Analysis of the Manufacturing Process and Development of Vavles

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Xiaoyun Li & Shanshan Lu

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Author

Xiaoyun Li & Shanshan Lu

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Abstract

The first aim of this thesis was to analyze the whole manufacturing process of how to make semi-finished products into finished products in Anhui Tongdu Valve Co., Ltd. The second aim was to analyze the common problems of using and maintaining valves and offer solutions. According to the situations, there were many different kinds of problems which appeared in different parts of the valves, such as stem, body and gate. The third aim was to analyze the problems in the production process, and learn how to solve them. The current producyion line and work environment were not as efficient as expected. They would cause unnecessary loss of time, energy and capital.

First of all, according to the analysis of the manufacturing process, all the steps of manufacuring gate valves must be understood. Secondly, based on the analysis of common problems, useful solutions were offered on two aspects which were how to avoid accidents before they happene and how to manage problems after they have happened. Thirdly, in the authors' research , the problems in the production process were mainly in two fields: work safety and health problems in the manufacturing process and quality management in processing. Beneficial suggestions were offered to reduce the harm, caused to workers by machines and materials. A new layout of workshops was designed to lower the loss.

These suggestions and designs are offered to the company managers and they can apply them in the practical production as needed.

Keywords

valves, manufacturing process, analysis of common problems, work safety, quality management

Confidentiality

Public

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Abbreviations and symbols

ISO	International Organization for Standardization
PN	Nominal Pressure
TN	Nominal Temperature
DN	Nominal Diameter
M	Mega (10^6)
Pa	Pascal

1 Introduction

Valve is the equipment for controlling flow, pressure and direction of fluid. The controlled fluid can be liquid, gas, gas-liquid mixture or solid-liquid mixture. Valve is generated as a result of fluid in the pipeline.

Valves have been used in the history of human beings for nearly 4000 years. In 2000 BC, in the ancient China, people used wood valve in the bamboo pipelines to produce salt in the salt well. In irrigation, we use a water-gate. In 1800 BC, ancient Egyptians used a similar wood cock to control water distribution for preventing the Nile flood. All of these are prototypes of valve. As the development of melting technology and hydraulic machinery, copper and lead plug appeared in Europe. The lever and weight safety valve were used in a boiler in 1681. About 1840, stop valve with threaded stem and wedge gate valve with trapezoidal thread appeared one after another, which is a major breakthrough in the development of valve. These two valves not only meet the requirements in the various kinds of pressures and temperatures in the industry, but also generally meet the requirements for flow regulation.

The wild use of the industrial valve starts from the steam engine that was invented by Watt. With the steam engine used in the industry, more and more types of valves were invented. In the early 20th century, cast steel valves, cast iron valves, forged steel valves and forge-welding valves appeared. After the Second World War, as the development of polymer materials, lubricants, stainless steel and cobalt-based alloy, the old plug valve and butterfly valve started their new lives. The ball valve and diaphragm valve were developed rapidly. There were more different types of valves and they were of higher quality. Valve manufacturing machinery industry has become an important part of modern industry. Nowadays, in our life, valves relate closely with people's daily lives. For example, the taps of water pipes, stove of liquefied petroleum gas are both valves. Valves are also an indispensable part of internal combustion engines, steam engines,

compressors, pumps, pneumatic actuators, hydraulic power units, vehicles, ships and aircraft. Because of the modern nuclear industry, petrochemical industry, electronic industry and aerospace industry develop at top speed; more and more valves are used by remote control and process control drive. The future of valves are energy saving, effort and automation, so new materials and technology will be used and valves will extend operating life. On the other hand, specialized valves will be developed, for instance, low temperature valve (for delivering liquid oxygen, liquid hydrogen and liquefied natural gas), vacuum valve, the valve working in the nuclear industry, safety valve, control valve, steam trap. [1]

This thesis is to introduce the structures, operation principles and the classification of valves. Taking Anhui Tongdu Valve Co., Ltd as an example, the thesis explains the manufacturing process of valves. Besides, according to the problems appeared during the processing, the authors analyze the situations and offer development methods.

2 Anhui Tongdu Valve Company Ltd

Anhui Tongdu Valve Co., Ltd locates in an ancient Chinese copper capital Tongling city, in Anhui province, China, which is known as “Chinese ancient capital of Bronze”. The city is next to the beautiful Huangshan Mountain and the famous Buddhism scenic spot Jiuhuashan mountains. The company has the history of producing valves for more than 30 years and the trademark is “Tongding”, mainly producing and selling series of the products, such as gate valve, check valve, exhaust valve, drainage valve, gate control valve, expansion joint, sluice gate, weir gate, headstock gear grille, suction dredger, stirrer and other environmental products. These products are sold to the whole country and exported to Europe and Southeast countries in which they are acclaimed. The production level of low water supply and drainage, the domestic marketing coverage and the drainage industry market coverage are all in the Top Ten in the same field. [2]

Figure 1. Logos of the company [2]

The company covers an area of 45,000 square meters; its registered capital is 57 million RMB and it has 400 employees. It has more than 400 kinds of machining and special devices. It possesses rich technology, a sound controlling system and good after-sale service. The company has already got ISO 9001 International Quality Management certification, ISO 14001 Environmental management certificate and European CE certification. It has also obtained certification of second grade measuring system, national title of qualified and stabilized quality products, high quality products of Anhui province. It has a self-owned import-export authority. It has been named as “the 100 top private enterprises of Anhui province” for many years since 1999, the provincial outstanding in private enterprise and the leading enterprise of Anhui province in

environmental protection industrial base. Its multiple products have gained the state patent, a scientific and technical progressive award. The products are widely used in drainage, metallurgy, petrochemical industry's electricity architecture and mineral and so on. They have been sold to overseas market and gained in general favorable comments. [3]

Figure 2. Factory of the company

3 Structures and Operation Principle of the Valves

Valves consist of four main parts: body, bonnet, stem and spool. Except these four main parts, valves also need other components such as sealing, fastener, rubber ring, screws and so on.

3.1 Structures

Figure 3 shows the structure of a gate valve as an example.

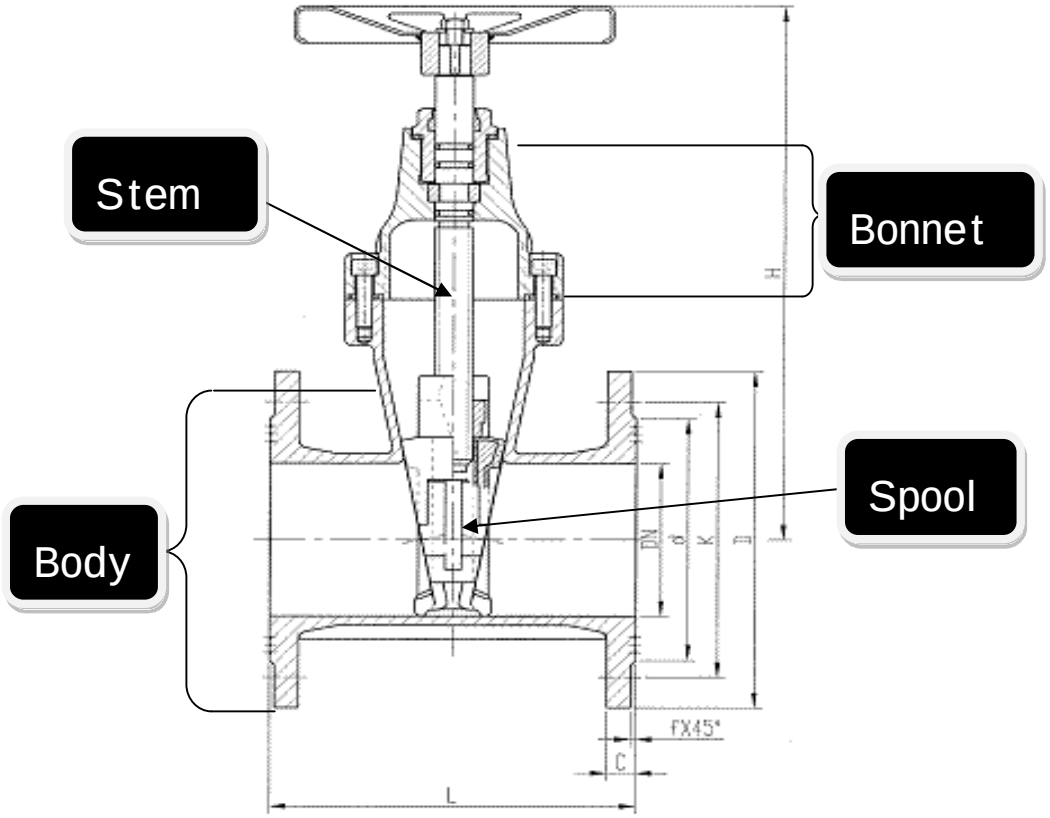


Figure 3. Section of gate valve

Body is the main part of the valve. The body of low-pressure valve is often produced with the casting process and the high-pressure valves mainly use the forging process. Different types of valves select different materials, most are cast iron, cast steel,

stainless steel and carbon steel.

Bonnet is the cover of the valve. Components of the stem seal are fixed in the bonnet to connect or support the operating part. Bonnet and body could be a whole or separated. It is used to position the stem to make sure the stem could drive the switch well. A second use of bonnet is sealing, because it has certain strength to prevent leaking. [4]

Stem is a key part of the valve, which is used to rotate. One end of the stem is connected with the operating part or handle, and another end directly drives the spool moving or rotating to make the valve open and close or regulate the size of the section. During the procedure of the opening and closing, stem is the moving part, the mechanical part and sealing part. At the same the time, the stem is impacted and corroded by the media and it has friction with filler, so when selecting the material of the stem, it must be ensured that enough strength, a good impact toughness, abrasion resistance, corrosion resistance under certain temperatures. The stem is consumable, machining property and heat treatment property are both in the consideration. [4]

Spool can be seen as the core of the valve. Its position is usually in the middle of the body. Spool relies on its own moving to control the direction, pressure and flow. In some valves, for example pressure reducing valve, the spool is the key part to control the pressure. [4]

The graph of Figure 4 on the next page shows the parts and small components of the valve.

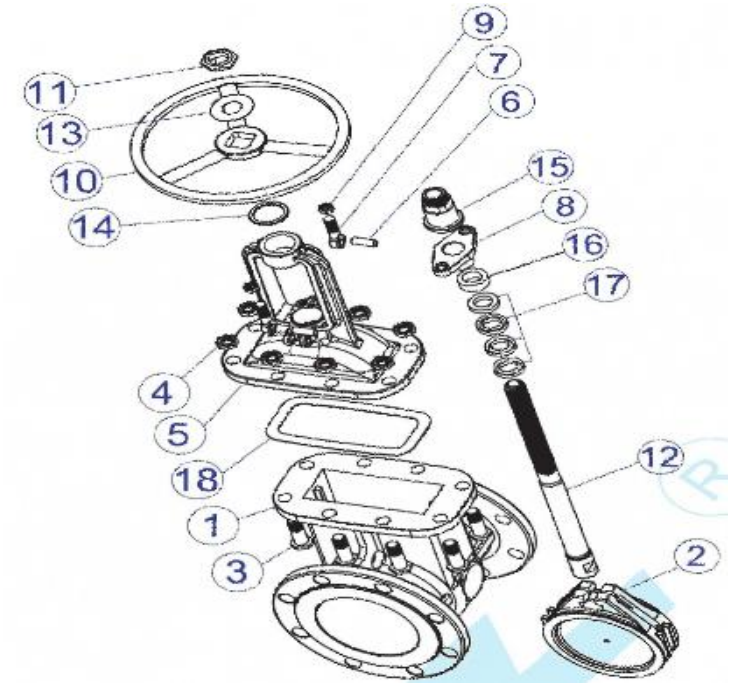


Figure 4.Structures and profiles of a gate valve.

1. Body 2. Spool 3. Bonnet bolt 4. Bonnet nut 5. Bonnet 6. Hinge pin 7. Eye bolt 8. Gland 9. Eye nut 10. Hand wheel 11. Nut 12. Stem 13. Name plate 14. Spring 15. Yoke Steeve 16. Gland packing 17. Packing 18.Gasket

3.2 Operation Principle

The drive principle of valves in simple words is relying on the driving mechanism or fluids to make the open and closing parts down, sliding, rotating or turning to change the size of flow area to work. The basic parameters of the valve are working pressure (PN), temperature (TN) and diameter (DN). For large-scale use in industry pipeline valves, commonly nominal pressure and nominal diameter are used as basic parameters. PN means the maximum pressure of a certain material valve working in the required temperature. DN refers to the body and the nominal pipe diameter of the end of the connection. [12]

According to the different types and requirements, the main performances of valves are sealing, strength, conditioning, circulation and open-closed. When designing and selecting a valve, people must consider the basic parameters and the performances, the

performance of the fluid including the fluid phase state (gas, liquid or contains solid particle), corrosiveness, viscosity, toxicity, flammable explosion hazard and radioactivity and so on.

The sealing property and the strength character are the most important and basic features. The sealing property of valves means the ability to prevent the leaking of the media of each part. The sealing of valves has two parts: an internal seal and an external seal. The internal seal means the seal between the body and the bonnet. For block valves, internal leaking is forbidden. The external seal is the sealing between the motion part of stem and bonnet, the body and the bonnet or the body and pipe joint spot. Bad sealing or not enough seal strength results in leaking or damaging of the component, such as the transportation of toxic, flammable or corrosive fluids, which can also lead to serious safety incidents. In order to ensure the valve seal and strength, reasonable structure of design with the standards to make sure the process quality and correct selection of materials are both important. The use of valves not only requires the a good sealing performance, but also a safety guarantee.

The material of valves for non-corrosive fluids with low pressure is cast iron or cast copper. High pressure valves need cast steel or the forging steel, high temperature or high pressure valves alloy steel, valves for corrosive fluids stainless steel, plastic, corrosion resistant alloys (such as copper and nickel-molybdenum alloys, titanium alloys and lead alloys, etc) or cast iron, cast steel liner corrosion resistant materials. The sealing surface of low pressure valves is often made by brass or bronze and the sealing surface of high pressure valves needs stainless steel. If there are specialized requires of high pressure and high temperature, the sealing surfaces of the valve need to be produced by co-based carbide alloy steel. Polymeric materials are also widely used in the manufacturing of valves, such as the seat of ball valve which is mainly made of PTFE plastic. The sealing ring of butterfly valve or the diaphragm of diaphragm valve uses various rubber materials. These materials are better in use than metal under a certain range of temperature. [12]

4 Classification of the Valves

Valves can be classified in many ways. According to different materials, valves can be divided into metal valves, non-metal valves and metal liner valves. According these classifications, workers can manage the products well and inventory can be more effective. [5] The next paragraphs introduce some ways of valve classification.

According to the function and use, valves can be classified as Figure 5 shows. In fact, valves are classified in this way in real industrial production.

