# Research on Casting Design and Casting Technology of Anti-Fracture Control Valve

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**Abstract**—Casting is a commonly used process forming method in the manufacturing process, which can produce rough parts with complex shapes and low processing cost, but the casting structure is prone to defects, resulting in waste products. In this paper, an anti-fracture control valve casting is designed, which can reduce the process of post-processing and improve the productivity of the process by adopting the integrated molding design of each flow channel. In view of the serious problems of sand and pores in the flow channel, casting coating is applied on the surface of the core to increase the hardness and drying strength of the core. In addition, by using the design of "dry" type core brace in the casting process, the problem that the flow path of the control valve casting is small and the core bone cannot be placed is effectively solved.

**Keywords**—Control valve; Casting; One-piece molding; Core

## 1. Introduction

Control valve is one of the most important equipment in the process automation device, and it is the actuator of the automatic control system in the process industry. Thousands of control points in the process control completely depend on various control valves [1]. The operation of the control valve is directly related to the operation of the control system and the operation of the process device. Once the control valve fails, the whole control system will fail.

A typical control valve is composed of a valve body, a valve internal part, an actuator that provides the valve operating power, and a variety of valve accessories [2]. At present, many domestic scholars have conducted a lot of research on the manufacture of control valves. Shao Jiannong et al. [3] chose 904L material to manufacture valve caps. Ordinary casting process was used for carbon steel materials, investment casting process was used for stainless steel and other precious metals, and suitable inner walls were used. Chen Yan et al. [4] adopted the iTNC 530 CNC machine tool shaft machining. With the high-speed milling, high-precision microprocessor and powerful servo control capability of the iTNC 530 control system, the CNC system can realize high-speed milling more easily. An Xiaozhong et al. [5] adopted a casting molding scheme for the light hole with keyway of the valve cover, then roughed, semi-finished and polished the taper hole of the valve body, and adopted the EDM microhole machining

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technology for the hole on the slide valve. Shanghai Yuanyuan Automatic Control Equipment Co., LTD. [6] adopts structural ceramics for the valve internals, which are more wear-resistant to high temperature and chemical corrosion than metal materials. At the same time, the use of surface sealing between the moving and fixing slide can effectively extend the service life of the valve. Yang Huilin [7] adopted the finite element simulation method to simulate and calculate the process parameters of the control valve for possible shrinkage holes and porosity defects in the isolated liquid phase region generated by casting, thus eliminating the casting defects and greatly improving the quality of the casting. Foreign scholars have also conducted a large number of studies on this. Oleksandr Lytviak et al. [8] believe that it is necessary to check the static characteristics of control valves when manufacturing them, so as to evaluate the quality of their manufacturing in the early stage of production. Lee HakSun et al. [9] studied and evaluated the magnetic force, electromagnetic force and resultant force according to the polarity direction and specifications of permanent magnets through finite element simulation, and designed an electromagnetic control valve with permanent magnets. In summary, scholars in this field have carried out a lot of valuable work, but it is still necessary to carry out some work, in the past, the casting process of casting control valve has not been introduced in detail, and there are few studies on the problems that may occur in the casting process.

In the casting production process, due to production process factors, there will be defects such as pores, inclusions, cracks, thin walls and other defects in the production of casting products. After the casting is put into use, due to long-term use, the wear situation at the defect will be more serious, and even lead to the failure of the entire product. In particular, the valve is a thin-shell castings under pressure and temperature, and its internal organizational density is very important. Therefore, the internal defects of castings become the determining factor affecting the quality of castings.

However, the flow path size of the valve casting is small, can't be placed the core bone, the casting is not placed the core bone is easy to cause the flow path in the casting fracture phenomenon, so consider placing the core stay in the casting, and the conventional core stay can't be used in the modeling, need to design a special core stay to solve this problem;通 The sand core is often coated with alcohol cornerstone ink coating or water-based coating, but after the use of these coatings, the flow channel of the casting is prone to porosity, sand and other defects, so it is urgent to design an anti-fracture control valve casting and casting process. In this paper, an anti-fracture control valve casting and casting process are designed, which can effectively improve the quality of castings and extend the service life of castings.

