AN ADVANCED TECHNOLOGY OF DRAWING IN GAS-STORAGE CYLINDER MAKING①

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ABSTRACT An advanced technology of drawing in gas-storage cylinder making is presented. The cylinder body is made of cogged bloom by process of reshaping, piercing, backward drawing in vertical and finish rolling with newly designed hydropresses. Using developed 2-way cartridge valves the presses are controlled electrically. The technology may be useful to ferrous and nonferrous industrial metal forming.

Key words forging gas-storage cylinder drawing hydropress 2-way cartridge valve

1 INTRODUCTION

There were two main industrial methods in gas-storage cylinder making before vertically backward drawing was put into practice. One is the process in which the cylinder body is made of seamless steel tube by closing the bottom and by spinning the neck. The other is a drawing process[1-5] in which the cylinder body is drawn from a billet on horizontal hydropress. The neck of drawn body is spun at next process step. However, the products made of tube were fallen into disuse in modern industry for the reason of complicated structure and unacceptable wall thickness biases. The cylinder body drawn horizontally has a very uneven wall thickness due to the facts that mandrel bending caused by itself is serious and that guide wear of drawing press occurs always on the lower side. In 1989, a development study on the technology of vertically backward drawing in cylinder making was adopted[6]. After it was done, the work was put into practice in an innovation on scale production of gas-storage cylinder.

This is an advanced technology. The operations of the process are as follows:

(1) Reshaping a piece of cogged bloom at high temperature.

(2) Piercing reshaped billet into a cup-like blank.

(3) Backward drawing the cup-like blank into a cylinder body, finish rolling the outer surface and forming the bottom of the body in vertical.

Two newly designed hydropresses are respectively used in reshaping and drawing.

2 TECHNOLOGY

1.1 Process

The backward drawing vertically in gas-storage cylinder making, presented in this paper, differs from the conventional drawing. The process is shown in Fig. 1.

First, a block of heated cogged bloom, the dimensions of which is 200 mm × 200 mm × 208 mm, is reshaped in a die. The reshaped piece is 264 mm in diameter and with a small draft angle along the length. The two end surfaces of the piece are parallel to each other. Second, the reshaped piece is penetrated to make a cup-like blank in piercing container. The cup-like blank is about 256 mm in outer diameter, 26.5 mm in wall thickness and is 380 mm in height.

Finally, the cup-like blank is put in a guide die of drawing with opening side up. When the slide crosshead of the drawing press is pushed upward, the drawing mandrel, which is fixed on the frame of the press in vertical, is slipped in

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the cup and then the blank goes through four drawing dies one by one. This thins the wall thickness and increases the length of cup gradually. After going throughout the last drawing die, the drawn cylinder body goes through four finish rolling dies continuously. The outer surface of the body is finished by rolling. At the end of the stroke the cylinder bottom is formed.

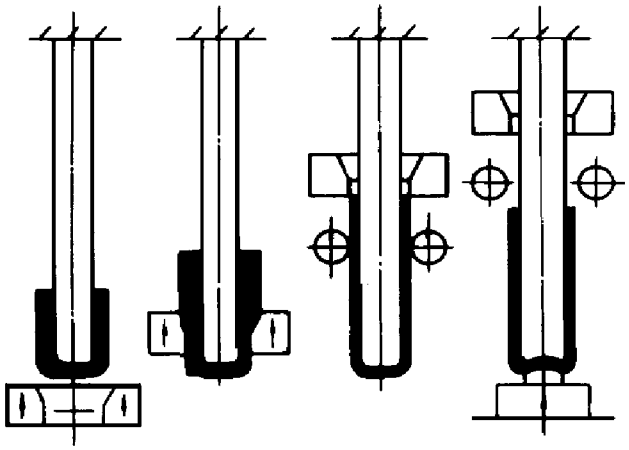

Fig. 1 Diagram of backward drawing in vertical

2.2 Sequence

ZP219-15 steel gas-storage cylinder and the drawn body are shown in Fig. 2. and Fig. 3.