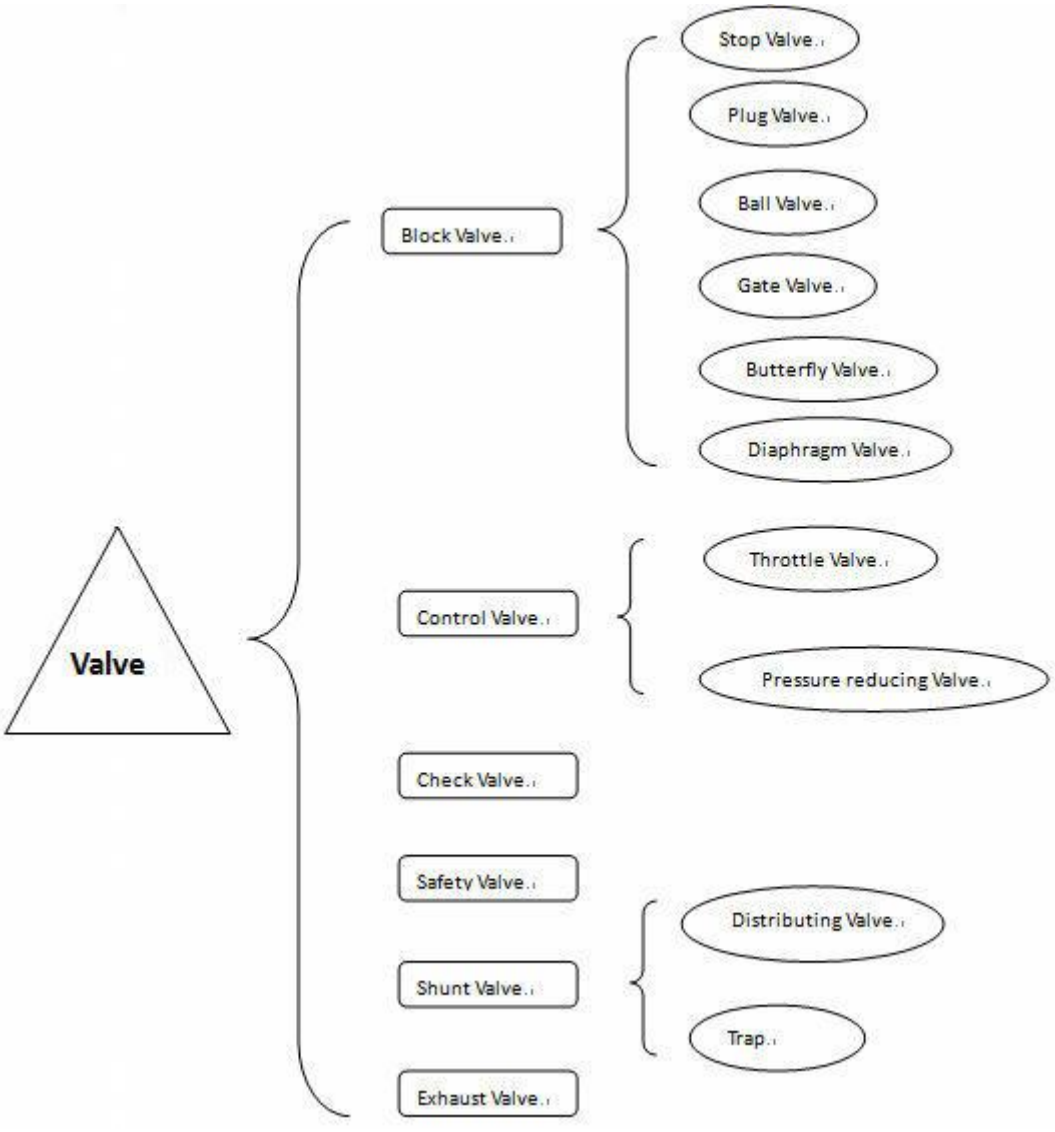


Figure 5. Classification of valves according to function and use [14]

Figure 6 shows the different valves according to PN (normal pressure). These valves can stand kinds of pressures in different work environments.

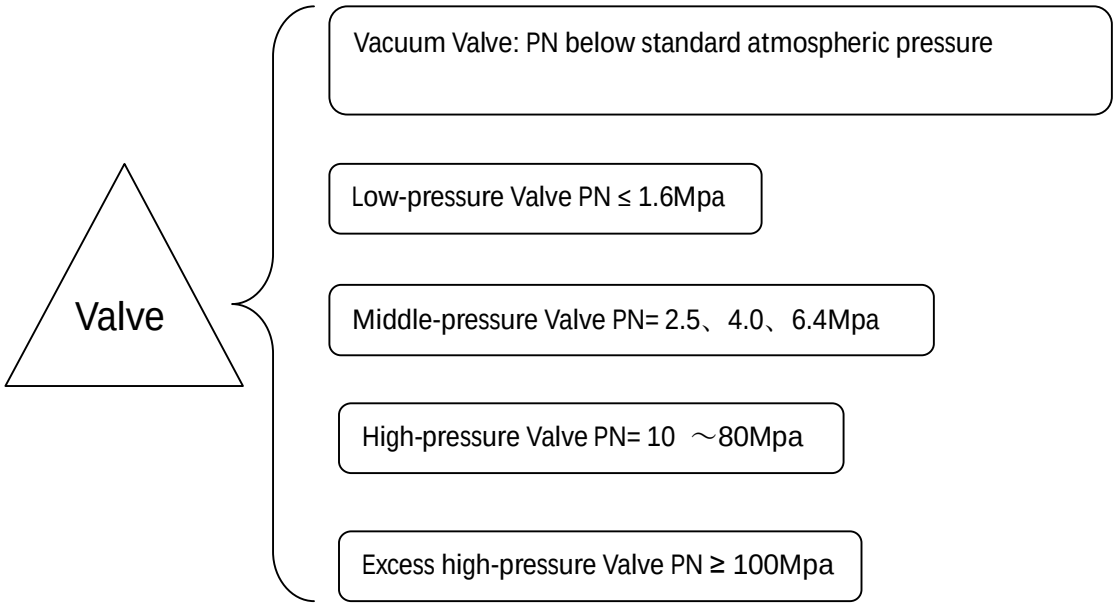


Figure 6.Classification of valves according to PN [14]

In different temperatures, the work environment requires some specialized valves,. Figure 7 illustrates some classifications.

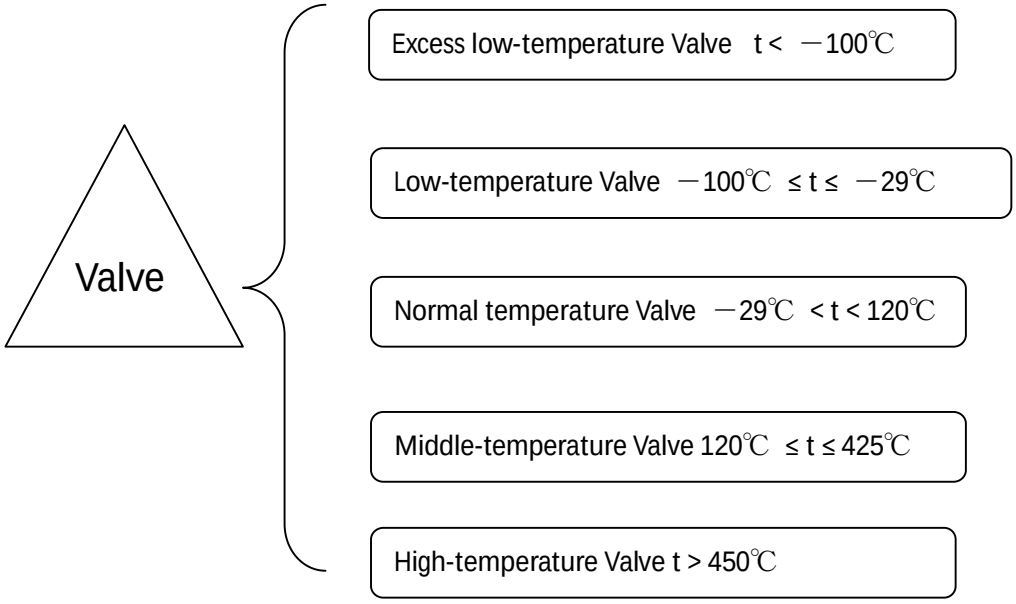


Figure 7. Classification of valves according to TN [14]

Valves have many drive methods. In general, they can be divided into three types: hand drive and power drive or no power drive. The next Figure 8 introduces some details about this.

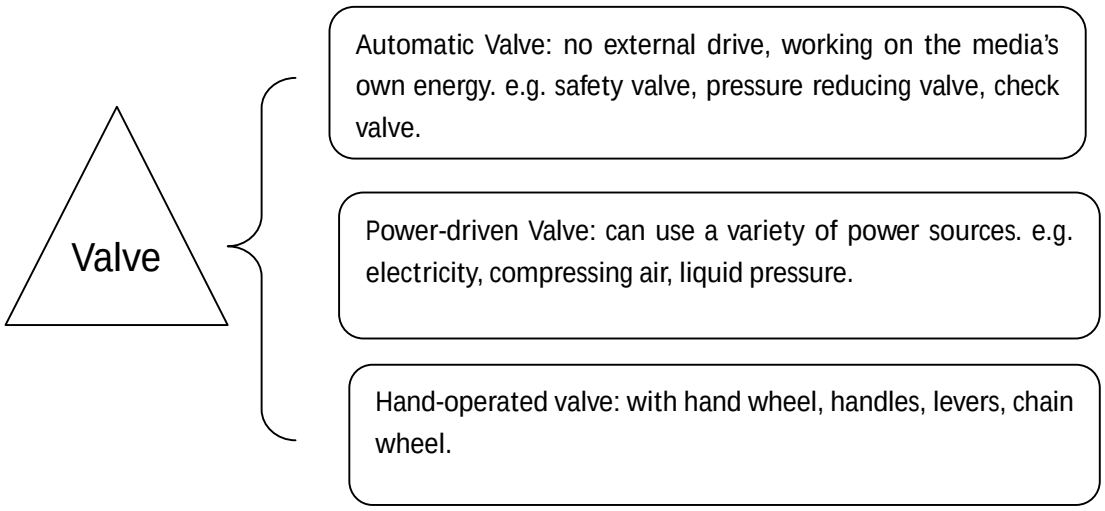


Figure 8. Classification according to drive methods [14]

According to the connecting methods, Figure 9 indicates that valves also could be sorted depending on the way how the valve links with pipes.

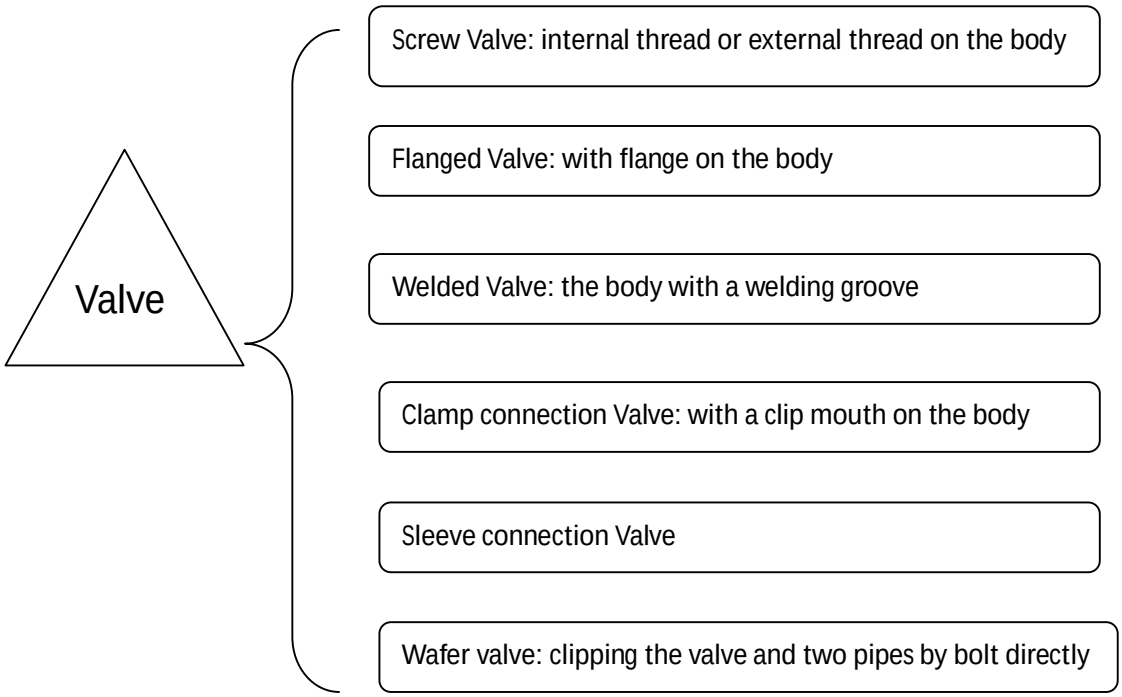


Figure 9. Classification of valves according to connecting methods [14]

5 Introduction to the Main Products

In industrial production, valves can be sorted into six types which are block valve, check valve, safety valve, control valve, shunt valve and air release valve. This company produces many types of these products, but their main products are gate valve, butterfly valve, check valve, stop valve and Y-strainer. Most of them, like gate valve, butterfly valve and stop valve, belong to block valves. Here are some detailed introductions of these five kinds of main products.

5.1 Gate Valve

A gate valve, also called a sluice valve, is a valve that opens or closes by lifting a round or rectangular gate to stop or put through the medium. By selecting different materials, gate valves are widely suitable for water, steam, oil, nitric acid, acetic acid, urea and oxidation medium. The direction of the gate's movement is perpendicular to the direction of the medium's movement. The gate valve is used to end the medium. When the gate is completely open, the pressure loss which is caused by the medium is minimum, which means the gate valves do not need to be opened or closed often (open or close the gate totally), and the gate valves cannot be regulated or throttled well. For example, the medium flows through the gate valve in a high speed. When the gate is partially opening, the rocking of gate will result in the shaking of the whole valve and the shaking will damage the sealing between the gate and the valve's body. On the other hand, throttling will bring erosion to the gate. [4]

Gate valve has many advantages, like a small fluid resistance, convenient open and close, so that it can be used widely. Besides, gate valves can also be used in an environment of two-way flows and without directivity. As a short structure, the gate valve is suitable for both big sized valves and small sized valves.