## 2. Design of anti-fracture control valve casting

### 2.1. Process overall scheme design

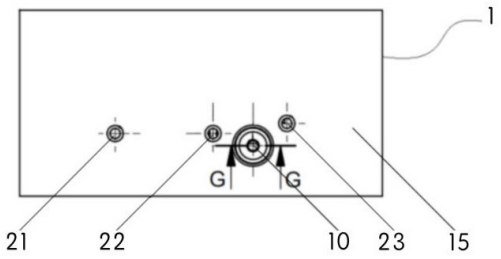
In order to solve the above possible problems, an anti-fracture control valve casting is designed, including the valve body, the first main channel and the second main channel are arranged in the valve body, and the second oblique flow channel and the first longitudinal flow channel are connected with each other through the valve body, as well as two staggered second longitudinal flow channel and the third longitudinal flow channel. In addition, the valve body is provided with auxiliary flow passage, auxiliary flow passage through the side of the second main channel, and the second main channel is arranged in parallel with the auxiliary flow passage, the external

contour of the auxiliary flow passage is "mouth" shape, the four corners of the auxiliary flow passage and the upper surface and lower surface of the valve body are provided with a second vertical flow passage.

Further according to the design requirements, the valve body is provided with a first transverse flow passage, the valve body from left to right in turn through the fourth longitudinal flow passage, the fifth longitudinal flow passage and the sixth longitudinal flow passage, the fourth longitudinal flow passage and the fifth longitudinal flow passage are arranged in parallel, and are connected with the first transverse flow passage, and the fourth longitudinal flow passage and the third main flow passage is connected, The sixth longitudinal flow channel is connected with the second main flow channel. The valve body is provided with three fourth vertical flow channels arranged in parallel, and the two ends of the fourth vertical flow channel run through the upper surface and the lower surface of the valve body.

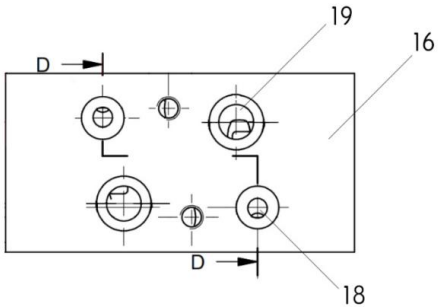
### 2.2. Analysis of process technology scheme

In order to more clearly illustrate the technical scheme of the design, the following will list the Figures 1 to 10 that need to be used in the embodiment or the prior art description, and will combine the following pictures to clearly and completely describe the technical scheme of the designed anti-fracture casting valve.




1- Body of valve,10- The first longitudinal flow channel,15- Front side, 21- The fourth longitudinal flow channel,22- The fifth longitudinal flow channel,23- The sixth longitudinal flow channel.

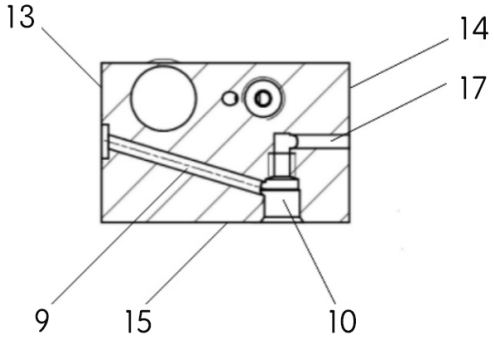
**Figure 1.** Main view of the anti-fracture control valve casting




16- Posterior side,18- The second longitudinal flow channel,19- The third longitudinal flow channel.