The operational sequence of industrial forming of the cylinder body by backward drawing in vertical is as follows:

Cogged bloom → Detection of defects → Gig saw cutting → Heating → Scaling under pressurized water → Reshaping → Piercing → Drawing → Finish rolling → Bottom forming → Necking

2.3 Advantages

Backward drawing in vertical brings in a lot of advantages. For example, the wall thickness is uniform, the bottom shape is precise, the outer surface is smooth and the mechanical properties reach high grade.

Because a billet with suitable shape and accurate dimension for being pierced into a cup-like blank is obtained by reshaping, the biases of the waveforms both on the cup blank opening and on the cylinder opening are cut down, which largely raises the utilization ratio of material. Drawing and finish rolling as well as bottom forming are performed at the same stroke, therefore the productivity is greatly increased and the cylinder quality is distinctly improved. In such a way, the bending deflection of the mandrel caused by itself and the non-uniform wear of the guide plates resulting from the weight of moving parts are eliminated, which are the main cause leading to the poor product quality in horizontal drawing, so that the cylinder body is accurate to dimension of the wall thickness. Besides, backward drawing makes the cooling, lubricating, clearing and the replacing of the dies convenient. It makes the height of shop building smaller.

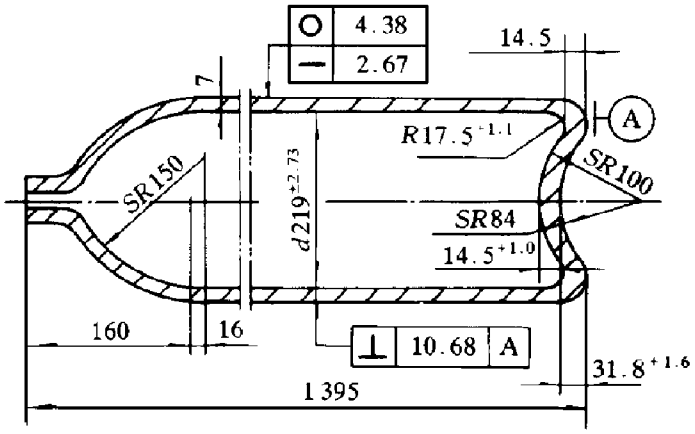

Fig. 2 ZP219-15 gas-storage cylinder

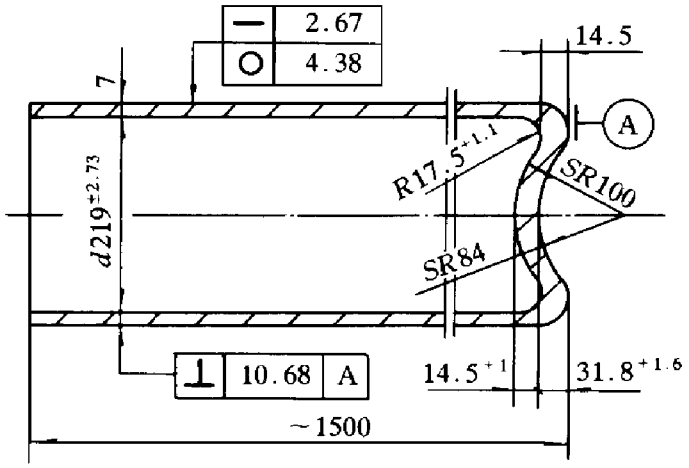

Fig. 3 Drawn body of gas-storage cylinder

3 HYDROPRESSES

In the process line there are one reshaping press, one piercing press and one drawing press. They are hydraulic. The piercing press is a prod-

uct of First Heavy Machinery Work of China. The capacity of the press is 10 MN. The maximum stroke is 1 600 mm. The daylight opening is 3 000 mm. The capacity of the ejector is 1.25 MN. The frame of the press is a prestressed structure that consists of an upper crosshead, a lower crosshead, four hollow columns and four tension bolts prestressed. The reshaping and drawing presses are specifically developed.