In accordance with the structures of the stems, there are two types of gate valves which are raising stem gate valves and blind bar gate valves. The stem nut of the former is on the bonnet or the support. When the gate is open, the stem rises by rotating the stem nut. This structure is beneficial to the lubrication of the stem and the situation of opening and closing is clearly shown, so it is extensively used in different fields. The stem nut of the latter is inside the valve body and directly contacted to the medium. The stem should be rotated in order to open or close the gate. The advantage of this structure is that the total height of the valve remains unchanged so that the installation space needed is very small which makes the inside stem valve suitable for installation of the valves in a limited space. It also requires an indicator to indicate the extent of the opening and closing. In the meanwhile, there is a shortcoming of this structure: not only cannot the thread of the stem be lubricated, but it is also easily damaged because of direct corrosion of the medium. The easiest way to distinguish the two kinds of gate valves is whether the stem can be seen from outside. As Figure 10 shows, if the stem can be seen, it is a raising stem gate valve. Otherwise it is a blind bar gate valve.

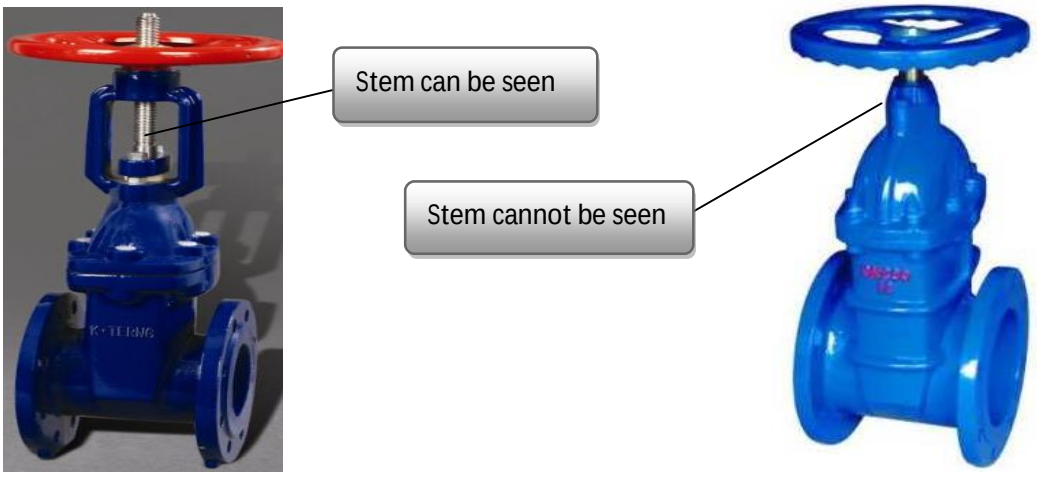
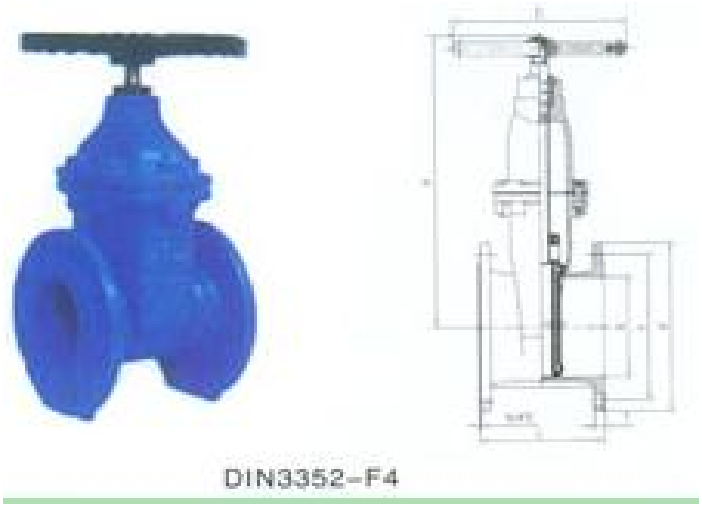


Figure 10. Raising stem gate valve and blind bar gate valve.

When using the gate valve, safety must be considered first. When the valve is working in an industrial process, a specialized spanner is used to open and close it, in order to aviod slipping. After checking the pipes or other problems, the valve can be opened by a hand wheel slowly and operators do not stand at the direction of sealing surface. If the medium

is an acid-base fluid, a protecting mask is absolutely necessary. During the first 5 minutes of working, the operator should stand near the position, then check the flows by an endoscopic.



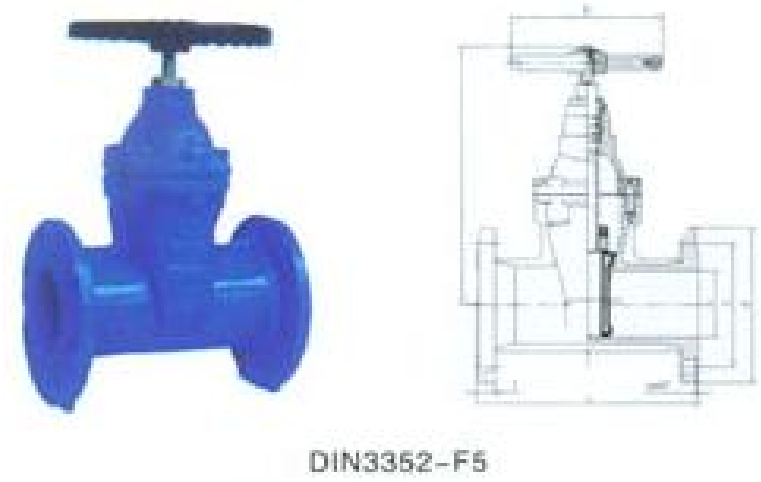


Figure 11. Two types of gate valves in this company [2]

5.2 Butterfly Valve

A butterfly valve is a valve that uses a disc which is rotated around a spool as a closing part to open and close. It is mainly used for regulating or isolating the flow. The key part

of butterfly valve is a round disc. It can revolve around its own axle in order to open and close, and when it is working, it seems like a butterfly is flying. That is the reason this is called a butterfly valve. The angle of the butterfly valve from completely open to completely close is less than 90o. As the butterfly valve and the stem do not have the ability to fix themselves at a certain position, it is needed to fix a turbine speed reducer on the stem which is very helpful to make the disc stop at any position, as well as to improve the operating performance of the butterfly valve. [6]

Figure 12. Wafer type butterfly valve and flanged butterfly valve

Figure 13. Different types of Flanges.

Sorted by the connecting methods, there are four kinds of butterfly valves: a wafer type butterfly valve (as in Figure 12), a flanged butterfly valve (as in Figure 12), a lug type butterfly valve and a welded butterfly valve. The first two kinds of butterfly valves are commonly used. The connecting method of a wafer type butterfly valve uses a stud to connect the valve between the flanges of pipes of the two sides. Being different from the wafer type butterfly valve, there are already flanges on both sides of the flanged butterfly valve, so the connecting method uses a bolt to connect the flanges of the valve to the flanges of the pipes.

There are many advantages offered by the butterfly valve. The first one is that it is convenient and fast to be opened or closed, and the resistance of the fluid is very small. Therefore it can be used very often. A second advantage is that the structure of a butterfly valve is very simple, leading to that the volume and the weight are small. A third one is it can be well sealed under a low pressure. Last but not least, it is adjustable.

However, the scope of butterfly valve's work pressure and temperature is limited. In China, the nominal pressure (PN) is between 0.25—4.0MPa, and the temperature is <=425oC. Actually, compared to a gate valve, the butterfly valve occupies less space, but the tightness of the gate valve is much better. So when they are used in practical applications, the temperature of the medium, the requirements of the tightness and other conditions must be all taken into consideration when decided which kind of valve is the best choice.

Figure 14. Types of butterfly valves in this company [2]

5.3 Check Valve

Check valve, which is presented in Figure 15, is also named one-way valve, and this name clearly shows that the direction of the medium in pipelines using this kind of valve is only from one end to another. The purpose of using a check valve is to prevent the medium from flowing back. The opening and closing parts work automatically by the force of the fluid's flow. This means that check valves belong to automatic valves which can work depending on the energy created by the medium, not the external force. There are two ports in a check valve, meaning one port is for fluid to enter and the other is for leaving. When a check valve is working, the clack of the valve opens under the pressure of the fluid and the fluid flows from the inlet port to the outlet port. When the force of the inlet port is smaller than that of the outlet port, the valve clack will close automatically because of the pressure difference of the fluid and the gravity prevents the back flow of the fluid. [7]

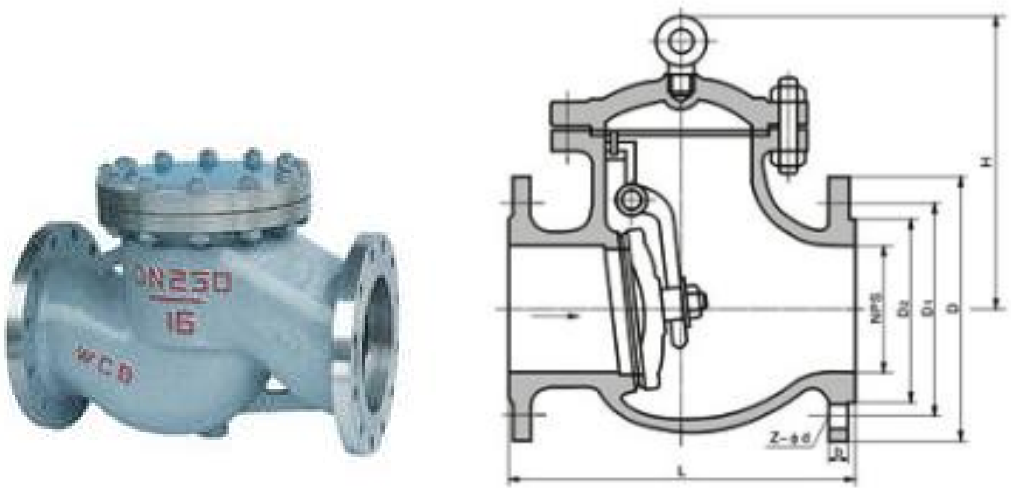


Figure 15. Check valve

Generally check valves can be classified to lift check valves, swing check valves, butterfly check valves and diaphragm check valves. Usually when a lift check valve is used, the resistance of the fluid is relatively large which makes it more useful in occasions where a small caliber is needed. Compared with the lift check valve, the swing check valve is much more helpful in a situation which requires large caliber as a result of

less fluid resistance. Besides, check valve is ordinarily used for cleaning medium without solid particles, and it is also not suitable for fluid with a high viscosity. The valve shown in Figure 15 is one of the main products in Tongdu Valve Co., Ltd.

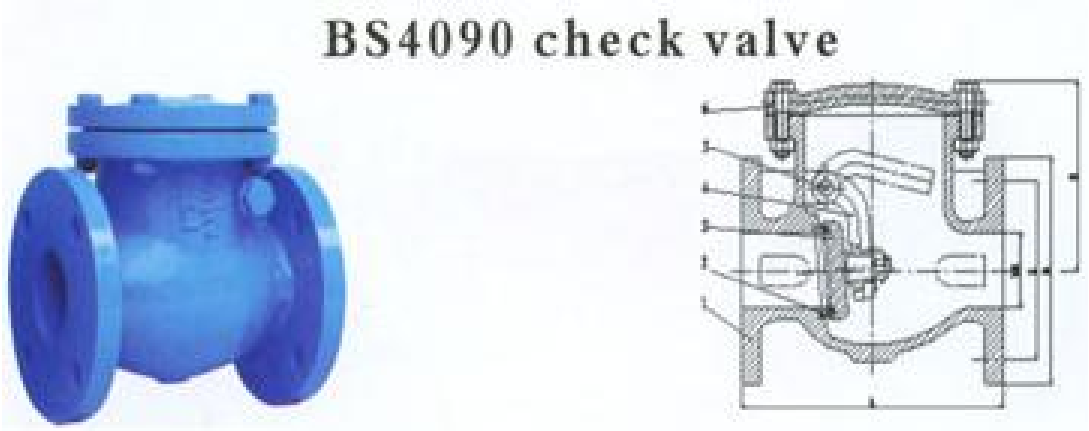


Figure 16. Check valve in this company [2]

5.4 Stop Valve

As with the gate valve, stop valve (also called globe valve) belongs to block valve as well. The opening and closing parts of the stop valve are plug-shaped valve clack, and the sealing surface is a plane or a conical surface. The surface is perpendicular with the centerline of the stem. The valve clack moves along the centerline of the fluid, and once the clack is open, the valve seat and the sealing surface of the valve clack will never touch. As the effect stops action, this kind of valve is particularly suitable for cutting off or throttling the fluid. [8]

Some typical stop valves are presented in Figure 17 and Figure 18.

Figure 17. Stop valve

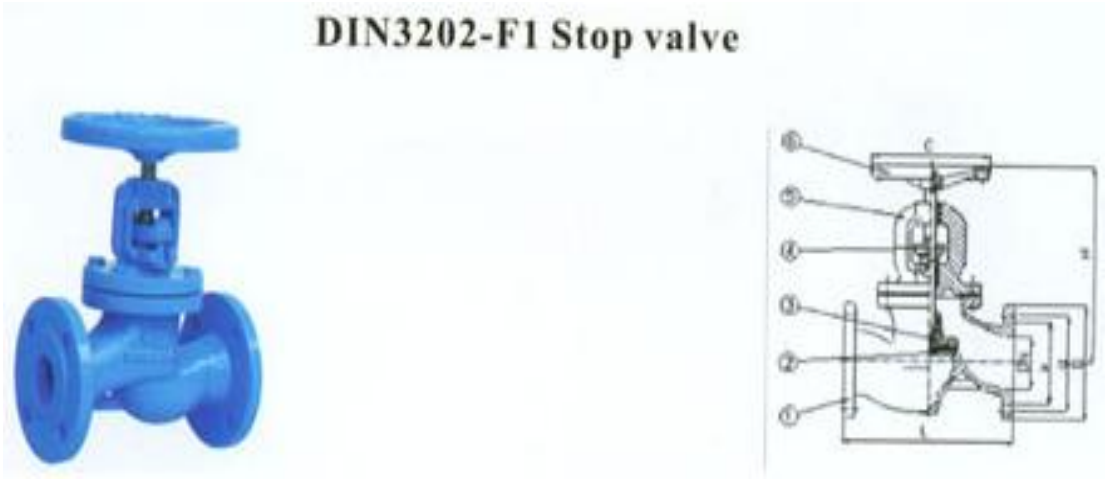


Figure 18. Stop valve in this company [2]

Stop valve is forcedly sealing valve, meaning that the valve clack should be pressurized when the valve is closing to make sure the sealing surface does not leak. Stop valve is one of the most popular valves because, on one hand, the friction between the sealing surfaces is rather small during the process of opening and closing which makes it extremely durable. On the other hand, it is uncomplicated to manufacture and maintain. At last, it can be used not only under low pressure, but also under high pressure. [8]

Actually there are still some inconveniences. Stop valve only allows a one-way flow, so it must be settled in the correct direction when installed. In the meantime, because of its structure, the length of the stop valve is larger than that of the gate valve. Besides, the fluid resistance is large, so the sealing is not completely reliable after it has been working for a long time.