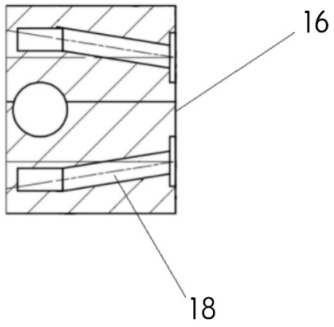
**Figure 2.** Rear view of the anti-fracture control valve casting

It can be seen from Figure 1 and figure 2 that the valve body is provided with a fourth longitudinal flow channel, a fifth longitudinal flow channel and a sixth longitudinal flow channel from left to right, and the fourth longitudinal flow channel and the fifth longitudinal flow channel are arranged in parallel, and they are connected with the first transverse flow channel, the fourth longitudinal flow channel is connected with the third main flow channel, and the sixth longitudinal flow channel is connected with the second main flow channel. Ports of the fourth longitudinal, fifth longitudinal and sixth longitudinal runner extend to the front side of the body.




9- The second oblique flow channel,10- The first longitudinal flow channel,13- Upper surface,14- Lower surface,15- Front side,17- The third vertical flow channel.

**Figure 3**.B-B sectional view of the anti-fracture control valve casting

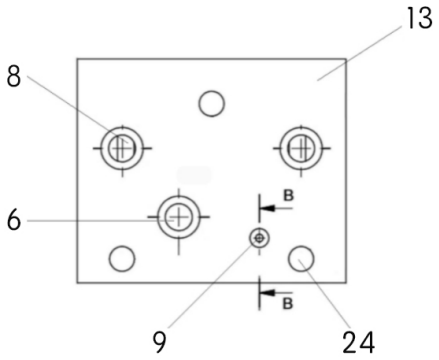



16- Posterior side,18- The second longitudinal flow channel.

**Figure 4.**D-D sectional view of the anti-fracture control valve casting

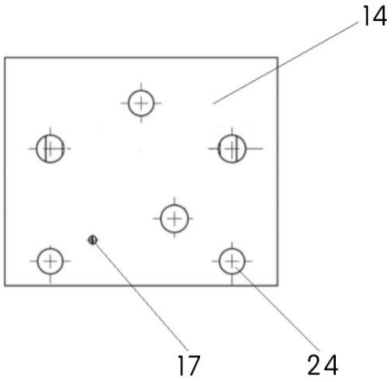
As can be seen from Figure 3 and Figure 4, the valve body is provided with a second oblique flow channel and a first longitudinal flow channel, and the port of the second oblique flow channel extends to the upper surface of the valve body; The valve body is provided with a first longitudinal flow channel, and the port of the first longitudinal flow channel extends to the front side of the valve body; The valve body is provided with a third vertical flow channel communicated with a third main flow channel and a first longitudinal flow channel respectively, and the port of the third vertical flow channel extends to the lower surface of the valve body; The valve body is provided with two staggered up and down the second longitudinal flow channel and the third longitudinal flow channel, the second longitudinal flow channel and the

third longitudinal flow channel port extends to the back side of the valve body, the side profile of the two second longitudinal flow channel is "eight" font.




6- The first vertical flow channel, 8- The second vertical flow channel, 9- The second diagonal runner, 13- Upper surface, 24- The fourth vertical flow channel.

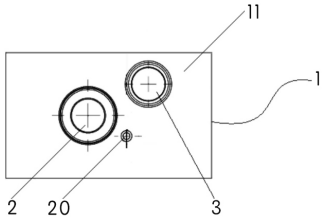
**Figure 5.** Top view of the anti-fracture control valve casting




14- Lower surface, 17- The third vertical flow channel, 24- The fourth vertical flow channel.

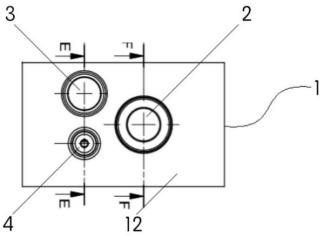
**Figure 6.** Upward view of the anti-fracture control valve casting

As can be seen from Figure. 5 and Figure. 6, the valve body is provided with a first vertical flow channel through the upper surface and lower surface of the valve body, and the first vertical flow channel is vertically connected with the second main channel; An auxiliary flow channel is provided in the valve body, and a second vertical flow channel is arranged between the four corners of the auxiliary flow channel and the upper surface and lower surface of the valve body; The valve body is provided with a second oblique flow channel and a first longitudinal flow channel, and the port of the second oblique flow channel extends to the upper surface of the valve body; The valve body is provided with a third vertical flow channel communicated with a third main flow channel and a first longitudinal flow channel respectively, and the port of the third vertical flow channel extends to the lower surface of the valve body; The valve body is provided with three parallel arranged in the fourth vertical flow channel, the fourth vertical flow channel at both ends through the upper surface and the lower surface of the valve body.




