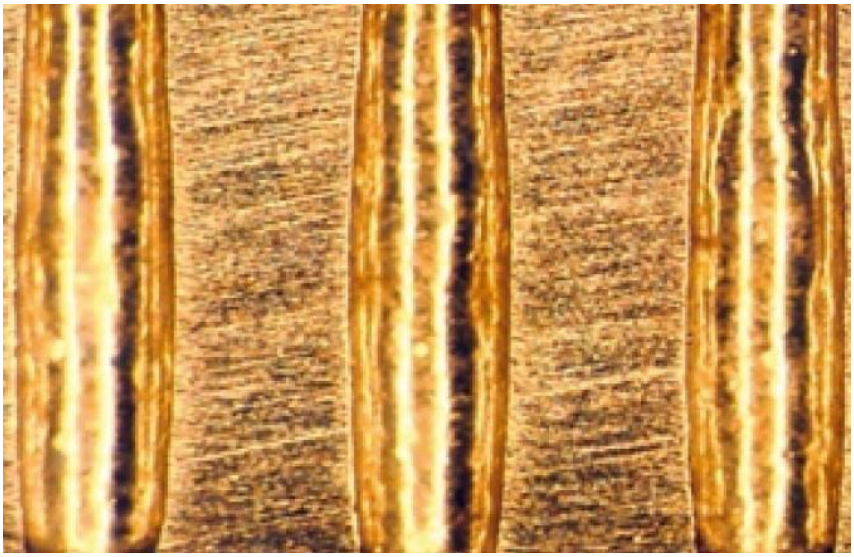

**Fig. 4.** Small diameter holes obtained by beam method.

Electron beam drilling has advantages:

- high performance;
- performing the process in vacuum ensures no oxidation;
- Large number of processed materials.

Obtaining of tangential holes in combustion chambers is not used due to the high error on this method (±0,01mm).

One of the most effective methods of obtaining tangential holes by machining - drilling. Transverse forces acting on the tool arise when forming holes of great depth [5]. Bending forces acting on the tool during the drilling operation of tangential holes shown in figure 5. The tool feed is reduced to prevent mixing of the drill from axis of the machined tool.

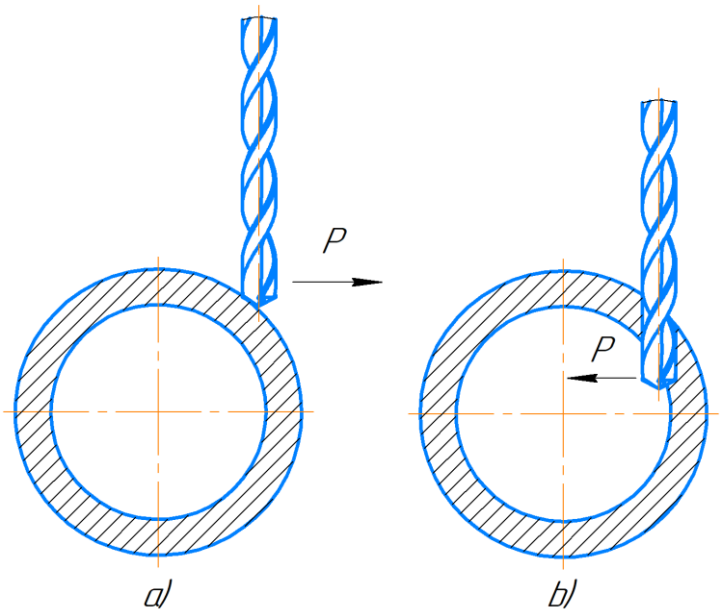


**Fig. 5.** The force on the tool when performing a drill operation (P) a) at the beginning of the drill, b) at the end of the drill.

Copper alloys are mainly used as material for details of combustion chamber shells. When obtaining small diameter holes in parts from copper during processing material is poured, this negatively affects the surface quality and tool stability [6]. It is necessary to remove from cutting zone during the drilling of blanks. Main factors affecting the timely removal of chips:

- Tool design;
- Cutting modes;
- Presence of coolant the treatment area.

Obtaining of a large number of tangential holes is impossible without not use of special tools. General view of tool used to obtain tangential holes in the chamber shell shown in figure 6.

The machined part is installed in the seat of the dividing disk. It fixed with pressure ring. Drilling is performed through replaceable bushings. Advantage of this arrangement is possible to perform a quick transfer on the conductor according to the dimensions of the header.

## Conclusions

As a result of the work performed, the analysis of the methods of obtaining small diameter holes existing in mechanical engineering was carried out. Advantages and disadvantages of modern processing methods are considered. Optimal technology for production of tangential holes in chamber shell is chosen.

The optimal method of processing for obtaining tangential holes is drilling [7]. Material and labor costs preparing for the manufacture of experimental samples of rocket and space technology were reduced due to the use of this method.

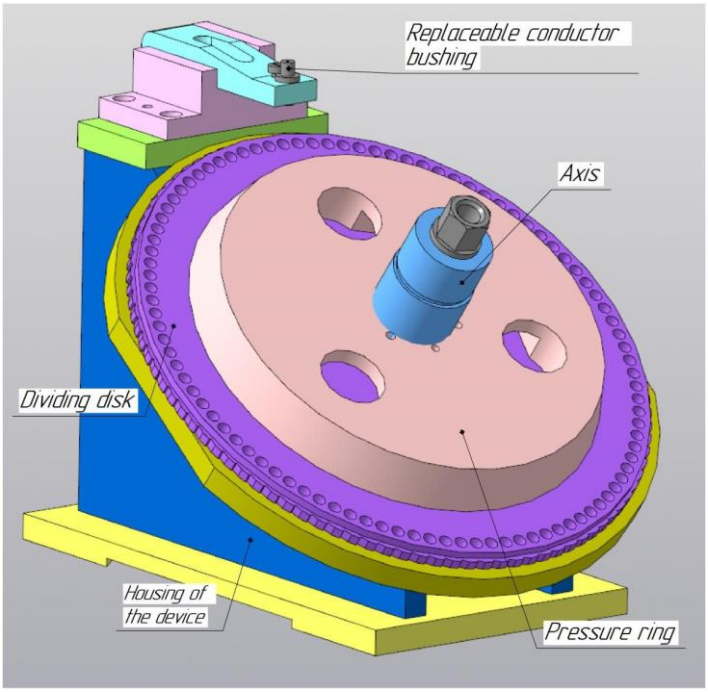


**Fig. 6.** General view of tool used to obtain tangential holes.

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