There are still some tips for operating the stop valve. When the valve is totally open, a hand wheel should be reversed a little to make the thread tight. If the valve is hard to open or close, there must be some problems which need to be analyzed carefully. For instance, there is too much filling; the stem is skew, close parts bulge and so on.

5.5 Y Type Strainer

Strainer, which is presented in Figure 19, is an essential device in the pipelines as a transporting medium. It is commonly fixed in the enter side of valves or other equipment so that it can eliminate the impurities in the medium to ensure that the valves or equipment work normally. The principle of strainer is to use filters of different sizes and numbers of holes to remove contaminants from the fluid (liquid or gas), in order to make the fluid achieve the required level of purity. When the fluid flows into the cartridge which has been fixed with a certain specified filter, the impurities will be blocked off, and the clean filtrate discharges through the exit side of the strainer. The most convenient thing is that if it gets dirty, the removable cartridge can be unloaded, washed and reloaded, and it is very simple to operate and maintain. [9]

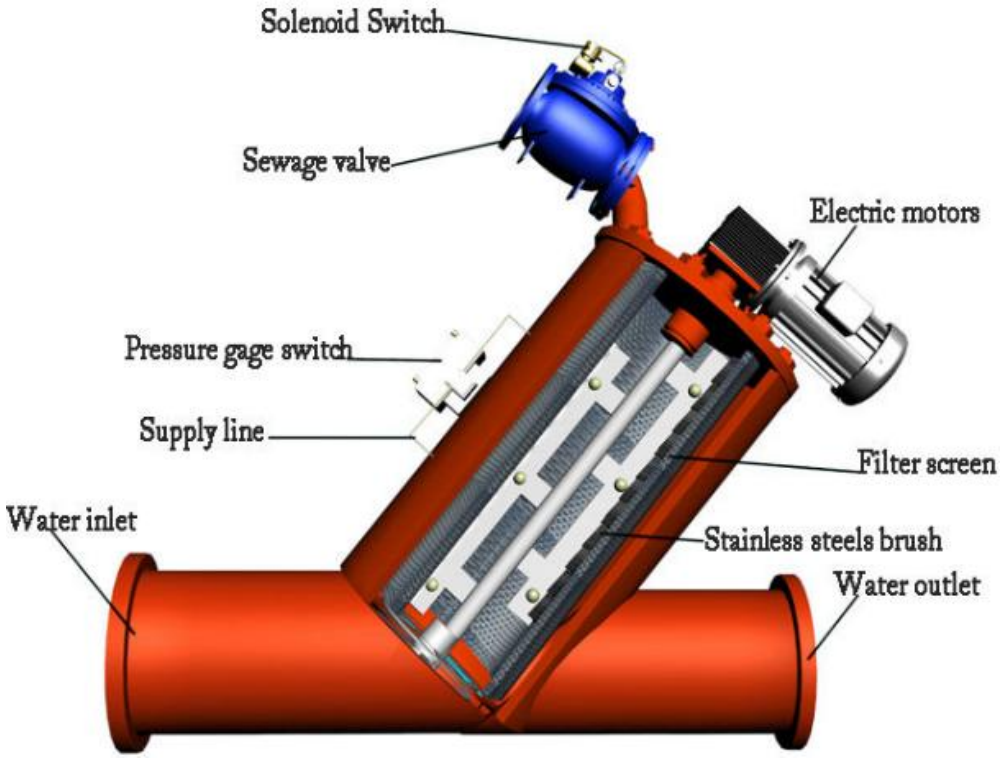


Figure 19. Strainer

The Y type strainer, as in Figure 20, is named by its Y-shape. Y type strainer is widely used owing to its advanced structure, low resistance and facilitation to get rid of the

sewage. It is applicable to water, oil and gas. The filter for water is 18-30 mesh, for gas is 10-100 mesh and for oil is 100-480 mesh. (The numbers mean how many wires per inch there are in the screen. The bigger is number, the smaller the particles which can go through the filter.) [11]

Figure 20. A Y type strainer in this company

6 Industrial Process of Gate Valve (DIN3352-F5)

The Gate valve is the most common valve in daily life and industrial production. The gate valve DIN 3352-F5 is the main product of Tongdu Valve Co., Ltd (this type belongs to the company's standard).

6.1 The Whole Working Process

The work process before manufacturing is divided into 4 steps.

First, sales department offers the customers a list of all types of the gate valves in order to help the customers decide which type is suitable. Besides, they can also customize special models of products. In that case, the CAD drawings and the material list are offered by the customers. On the other hand, the customer can employ an engineer of the company to design the valve for them. After the products are decided, they need to make an order and pay the deposit (usually 30% of the total price). According to the order, the manufacturing department needs to make a distributive plan for the production process.

Secondly, after the order has been made, the manufacturing department should check the storage of each component (body, bonnet, stem and spool). If there are no enough components, the purchasing department must contact the suppliers to get sufficient parts, the quality of which should be as required. At the same time, the financial department should offer capital support.

Thirdly, every workshop checks the materials on the basis of the design paper and list. Then the manufacturing process starts. An important step is that all the products should be examined by the quality management department to distinguish the unqualified ones and deal with them later. The qualified products will be marked and sent to the warehouse. The worker of the warehouse should classify and record detailed

information.

At last, the products will be delivered to the customers before the deadline of the contract.

6.2 Production Process

Table 1 below is the data parameters of the gate valve DIN3352-F5.

Table 1.Materials List [2]

Spare part's name	Material
Body	Ductile iron GGG50
Wedge	Ductile iron GGG50+NBR
Bonnet	Ductile iron GGG50
Stem	Stainless steel 2Cr13
Stem nut	Brass
Holding ring	Brass
Seating nut	Brass
Hand wheel	Ductile iron GGG50
0 Ring, Gasket, Dust Ring	Rubber NBR

Body

The semi-manufactured body should be cleaned first, and then turning (as in Figure 21) starts in order to make the surface smooth, so the copper could be plated better. Turning is a common technique in the industrial process.

After turning the surface, next step is plating copper. There are three cross-sections of the body: top section, bottom section and side section, all of them need to be plated with copper. The purpose of copper plating is to make sure the body can be sealed completely, because copper is a soft metal with good flexibility. At the same time, the

surface which contacts the spool also needs to be plated with copper for the same reason. Then after all sections have been plated, they should be polished.

As the top, bottom and side section need to be connected to the bonnet or other pipes and valves, the surfaces must be threaded. The three sections all need to be holed, too. Figure 22 shows the drilling process of holes, and by these holes, screws can be used to combine the body with other parts. Each sized valve has a different size of holes, so the dimensions can be regulated to get different products. Many kinds of models are used to drill different holes of different sizes, meaning each valve type has a specialized model of holes.

Figure 21. Turning of contact surfaces of the flanges

Figure 22. Drilling

When the drilling is finished, the body is sent to the equipment where the paint is sprayed. Actually this step is baking varnish, so when the painting is finished, the products need to be baked under a very high temperature. The material of the paint is Polytetrafluoroethylene (Teflon). This material is a unique painting with thermal resistance, chemical inertness excellent dielectric stability and low friction. Besides which, almost no materials can bond with Teflon. In such a condition, the color is bright and it stays colorful for a much longer time than normal paint. In the painting workshop, normal-painted products can also be produced.

The equipment in Figure 23 is a paint room where the varnish is baked. The temperature in the room can be up to 50°C to 60°C in a short time. Fans absorb fresh air and filter it, and then lead the air into the heat exchanger. After the air has got energy and become hot, it is sent to the air chamber which is located in the top of the paint room. Hot wind will circulate inside and the air must be kept clean.

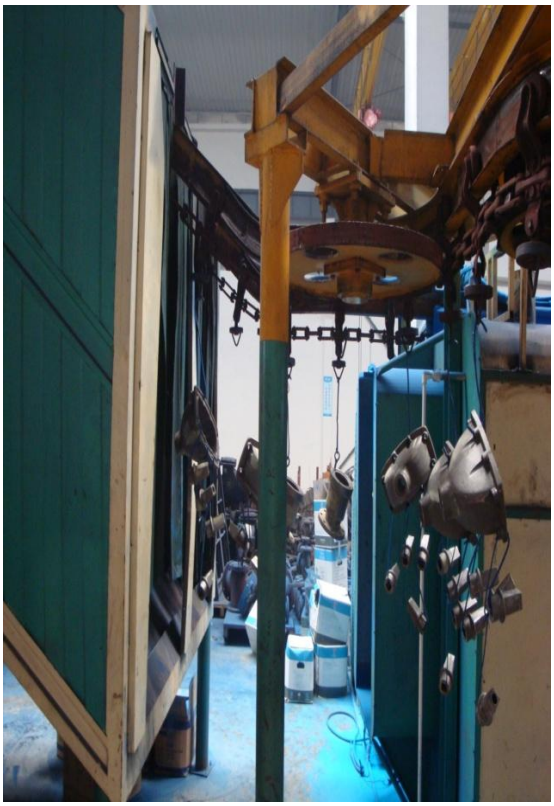


Figure 23. Baking of painted

Spool

The first thing to be done to the semi-manufactured spool is the same as which was done to the valve body. It means the spool also needs to be turned first. When the surface is glossy, the spools need to be sent to the painting workshop to be plated with copper, too. Then the spool is wrapped with rubber, which make the spool and the inside section of the body fit together perfectly. The spool can be seen in Figure 24.

The valve spool is located in the core of the valve body. It needs some components to make connection. Figure 24 below shows the cross section of spool part.

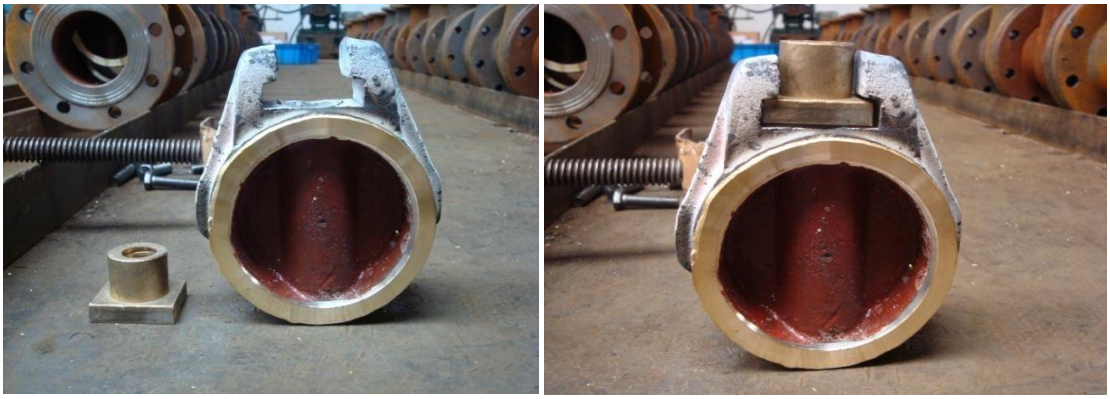


Figure 24. Spool

Stem

When the stems are delivered to the factory, they are already finished products. The only thing that needs to be done is quality control.

In Figure 25, are the stems transported from other work factory.

Figure 25. Stem

Bonnet

The working procedure of making a bonnet is the same in the body, which could be clear to be seen in the Figure 26 below.

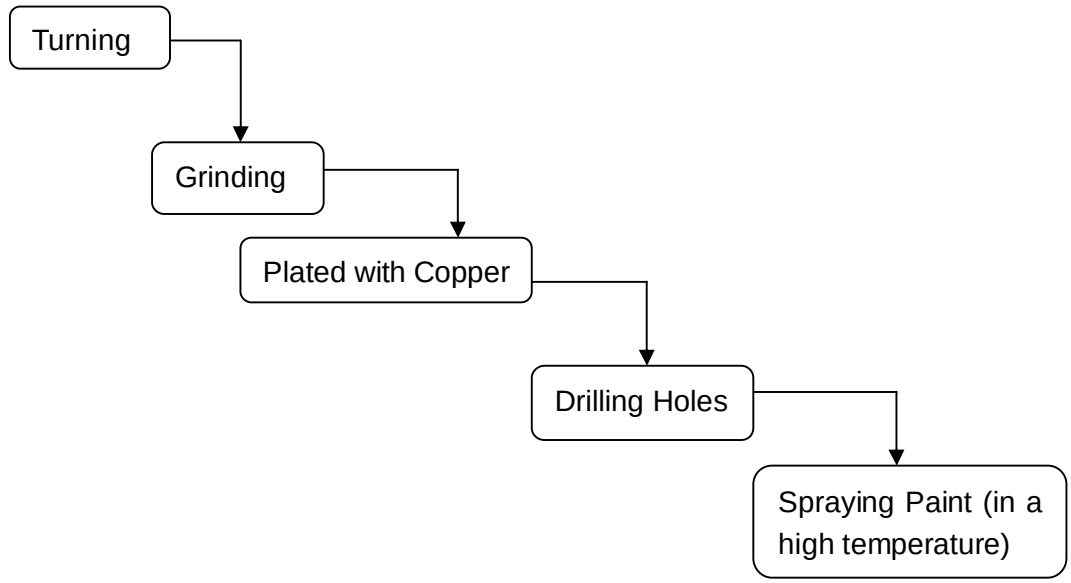


Figure 26. Working process of a bonnet

Figure 27. Bonnet

Assembly

Where all the parts are ready, the next mission for the workers is assembly. Except for these four parts, rubber rings and screws are also needed. Rubber ring is used to eliminate chinks and to make the interface seal. All the work is done by hand.

Figure 28 shows the inside structure of a finished gate valve.

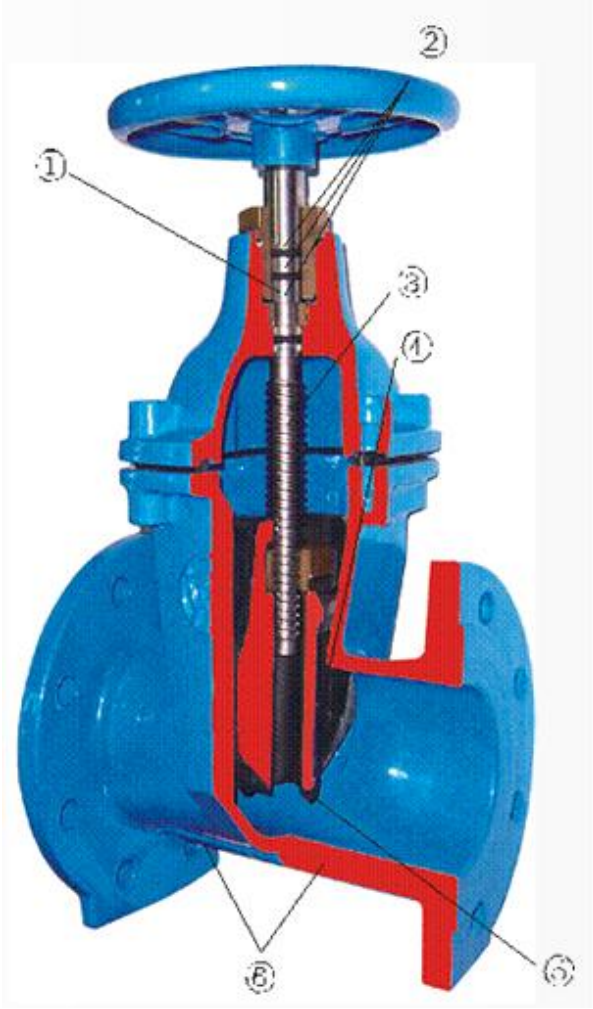


Figure 28. The structure of a gate valve

① Thrust bearing
② Triple O-rings
③ Precision stem
④ Wrapped with rubber
⑤ Flat seat ring
⑥ Non-toxic painting

Pressure Test

There is specialized equipment presented in Figure 29 for testing the sealed situation of a valve. First, a water spray gun is used to inject water to the cavity inside the valve when the cavity is full of water, then water is injected continually. The more the water is, the bigger the pressure becomes. As the pressure becomes bigger, if the water is exuded out of the valve from some gap, which proves the valve is not totally sealed; if the pressure achieved a certain level, the water is not exuded, the valve is qualified.