1- Valve body, 2- The first mainstream channel, 3- The second mainstream channel, 11- Left end face, 20- The first transverse flow channel.

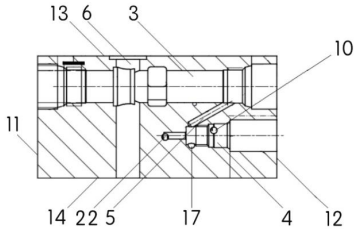
**Figure 7.** Left view of the anti-fracture control valve casting




1- Valve body, 2- The first mainstream channel, 3- The second mainstream channel, 4- The third mainstream channel, 12- Right end face.

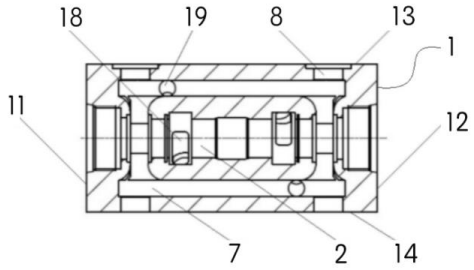
**Figure 8.** Right view of the anti-fracture control valve casting

As can be seen from Figure 7 and Figure 8, the valve body is provided with a first mainstream channel and a second mainstream channel, the first mainstream channel and the second mainstream channel through the valve body and extend to the left end face and the right end face of the valve body, the valve body is provided with a third mainstream channel, the third mainstream channel port extends to the right end face of the valve body, The third mainstream channel and the second mainstream channel are arranged in parallel, and the two are connected through the first oblique flow channel, and the first mainstream channel and the second mainstream channel are staggered. The valve body is provided with a first transverse flow channel, and the port of the first transverse flow channel extends to the left end face of the valve body.




3- The second mainstream channel, 4- The third mainstream Channel, 5- The first oblique flow channel, 6- The first vertical flow channel, 10- The first longitudinal flow channel, 11- Left end face, 12- Right end face, 13- Upper surface, 14- Lower surface, 17- The third vertical flow channel, , 22- The fifth longitudinal flow channel.

**Figure 9.** E-E sectional view of the anti-fracture control valve casting




1- Valve body, 2- The first mainstream channel, 7- Auxiliary flow channel, 8- The second vertical flow channel, 11- Left end face, 12- Right end face, 13- Upper surface, 14- Lower surface, 18- The second longitudinal flow channel, 19- The third longitudinal flow channel.

**Figure 10.** F-F section view of the anti-fracture control valve casting

As can be seen from Figure 9 and Figure 10, the valve body is provided with an auxiliary flow channel, auxiliary flow channel through the side of the second main channel, and the second main channel is arranged in parallel with the auxiliary flow channel, the external contour of the auxiliary flow channel is "mouth" shape, the auxiliary flow channel is provided with a second vertical flow channel between the four corners and the upper surface and the lower surface of the valve body; The third main channel and the second main channel are arranged up and down in parallel, and the two are connected by the first oblique flow channel, and the first main channel and the second main channel are arranged up and down staggered; The valve body is provided with two staggered second and third longitudinal flow channels, the second and third longitudinal flow channels of the port extension to the rear side of the valve body, and its inner end is pierced in the first main flow channel, two third longitudinal flow channels are connected with both sides of the auxiliary flow channel. The valve body from left to right in turn through the fourth longitudinal flow channel, the fifth longitudinal flow channel and the sixth longitudinal flow channel, the fourth longitudinal flow channel and the fifth longitudinal flow channel are arranged in parallel, and are connected with the first transverse flow channel, the fifth longitudinal flow channel port extends to the front side of the valve body.