3.1 Reshaping hydropress

Reshaping hydropress[7, 8] is used to forge the heated bloom into a precise piece for being pierced. The hydraulic cylinder of the press is equipped a movable cylinder body matched with a fixed trunk piston, instead of a movable piston with a fixed cylinder body. The press is made up of a double layer frame which is a combination of main frame and assistant frame, a hydraulic cylinder assembly, an ejector and a table shifting device, as shown in Fig. 4.

Table 1 gives the specifications of the reshaping hydraulic press.

The main frame is constructed by joining lower crosshead and middle crosshead with four columns. The assistant frame that is mounted on main frame is comprised of middle and upper crossheads by assembling with other four columns which are thinner than those of main frame. When press works, the hydraulic cylinder body is moved under the guidance of the middle crosshead.

Table 1 Specifications of reshaping hydraulic press

Description	Unit	Value
Capacity	MN	20
Return force	MN	2
Cylinder stroke	mm	1 600
Daylight opening	mm	3 200
Ejector force	MN	4
Ejector stroke	mm	400

Compared with the conventional press, the newly designed one has some advantages:

(1) The hydraulic cylinder body can be safer with no supporting flange on it.

(2) The hydraulic cylinder opening up, the

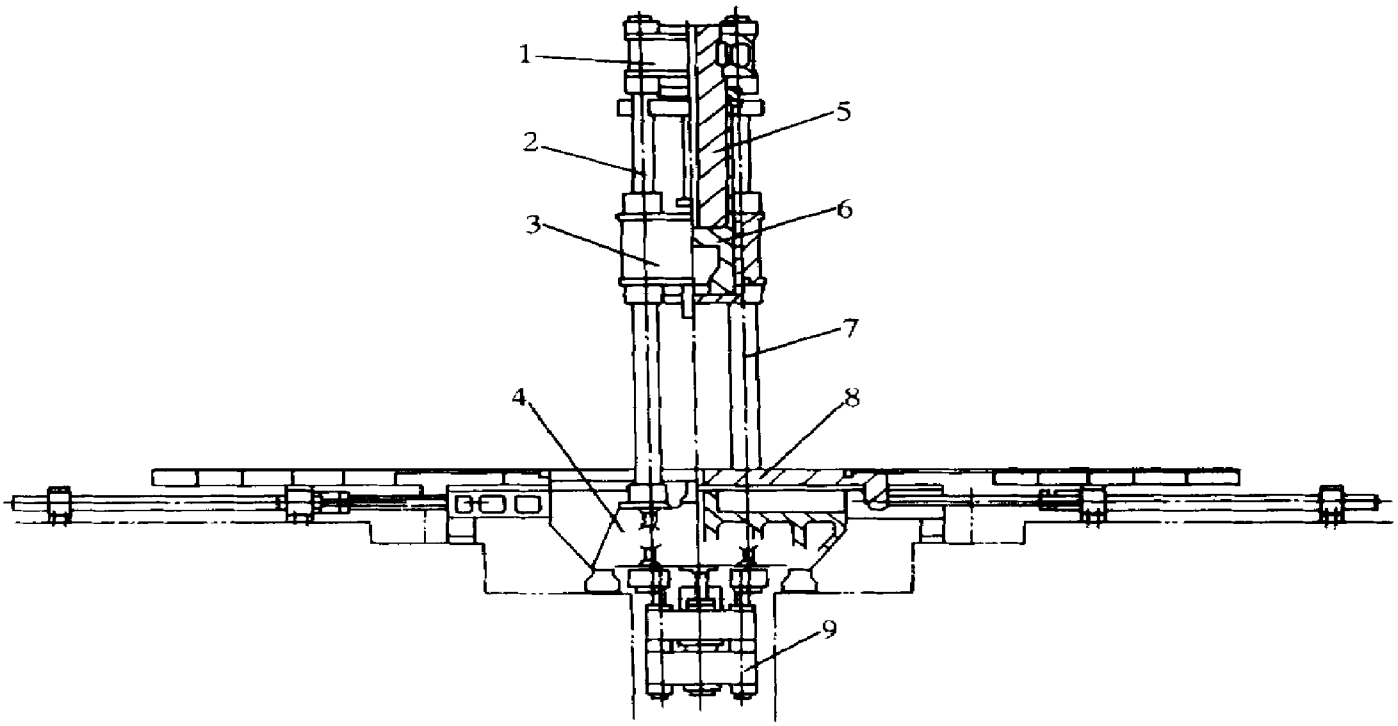

Fig. 4 Diagram of reshaping hydropress

1—Upper crosshead; 2—Columns; 3—Middle crosshead; 4—Lower crosshead
5—Trunk piston; 6—Cylinder body; 7—Columns; 8—Table shifting device; 9—Ejector

packing is far from forging area of the press and gets less heat so that life span of the packing can be prolonged.

(3) Main frame has a large rigidity and a strong eccentric resistance owing to the main frame is short and has no acting force upon the columns.