Figure 29. Equipment of pressure test

According to the pressure test, the valves are divided into two groups: qualified and unqualified. Valves as it can be seen in figure 30, the left shows qualified products and the right shows unqualified ones. The qualified ones are sent to the finished products warehouse. About the unqualified products, quality management department will assign a group of skilled workers to check where the problem is and how to fix them.

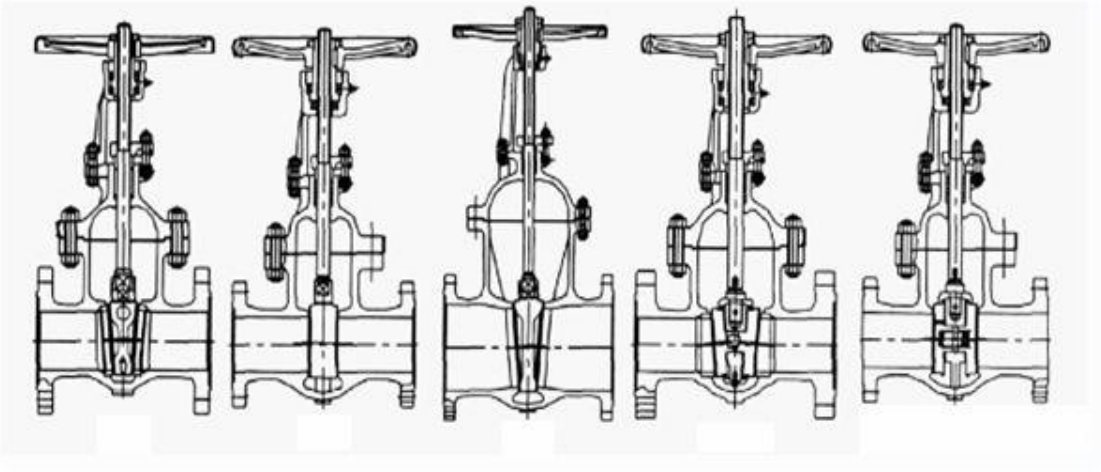
Figure 30. Qualified products and unqualified products

7 Analysis of Common Problems and Development

Gate valve is widely used in various types of industrial systems to achieve the opening and closing of fluids as it has numerous advantages e.g. it can work under high pressure and in a high or low temperature. Besides, it can also work normally in a corrosive medium. Apart from this, it has the function of bi-directional sealing and its work life is very long. These advantages play an extremely important role in the stability control of the whole system.

As mentioned before, a rising stem gate valve is a valve whose stem can be seen from outside. There are also many types of this kind of valves, so the suitable types should be chose according to the requirements of the work situation. In addition, the operations about installation, debugging and maintenance should be standardized in order to avoid or eliminate the occurrence of accidents.

Figure 31 shows the inside structures of some common gate valves Different inside structures would lead to some different problems in use.



(a) (b) (c) (d) (e)

Figure 31. Inside structures of different gate valves

7.1 Common Problems Occurred in Use

When valves are used, many problems will appear because of not only the quality of the valves, but also the operators' using methods. So some common problems will be analyzed next.

7.1.1 Fracturing of the Stem

Fracturing of the stem mostly occurs at the roots of the upper and lower thread parts because the cross-sectional areas are the smallest at these places, and it will cause centralization and excessive stress. Especially the working conditions comparatively deviate from the design parameters. For example, in a power plant in China, it happened that the thread parts of the stem in an electric gate valve broke after the valve was turned on. The investigation afterwards found out that the nuts on the bonnet were not tightened which leads to the movement of the bonnet. Then the nuts of the stem got stuck and the stem broke down. The most probable reason of this accident is that the debugging operation was not done correctly during the installation which causes that the protecting torque is too large. [10]

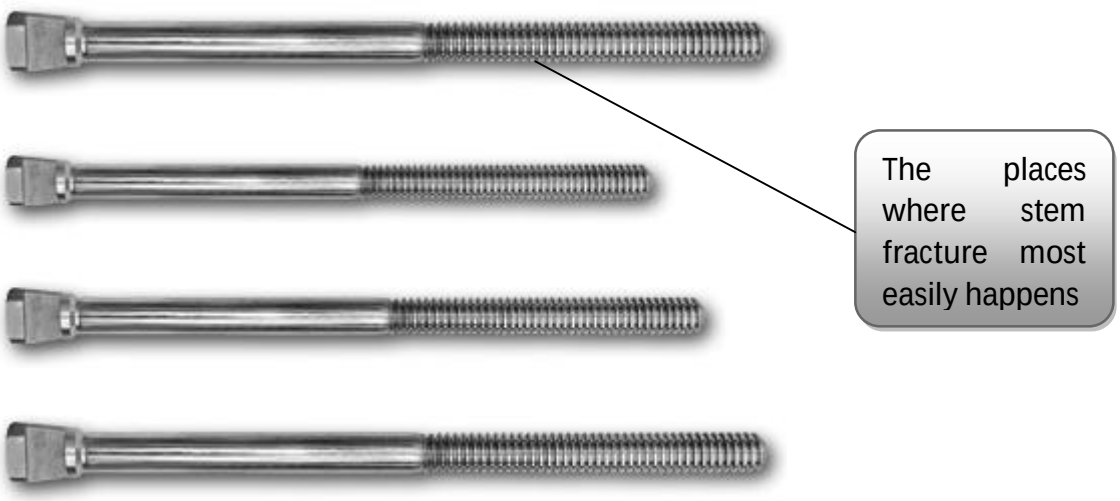


Figure 32. Thread of valve stem

Another kind of stem fracture often happens exactly at the opening moment of the valve. It appears that the valve gate does not leave the gate seat yet and the stem is already broken at the root of the thread parts. It is usually considered that the reason for this kind of fracture is that the valve gate gets stuck. But in fact, this is just part of the reason. In other words, this is the second reason. The most important reason is the unusual stress boost after the cavity of the valve body closes, which means that after the valve is closed, the stress caused by the fluid in the cavity of the body is much higher than the upstream stress. [10]

There are two explanations for this phenomenon. The first one is that the fluid in the cavity is heated by the upstream fluid and starts to expand which leads to a dramatic increase of stress. A second explanation: at the moment the valve gate is closing, the fluid is sealed in the body cavity and cannot flow out. Then the cavity space will be extruded further. Because of the compressibility limitation of the fluids, the stress will also increase rapidly. At the same time, this type of usual increase of stress is far more than the designing strength that the stem can afford.

7.1.2 Deformation of the Stem

Deformation of the stem usually happens when the gate valve is not debugged properly and the damage is very large.

7.1.3 Leak

Generally there are two kinds of leaks which appear during use which are outside leak and inside leak.

Outside Leak

Usually casting parts are used for processing the valve body. Although the forging parts can replace them under high temperature and pressure work conditions, due to

restrictions set by the technology and the cost, a big-sized body is ordinarily made of casting parts. As there is a large number of defects in the casting parts (including porosity, slag, cracks and so on) and these defects can occur at any time when the valve is running. These problems have become hidden dangers and they threaten the worker's safety.

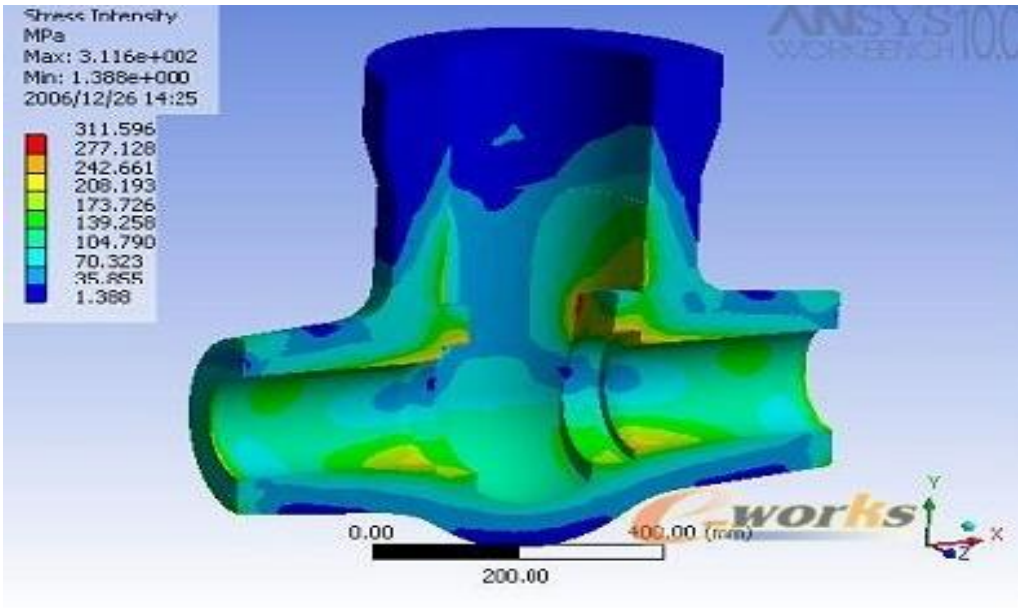


Figure 33. Stresses of body

Another reason is that the surface of the stem is corroded by the medium because of the unsuitable choices of operations, materials and wrong fluids. The stem moves up and down, and the corroded surface will take out the small particles in the filler. It happens again and again, there will some mild leakage. Then if appropriate maintenance is not given, high pressure or high speed medium will gush out in an extremely short time and cause a leak.

Inside Leak

Actually there are many reasons for inside leak and they should be analyzed according to the situation. Usually, the reason is that the wear and tear gap between the stem and the body is too big. In a normal situation, the gap is very small and causes extremely little leak. It does not affect the operation. But when it is too big, a long time use or the fluid

inside the valve is not clean enough, the wear of stem and body are accelerated and the seal surface is damaged, which leads to an inside leak. If there is an inside leak in a new valve after short operation, the reason is probable that there is something unnecessary attached to the sealing surfaces. So before a new valve is put into use, it should be checked carefully. Rinsing the pipeline can reduce the probability of this kind of accidents. [10]

7.1.4 Problems Caused by the Valve Gate

According to the situation, the problems which occur in the valve gate include being stuck and damage of the surface. These are very serious problems and often cause accidents. These problems will cause danger to both operators and the machines. A detailed analysis on these two aspects will be given next.

Being Stuck

This problem means that the valve gate is stuck in its track in the cavity of the valve, and this problem is caused by the defects in designing and manufacturing process, for example, the contact width of the track is too short or too long or the surface of the track is too rough and so on. When the gate is stuck in the valve seat and the stem is forced to rise, normally the valve gate is fractured or deformed. Besides to the factor of unusual stress boost, there is another possible factor: the temperature differences. As shown in Figure 34, a typical situation caused by temperature differences is that the valve gate is closed in cold status and opened in hot status. The stem will extend to be longer because of the heat, which means the valve gate is compressed further. It leads to sticking of the valve gate. [10]

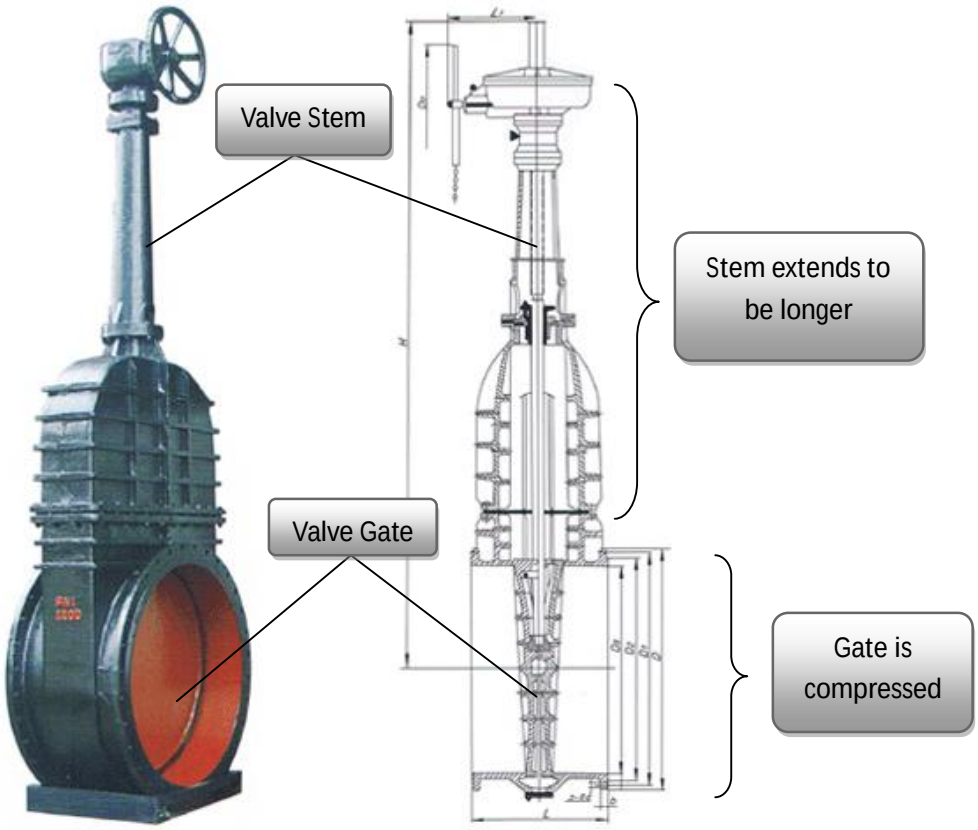


Figure 34. Structures of gate and stem

Damage of the Seal Surface

There are two kinds of reasons which cause damage to the seal surface: man-made damage and natural damage. Man-made damages are caused by poor design, unqualified manufacturing, wrong material choice and some other reasons. Natural damage is the damage caused by the normal work of valves, such as inevitable corrosion and erosion of the medium. [10]

A very common phenomenon of man-made damage is crack on the surface. Crack on the surface mainly appears in the valves which are made of alloy steel, and it is commonly caused by irrational manufacturing methods. Selecting the right materials and controlling the manufacturing process properly will help to avoid this problem. Not properly installed and irregular maintenance will also cause problems to the seal surface, and it may get damaged too early.