## 3. Research on casting technology of anti-fracture control valve

The casting process is shown in Figure 11.

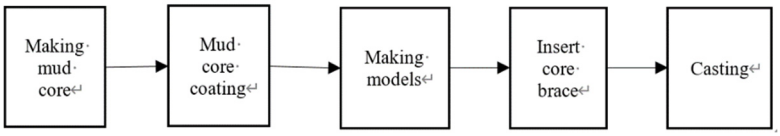



**Figure 11.** Casting process flow chart

The specific steps of the casting process are as follows:

(1) Making mud core: The coated sand is injected into the hot core box and solidified to form a number of mud cores. The number of mud cores is preferably eight, and four of eight mud cores are a group divided into two rows.

(2)Mud core coating：The core surface is coated with casting paint, the main composition of the casting paint is composed by the following weight percentage: Zirconium powder: 49-51%, titanium dioxide: 1.5-2%, iron oxide red powder: 3-5%, lithium bentonite: 3-5%, attapulgite: 1.5-2%, binder: 2%-3%, methanol: 35-40%, The casting paint is coated on the surface of the core, which makes the surface of the core smoother, and also increases the hardness and drying strength of the core, so that the flow channel in the casting is smooth, and effectively solves the serious problems of sand and pores in the flow channel.

(3) Making models: The simulation device is used to generate two models of upper and lower mold, and the model is made according to the generated model. The two rows of mud cores are fixed on the linear plate of the lower mold at intervals, and the core support position mark is added on each mud core.

(4) Insert core stay: The core stay is made into a "dry" type core stay, and the core stay is inserted into the mark, thus solving the problem that the flow channel inside the control valve is small and the core bone cannot be placed, which leads to the mud core easy to break.

(5) Casting: The upper mold and the lower mold are closed, and hot metal is poured into the mold, and the hot metal is solidified to obtain the control valve castings. The number of control valve castings is eight.

Part of the experiment process is shown in Figure 12, Figure 13, Figure 14.

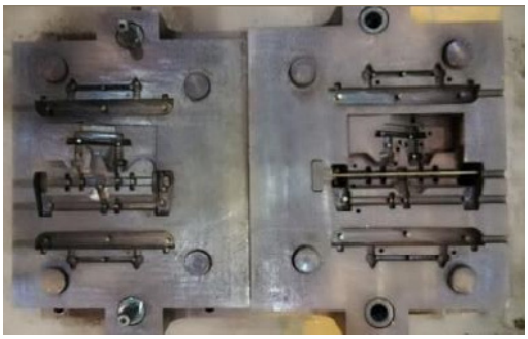


Figure 12 Hot core box

Figure 13 Linear plate

Figure 14 Mud core after coating (graphite powder coating)

Experimental results: The appearance of the casting meets the technical requirements, the spheroidization grade: ≥3, the hardness requirement: HB160-210, the flow channel is free of sand, deformation and other defects, in line with the design requirements.

## 4. Conclusions

As a key component of automated distributed control, control valves are widely used in the field of process control and various industries in the field of fluid. The success of the control valve manufacturing is not only the first step to achieve the reliable operation of the process control system, but also to ensure the safety of the process and production. Valve casting is an important part of the valve manufacturing process, with a good casting to improve the proportion of valve success.

(1) The castings designed in this paper adopt inclined channel, mainstream channel and each channel integrated molding design, and the interconnected channel in the valve body effectively solves the problem of small size of the control valve channel and difficult processing equipment, thus improving the life of the control valve.

(2) The casting adopts the "dry" type core stay in the manufacturing process, thus improving the strength of the flow path and effectively solving the problem that the control valve flow path is easy to break.

(3) Through the design of coating mold paint on the mud core, the surface of the mud core is smoother, and the hardness and drying strength of the mud core are increased, so that the flow channel in the casting is smooth, and the serious problems of sticky sand and pores in the flow channel are effectively solved.

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