(4) The precision forgings can be made as a result of the structural benefits.

3.2 Drawing press

Drawing press is used to draw gas-storage cylinder body, to finish the outer surface of the body and to form the body bottom[9]. The press comprises a single casting frame, a slide crosshead in the shape of T and two hydraulic cylinder assemblies, as shown in Fig. 5. The specifications of the press are listed in Table 2.

Table 2 Specifications of drawing press

Description	Unit	Value
Capacity	MN	4
Return force	MN	1.6
Max. stroke	mm	6500
Daylight opening	mm	7245

A very large stroke and a very high daylight opening of the drawing press are necessary to draw the cup-like blank through four drawing dies and four rolling dies so that the frame height of the press, which is about 10000mm, is out of all relations to the table dimension of 1100mm × 900mm. In order to get a good overall accuracy of the press, a special attention must be paid to the structure design. Based on the structure analysis of FEM and the model test, a combined structure of the hydraulic cylinders, along with a T-shape slide, a single cast frame with four columns and a plane plate guide with clearance regulating apparatus are adopted. Using combined cylinder, frame decreases in height. Piston of drawing cylinder is also a return cylinder body.

Drawing mandrel is fixed on upper crosshead of the frame. Drawing dies, rolling dies and discharge die are mounted on the T-shape slide. Bottom forming die is set on a small crosshead of the assistant frame that is suspended from the T-shape slide. When slide returns, drawn body is put off from the mandrel by discharge die.

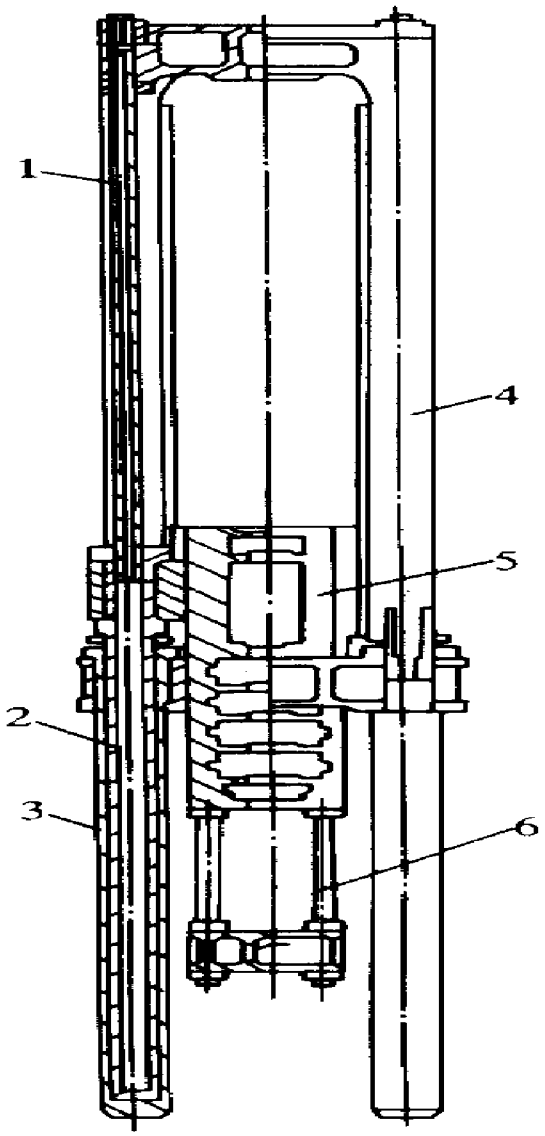

Fig. 5 Scheme of drawing press

1—Return piston;
2—Drawing piston/return cylinder;
3—Drawing cylinder; 4—Frame;
5—T-shape slide; 6—Assistant frame