Natural damage includes many aspects: chemical corrosion of the medium, electrochemical corrosion, medium erosion, mechanical damage and fatigue damage. Chemical damage means that in a situation of not producing current, the medium and the seal surface have a chemical reaction directly and cause damage to the surface. Another situation is that the surface and the valve body contact with each other in medium under special conditions, potential difference will be produced and the surface on anode side is corroded. This is called electrochemical corrosion. Medium erosion, mechanical damage and fatigue damage are all physical damages. Medium erosion is the result of scour caused by medium flow. The scour caused by floating particles in the medium or the direct scour by high speed medium will both cause damages to the seal surface. Mechanical damage is the bruise and bumps during the opening and closing operations. The last reason is fatigue damage. It means that during long-term use, the seal surface suffers from fatigue and cracks, which leads to performance deterioration. [13]

From the above analysis, the common problems are elaborated clearly. The next part will focus on how to deal with the problems. Before using them, the first step to avoid accidents is to select appropriate valves types.

7.2 Selecting the Type

The valve is a control device of fluid pipeline, whose fundamental function is to put through, cut off or change the circulation of the medium in the pipeline, to change the flow direction, to adjust the medium pressure and the rate of flow, as well as to keep the regular running of the pipelines and the equipment.

As there is a variety of valves, selecting the most appropriate type of valves according to the pipeline system is a very significant step before installation, which can reduce the possibility of problems. First, features of valves, using position, types of circulating medium inside the pipelines are needed to be taken into consideration. Secondly, on the basis of the work environment, valves which have reasonable prices and reliable quality

should be selected. During the selecting process, there are a few items which should be paid attention to.

7.2.1 Features of Valves

Features of valves can be divided into two: using features and structure features. The using features of valves which include the type of products (gate valve, stop valve, butterfly valve and so on), the main components (body, bonnet, stem, spool and so on) and the transmission methods of valves define the principal functions and areas of use. The structure features contain the length and height of the valves, the connecting methods with the pipelines, the form of sealing surface and the structure form of stems. [15]

7.2.2 Selection of Valve Types

Usually, valves are required to be open enough to lower down the loss in the pipeline. But once needed, valves should be closed quickly to cut off the flow immediately. Based on these principles, the applications of some widely used valves in water supply system are elaborated as examples.

Selection of Gate Valves

In the water supply system which uses a pipeline of 100mm ≤ DN ≤ 600mm, traditional hard seal gate valves are usually used. In fact there are many defects, like cannot close tightly, outside leak and not working well when opening and closing. These problems lead to frequent repair. Actually there is another type of gate valve which can basically avoid these problems. It is a soft seal gate valve, which is also called resilient seated gate valve. There is no slot on the bottom part, and small pieces of debris cannot be accumulated, so it can be closed tightly. The gate of this valve is wrapped with rubber entirely, which means the flexibility is used of rubber to increase the sealing performance of valves. The price of the resilient seated gate valve is higher than that of a rising stem

gate valve, but depending on the using situation of the valves, the using resilient seated gate valve is profitable in terms of both maintenance price and the using reliability. [15]

Selection of Butterfly Valves

The price of a butterfly valve is cheaper than that of the gate valve which has the same specifications. But the work life of butterfly valves is short, and some of them need an overall change after three to five years use. Among the medium-sized and large-sized butterfly valves, there is a distinction about valve shaft: vertical shaft and horizontal shaft. Usually the vertical butterfly valve works in a deeper place in the water, so the debris in water may twine around the top of the shaft, which affects the opening and closing. However, the gear box of the horizontal butterfly valve should be fixed on the side of the valve, which means more space is needed to place the valve and pipelines. Therefore when using a medium-sized valve, the vertical shaft butterfly valve is better, and the horizontal shaft butterfly valve is better for large-sized butterfly valves on the condition that enough space can be offered. [15]

In addition, there is one more factor that must be considered. Butterfly valves for water pipelines are most soft seal valve and metal seal valve. They both have advantages and disadvantages. A soft seal valve is cheaper but the rubber ring for sealing is easy to get wear and tear and make the seal performance become worse. The seal surface of metal seal valve is not easily to damage but it has less flexibility, and the price is higher.

To summarize, when choosing a butterfly valve, the factors that must be considered include:

a. The materials of rubber ring on the seal surface.
b. The size, accuracy and the material of the important components.
c. Work environment.
d. Price.

Comparison of the Gate Valve and the Butterfly Valve

As Figure 35 shows, the main shortcoming of butterfly valve is that the disc inside the valve occupies a certain area of the water cross section, which creates a large amount of water loss in the pipelines. Though such kind of problem does not occur in the gate valve, there are still some defects. The height of the vertical gate valve affects the depth the whole pipeline under the ground, while the horizontal gate valve affects the arrangement of other pipelines nearby because the length of that increases the area of pipelines. Moreover, according to the using situation, the seal performance of the gate valve is better and the probability of a breakdown is smaller. So in a water supply system, butterfly valve is usually chosen in order to reduce the area needed for the installation the valve and the depth of the pipelines underground. If there are no requirements about the occupied area and depth of pipelines, the gate valve is more suitable.

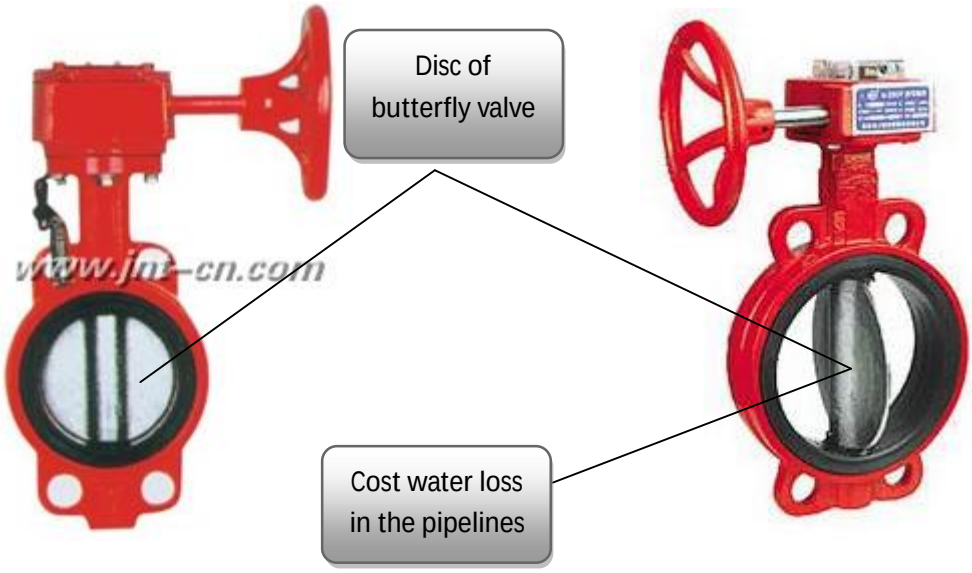


Figure35. Disc in the butterfly valve [11]

Selection of Stop Valves

In the water supply system which uses pipeline of DN≤50 mm, the stop valve is the most widely used valve. In order to make sure the most proper stop valve has been chosen, it should be measured by five aspects as follows:

a. The minimum size of the water flow section
b. The flow form in the valve cavity. Choosing a straight-through stop valve or a

angle typed stop valve as needed.

c. The size of valve stem, the thickness of the valve body and the material of each valve part
d. Seal form. Using an O-shaped seal ring as possible.
e. Anticorrosion performance. The valve surface cannot get rusty and corroded both inside and outside surface, especially the parts contacting water. It means they should stay clean anytime.

Selection of Check Valves

The role the check valve plays in the water supply system is to make the medium flow only into one direction. When choosing check valves, the area of the medium flow inside the valve, the form of seal surface and the material of the body should be considered first, then the structure of the check valve. The swing check valve can be used not only in horizontal pipelines, but also in vertical pipelines. While the lift check valve can only be used in horizontal pipelines.

7.3 Analysis and Countermeasures

Based on the analysis of common problems above, many development countermeasures are offered to solve the problems. These solutions are mainly concerned with three aspects: designing and manufacturing, installation and debugging and operation and maintenance.

7.3.1 Designing and Manufacturing

In China, there are no requirements about the opening level in national standards, so the opening level is usually judged by operator's feeling. It's unreasonable in many occasions. Suggestion: A limitative device should be designed and settled at the top of the valve stem in order to avoid excessive closing of the valve.

The stress of the valve stem can afford is reduced in many positions, and these parts will be fractured first when the unusual stress boost happened. So the stem diameter of electrical valves should be increased appropriately. .

Limited to the current level of technology, it is better that the valves which need to work at high temperature and pressure circumstances should be made of forged steel or manufactured with a forged welding structure. Valve parts should be selected, tested, handled strictly in accordance with relevant standards.

The materials of the sealing surface should be selected appropriately in order to match the hardness. In the process, the surface roughness, flatness, and goodness of fit should be ensured to meet the requirements. Besides, the treatment to the stem surface must meet the design requirements so that the rusting, corrosion or coating of the surface won't appear too early.

7.3.2 Installation and Debugging

About the important large-diameter high-pressure valve, a bypass device which is presented in Figure 36 can be installed between the upstream and downstream to reduce the opening and closing pressure, reduce the scratches on the sealing surface caused by the gate at opening and closing moments, simultaneously to reduce the manufacturing costs. [16]

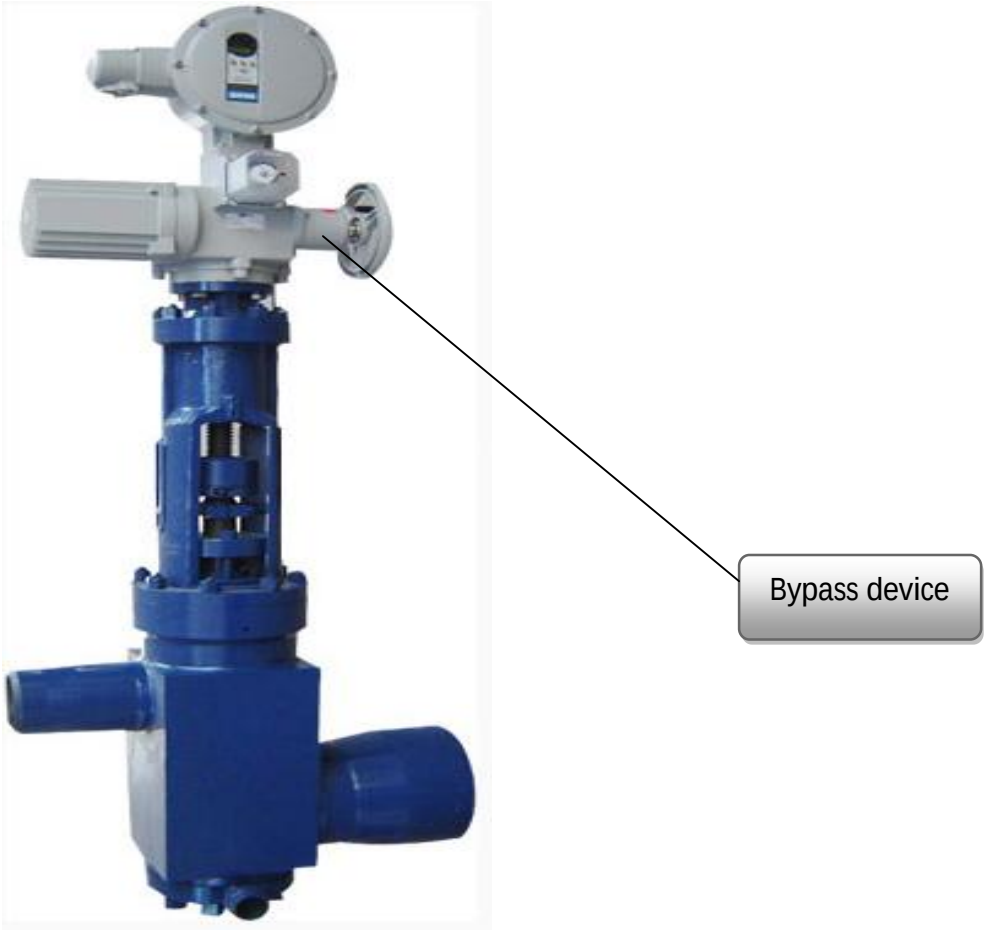


Figure 36. Bypass device

Installing a safety valve (as in Figure 37) in the cavity is an effective measure to control the abnormal pressure. This measure can not only protect the valve is opening and closing pieces, but also maintain a safe operation of the system. Also installing the bypass in the cavity and the upstream side or relieving holes in the upstream side of the gate are effectively feasible ways.

Figure 37. Different types of safety valves

Pipeline should be thoroughly washed to prevent the pipe debris from (such as iron, welding slag, nuts, etc.) injuring the sealing surface.

It is recommended that the valve stem is installed vertically upwards because tilt installation will increase the probability of stem stuck. If it needs to be installed horizontally, a mounting bracket is also needed at the same time.

7.3.3 Operation and Maintenance

After the valve has been running for a period of time, the bolts should be tightened again to prevent the media leaks caused by the sink of the valve cover. When the pressure fluctuates, the media will rush out of the sealing ring. During the operation, all the bolts need normal maintenance and timely tightening. Bearing bodies and all kinds of threads need periodical lubrication as well as timely removal of dust and dirt. In addition to the above, testing regularly (important valve must be opened and closed in order to test the performance of its action to prevent corrosion, jam, and to discover hidden problems), maintaining regularly (important valve needs regular maintenance to check its sealing surface, drive mechanism and the key ring, etc.), and establishing the equipment maintenance log files are extremely helpful measures to avoid accidents. [17]

Only if designing, manufacturing, selecting, installation, commissioning and maintenance are all taken into consideration, valves can be used effectively and safely, which can prevent accidents and ensure the normal operation of the products and process, thereby extending the equipment life and maintenance cycle, and also saving maintenance and production costs to improve business effect.

8 Analysis and Development of the Production Process

In the production process, small problems lead to big mistakes. Therefore, solving these small problems may create a high effect in production. These problems are about safety management, quality management, material handling and others. The next paragraphs study the problems the author observed in the factory.

8.1 Work Safety and Health Problems in the Manufacturing Process

The employer shall have a policy for action needed in order to promote safety and health and to maintain the employees' working capacity. The policy must incorporate the need to develop the working conditions and the impact of the work environmental factors. The objectives for promoting safety and health and maintaining the work capacity deriving from the policy must be taken into account in the workplace development and planning. [18]

8.1.1 Work Safety in the Workshop

In the processing of the valve body, bonnet and spool, turning and drilling are used repeatedly. These two steps are quite dangerous parts of production. Workers use wheels to turn the surface of the valve parts. With the high-speed rotation of wheel or drills, some waste materials fly out of the original part at speed. These small fragments are quite sharp and sometimes hurt other workers.

The factory owner has built some cell pits for these machines. But these pits are still not easy for workers. When they begin to work, they need to jump into the hole to operate the machines. Because of the small space of the hole, the waste materials often hurt the workers. As digging a deep hole is very troublesome, the depth of the holes is not big enough, and then the waste materials often hurt the workers pass by, too. If the hole is

built deep enough for the operation, it will be not convenient for the operators to jump into and it is difficult for maintenance. Besides, waste materials are still valuable metals and should be recycled, but they drop down everywhere. Some are on the ground surface and some stay in the working holes, which is not easy for collecting and adding more work for cleaning.

Figure 38. Turning of a valve body

A new workshop is designed for turning and grinding. Aluminum alloy plates are the only one material needed. The plates can be assembled together as a wall. The plates can be placed as the Figure 40 shows; there is a certain angle between the two plates, which make them stand.

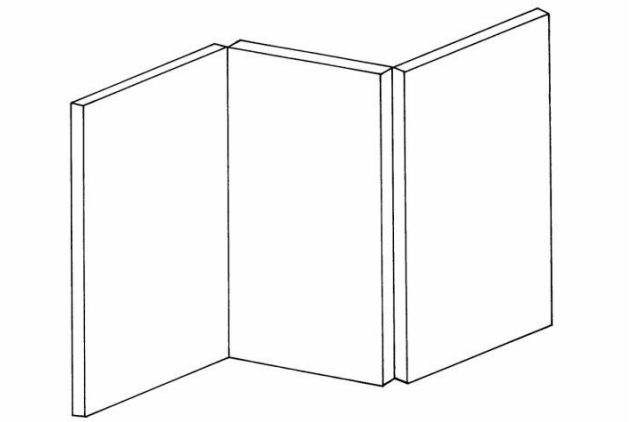


Figure40.Outline of the standing plates

There are connections on the two sides, one is a hook and another is a bolt, which is illustrated in the next figures (Figure 41),

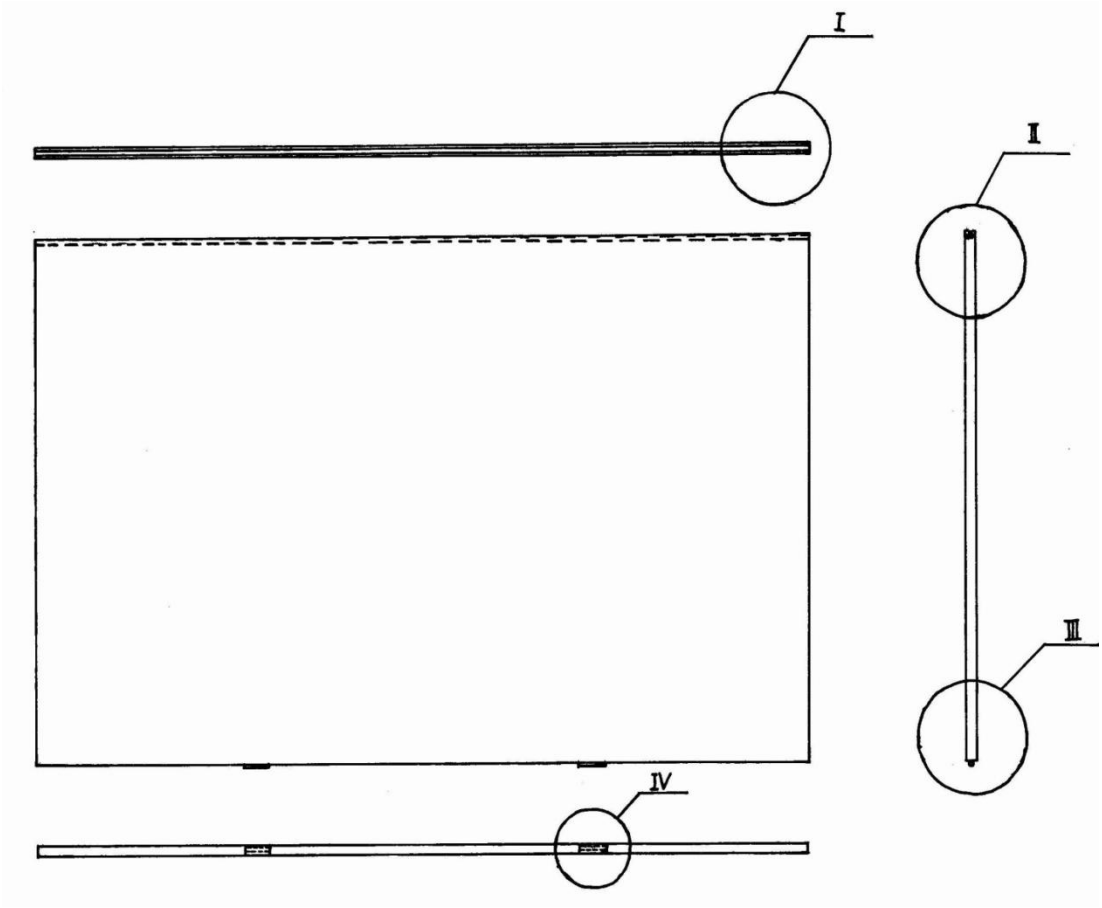


Figure 41. Structures of plate.

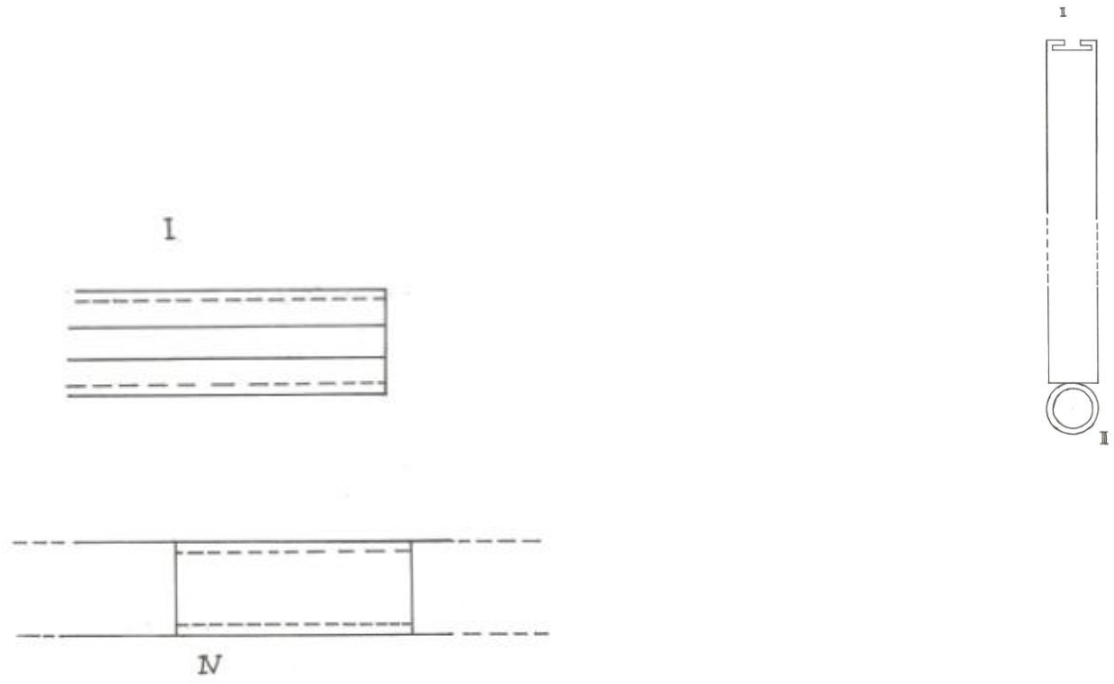


Figure 42. Partial zoom

The Figure 42 shows the three parts of the plates form Figure 41. Some key parts are enlarged without proportion.

A unique design of the activity slots let the hooks up and down, if so, every plate can be moved and turned. According to Figure 43, it could be seen clearly that the structures of the different two sides.

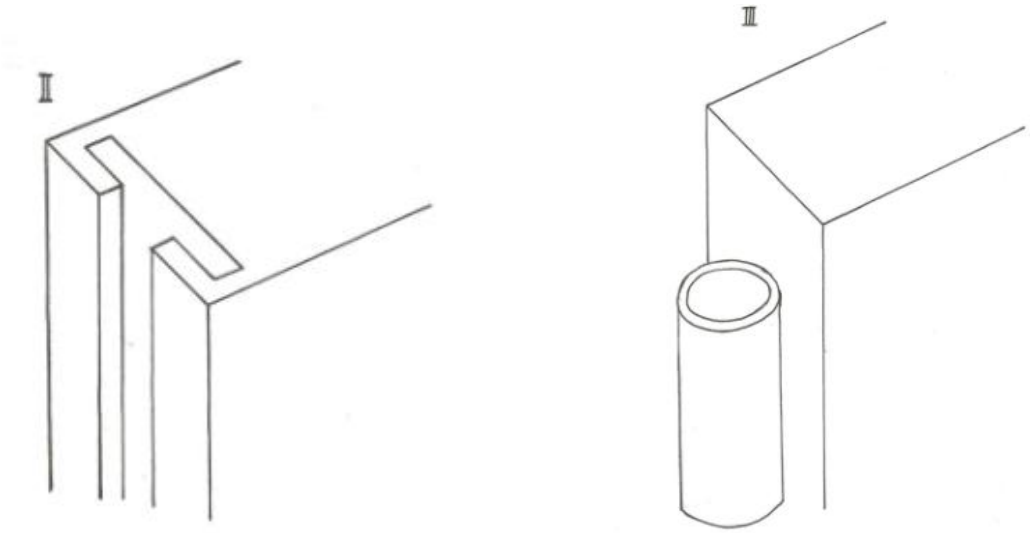


Figure 43. Three-dimensional drawing of part II and III

The part II is the slot. The hook which is shown in Figure 44 could slide in the slot. The long part of the hook could be plugged in the part III, and then combined into a bolt, as the Figure 45 shows.

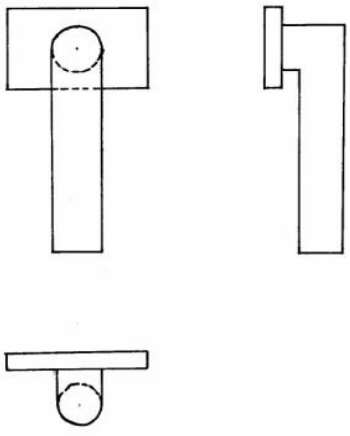


Figure 44. Drawing of a hook

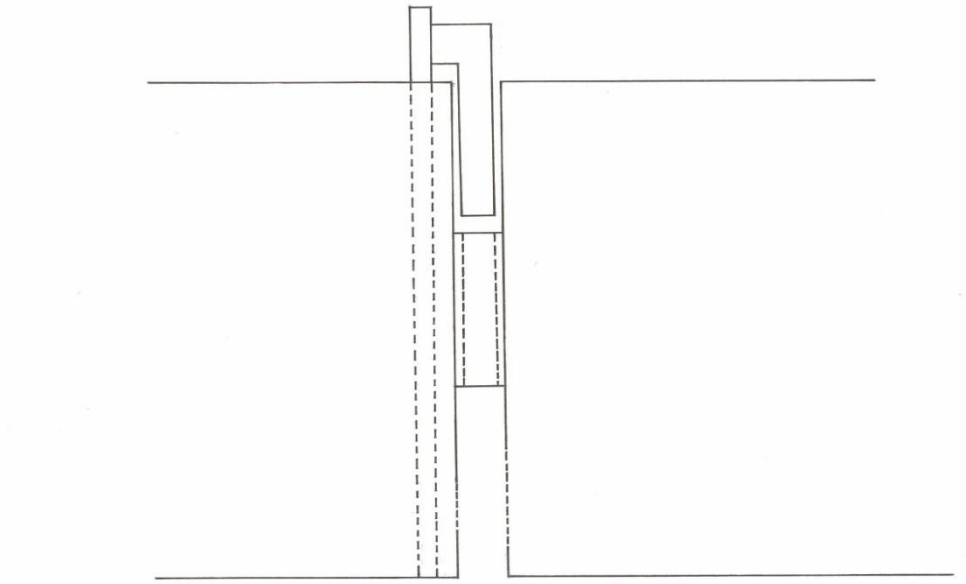


Figure 45. Connection of the bolt

The height of the plates is 1500mm-1700mm. This height is enough for the operation, preventing the spark or the waste materials from hurting workers. Many pieces of plates are arranged along the two opposite walls, the length could be designed depending on the operators' experience. The space of the two plate walls is the workspace where the machines will be located. The space between two machines is the safety distance, so the two machines next to each other do not interfere each other. If something is wrong with one of the machines and needs maintenance, it can be moved out quickly because every plate can be removed like opening a door. As a result of easy assembly, the aluminum alloy plates can be used everywhere and moved quickly.

Aluminum alloy is selected as the material of the plate because the excellent features of this alloy. The small density of pure aluminum (ρ=2.7kg/m3), low melting point, high plasticity and good corrosion-resistance make it easy to process. But the strength of pure aluminum is bad. Therefore it cannot be used as a structural material. In this condition, by alloying aluminum, it can get high strength and keep the own fine features of itself. So the advantages of aluminum alloy are low density and high strength, nearly or even better than those of superior steel. It is quite useful in electrical conductivity, thermal conductivity and corrosion resistance. Using this metal to make the plates is safe and

easy to move.

Two plate walls construct a separated workspace which likes a “belt space” (as Figure 46 shows). It could be a group, if it is necessary. Many groups could be built in the workshop and every group works separately, so this method can save much space. A general outline of the workshop is shown in the Figure 46.