4 TWO-WAY CARTRIDGE VALVE

Three hydropresses on the process line share a pump-accumulator works which is made up of five pumps, five high pressure gas containers, two high pressure liquid containers and some other equipments. The service power is about 1200kW.

A new type of 2-way cartridge valve, which

is specially developed for water-based soap emulsion, is used in the hydrostatic transmission system. For this reason, the hydraulic presses are controlled electrically. This is an innovation on the control of the hydropress that works through the medium of water-based soap emulsion.

The valve is shown in Fig. 6. It is compr-

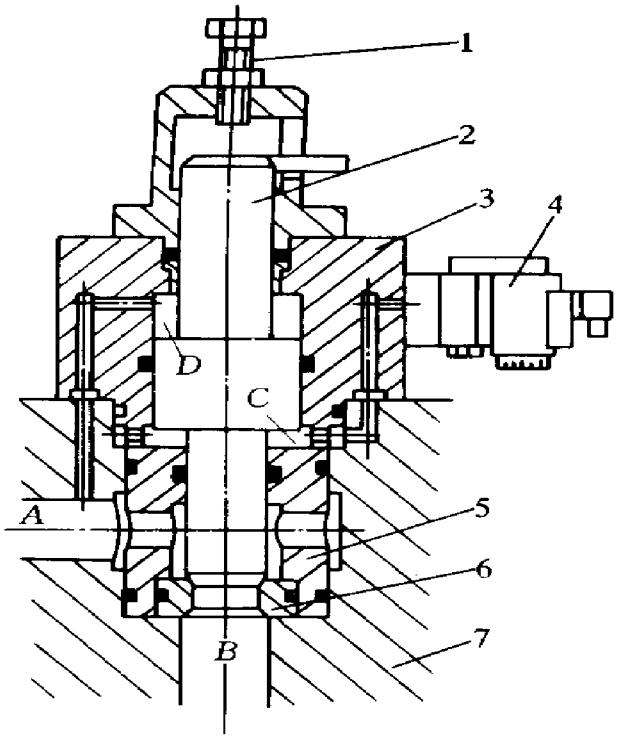

Fig. 6 Diagram of two-way valve

1—Regulating bolt; 2—Valve core; 3—Control plate; 4—Solenoid valve; 5—Valve bush; 6—Valve seat; 7—Block

ised of a base component along with a control plate and a solenoid valve that are used for leading control. The base component includes a core, a bush and a seat. The core is opened and is closed by the action of the pressure in chamber C and D, which depend upon whether the solenoid is power-on. On condition that the solenoid is power-off, the chamber D is under the high pressure while the chamber C is connected with the low-pressure end, therefore the core is closed. Only if the solenoid is power-on, the chamber D and C are under the high pressure so that the core is opened by the differential pressure of chamber D, C as well as A. The opening height of the core is adjustable. Some of the dynamic characteristics is governed by throttle element in control plate.

5 CONCLUSIONS

The technology presented in this paper has been brought to use in commercial scale production of gas-storage cylinder for four years. In accordance with the practical results and the retrieval information, we can lead to the conclusions as follows:

(1) The technology is advanced. The quality of the drawn cylinder body comes up to the standard of ISO.

(2) The reshaping and drawing presses are new in structure, which may be useful to the developing of new hydropresses.

(3) The electrical control of the hydropresses is accomplished owing to the use of the developed valve. This lays the foundations for computer control of the hydropress which works with water-base soap emulsion.

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