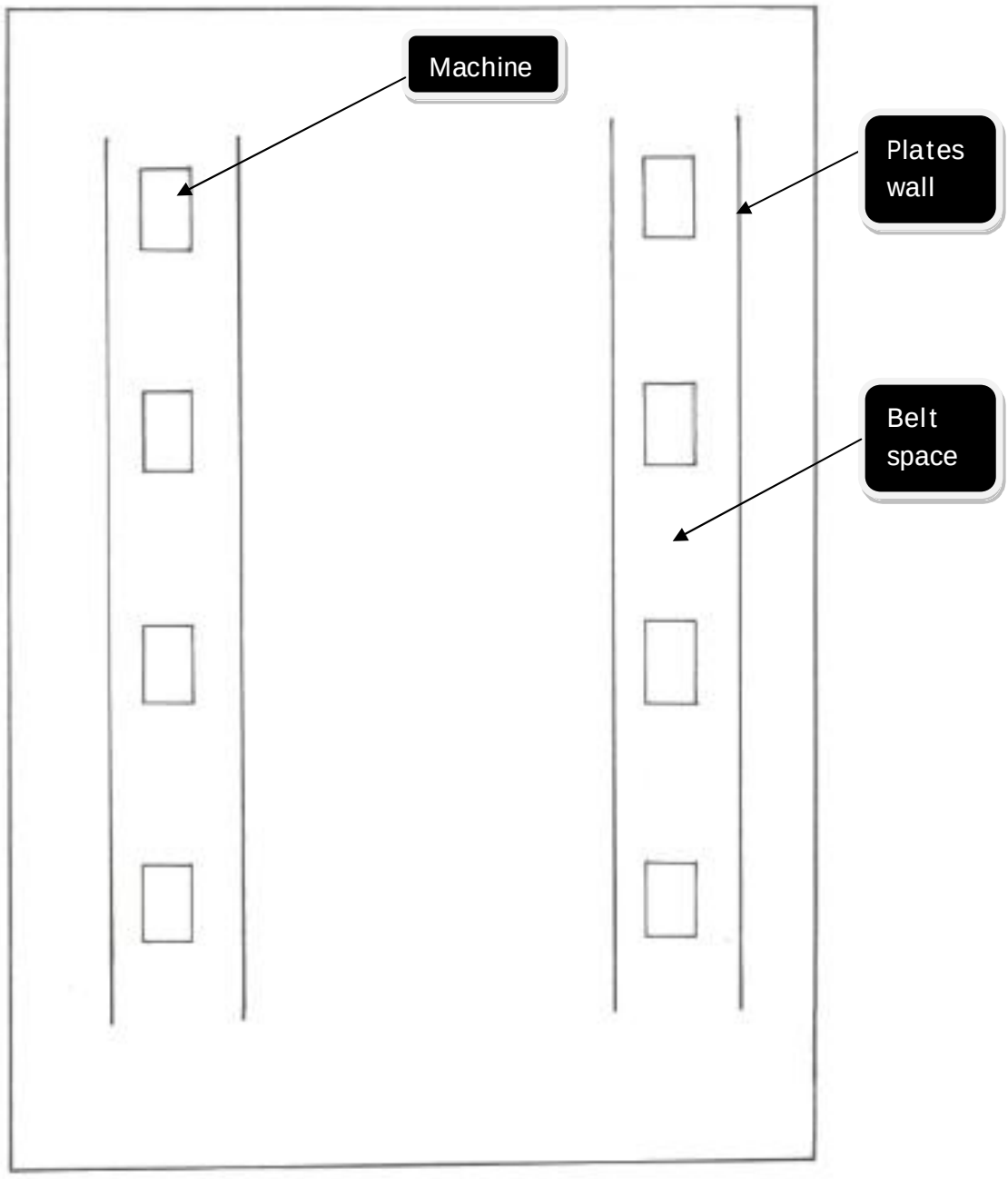


Figure 46. Outline of the workshop

8.1.2 Health Problems of Workers during Processing

In the painting workshop, a lot of paints make the air smelly. The work environment is unhealthy for workers. Although the factory owner buys a health insurance for the workers, it cannot be a fundamental solution of the problem because the smell and the pollution of the paint do not disappear. So effectively removing the smell from the air is a workable way.

Activated carbon is an excellent material to absorb outside air, water or other things. It is a good absorbent, which consists of wood charcoal, bamboo-charcoal, kinds of shell and quality coal. These materials are mixed together by break, sieve, and a set of physical and chemical ways, so it has both physisorption and chemisorptions. It could absorb many materials in the gas or liquid by choice, to make depolarization, deodorization or purification. This material could be used to absorb the smell of the paint.

The activated carbon could be put into some paper bags with many small holes so that the activated carbon absorbs the smell. These bags don’t need to be too big so that many bags can be connected in a line and then hang on the wall of the paint workshop. The carbon bags need to be changed regularly.

However, the carbon could absorb the smell but could not reduce the toxicity of the air. So removing the gas totally outside from the work room is the solution. An effective way to the factory is installing some blowers in the painting room. The blower generates eccentricity motion by the inside rotor, which makes the fans rotate to blow the air out. Thus a large number of toxic gases will be out of the workplace.

8.2 Quality Management in Processing

Quality management means some activities for achieving effective processing. Excellent quality management could promote the development of industrial chain, reasonable allocation of the resources and so on. In the Tongdu Valve Co., Ltd, the authors studied two main points: checking and motion of the products.

8.2.1 Inspection of the Products

Inspection Methods

The last step of valve manufacturing is using pressure equipment to check whether the valve is qualified or not, the unqualified products are sent to inspection pending zone, then the inspectors fix them. But before the inspector repairs a valve, it needs to be checked again, which is rework.

Rework is a typical waste of labor; it means any repair or repetition of work. Scrapped components and external failure costs are double lost. Thus, inspection needs to be re-planned by the company.

In the management theory, there are three main types of inspection.

a) Attribute Inspection. This way aims at finding failures.
b) Informative Inspection. This is used to reduce the number of failures.
c) Cause (Preventive) Inspection. It can eliminate the causes of failures.

Attribute Inspection

In the valve company, obviously, attribute inspection is used. Attribute inspection is normally used at the end of the production line, the purpose is to separated the bad from good products, parts, subassemblies and so on. This inspection has no effect on the failure level and it is a waste of money from the viewpoint of accepted products. In a word,

attribute inspection is the most simple and common way of quality check. It should be developed towards informative or preventive inspections. [19]

Informative Inspection

Informative inspection is used when a failure takes place, then the information will be transferred immediately backwards in a process for corrective actions as the next three steps:

- Statistical process control
- Sequential inspection
- Self inspection

The Figure 47 below illustrates the effect of an informative inspection. [19]

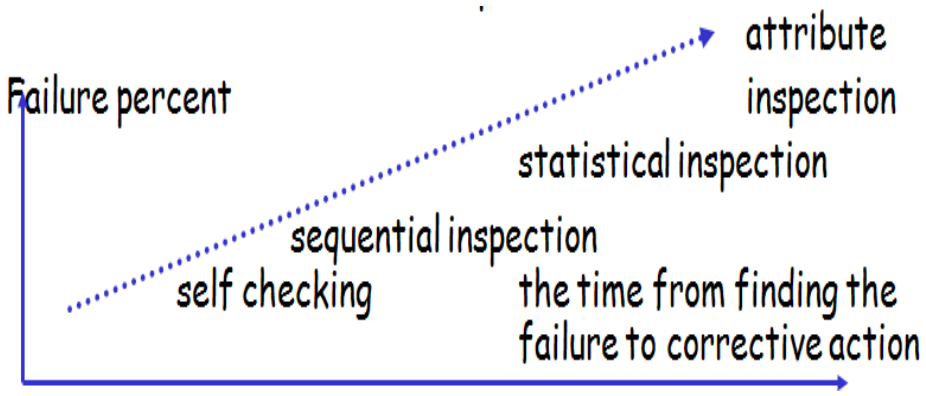


Figure 47.Effect of informative inspection [19]

Cause (Preventive) Inspection

The basic idea of the preventive inspection is to prevent failures. There are always failures in the daily process, but there are always one or more reasons for them. The connection between cause and effect is often difficult to detect because of the long time between the cause and detecting the failure. So it is necessary to have a quick feedback system if it happens, sometimes it is possible to develop a technologically robust – fool proof – system.

Vertical inspection and Horizontal inspection are the two types of cause inspection. Vertical inspection means controlling the process when it is causing failures, however,

horizontal inspection focus on the prevention, this method tries to detect the failure before it turns itself to a serious problem. [19]

Inspection of the Valve Company

In the company, the Attribute Inspection way is the only method to check the valve quality. Once the inspectors separate the bad ones from the qualified products, the bad ones are laid in the same place. There are different reasons for each unqualified product, so the rework of checking the unqualified points is quite waste of time and the single way doesn't work well.

Attribute inspection can only separate the bad ones from the products, but this step is necessary. After checking the bad points of a valve, different marks could be pasted on the valves. As thinking about the workers' busy work and inconvenience to record and write the reasons of the bad valves, workers could stick mark papers with different colors. Each color stands for different mistakes, for example, red means the gate is unsealed, green mark stands for something wrong in the bonnet and yellow one tells the stem could not be up and down well. In the qualified management workplace, big boards (the sample is showed by Figure 47) could be located in some conspicuous places. A color-blind person is not suitable for the job as this work needs excellent sensitivity in color.

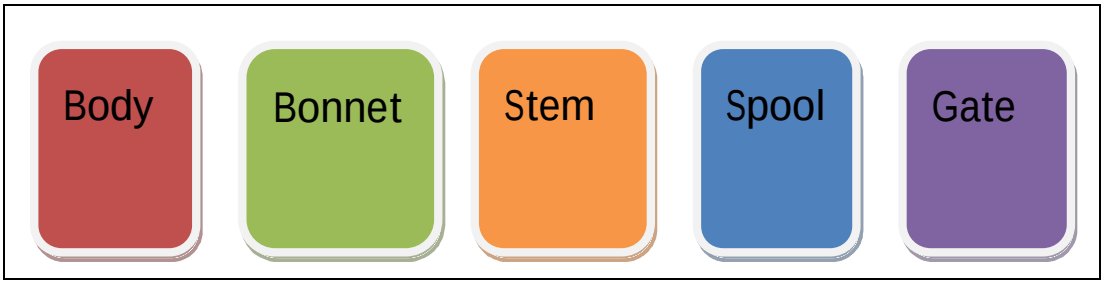


Figure 48. Sample Board

Nevertheless, the root of quality key is how to reduce and prevent similar problems, so systematic summary and feedback are both important. They will relate to the next two inspection ways, informative inspection and cause inspection. So except the inspectors

to check the valve quality and the workers being responsible for repair, also some workers are needed who record reasons for the different problems of valves. These workers need to record every problem of daily work. If some problems appear often or a new problem appears up, they should be reported to the department. If so, old problems can be solved or improved, and new problems can be reduced in the producing.

8.2.2 Material Flow Problems

During the production process, linking of each department is very important. In the valve factory, there are five workshops (A, B, C, D and E) placed in a line and connected with each other. Different manufacturing steps are located in different parts of these workshops. When the surface grinding is finished, holes need to be drilled. So the motion between the workplaces should be paid attention to. The distance of the motion is quite short and reasonable design could save much time and labor.

As it was mentioned, the workshop of the valve factory is conventional and the work flow here is in a long linear flow. Every workshop is separated by walls but they are not totally independent. There is a path through the whole workshop (the outline is shown by Figure 49). There is little attempt to minimize the distance to be traveled. Handling activity is high, and balancing of the line is a continual struggle when the product mix changes from day to day.

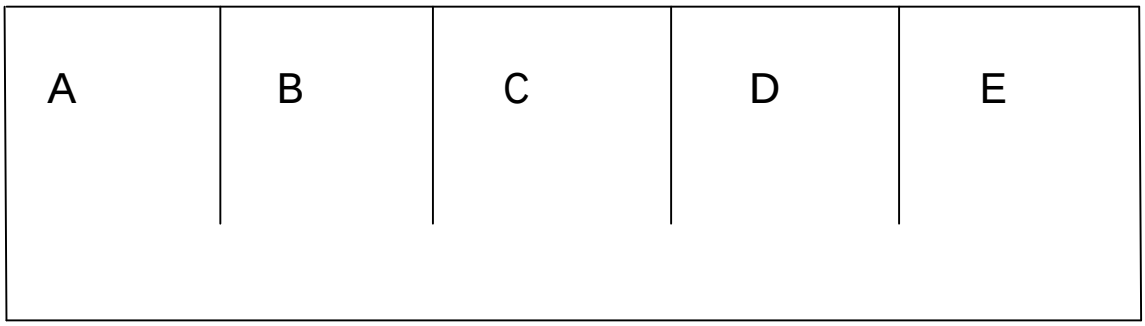


Figure 49. Outline of the factory workshop

Actually, reasonable design to move the components is better for manufacturing. In this kind of workshop, tracks can be used. Because the valves are heavy, the suspended path (conveyer belt) is not a good choice; the tracks must be on the floor. The tracks can be designed as the Figure 50 shows: a main track through all the rooms, the branches into each workshop. Workers use a trolley to transport the products on the tracks.

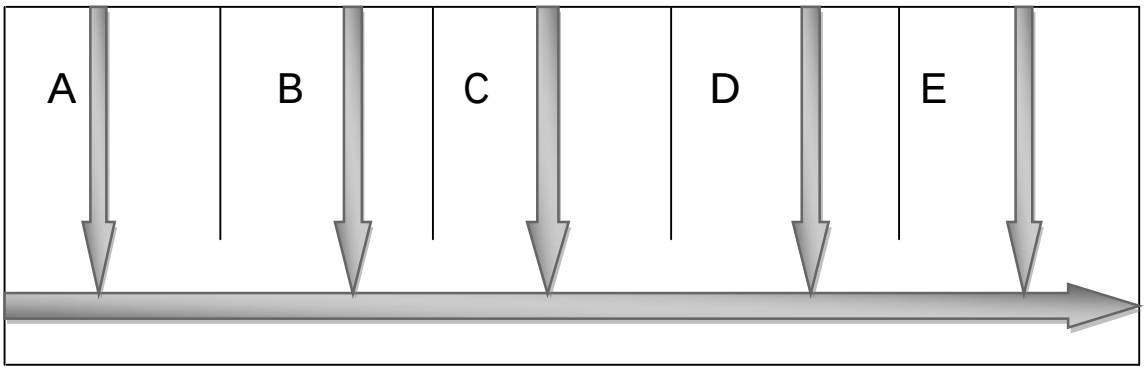


Figure 50. Work flow models

In this case, the workers could work on their tasks and carry the components to the trolleys, and then specialized transporters will move them to the next steps. It is easy and saves much time. One workshop needs one transporter. The efficiency of the processing is improved.

9 Conclusions

This thesis introduced the history and the current situation of valve industry and the manufacturing process of valves. Also the problems during use and production process were analyzed and solutions were offered. The results of this study were summarized as follows:

According to the research of Tongdu Valve Company Ltd, the valves which were ordered most contain gate valves, butterfly valves, check valves and stop valves. So the manufacturing process was introduced by taking a gate valve as an example. After the orders were made, the manufacturing department should make a distributive plan to assign the production task to each department and workshop. Then the manufacturing process would start. The main parts of gate valves are body, spool, stem and bonnet. Each part should be produced separately based on the requirements of customers. When all parts were all finished, they are be assembled and need to be tested. If they qualify, they are sent to the finished products warehouse.

Valves are widely used in numerous industrial systems because of their merits which include work flexibility in different conditions, long work life and some others. They are easy to use, but during the using process, there are still problems. The fracture and deformation of the stem, the leak, gate getting stuck and damage of the seal surface are the most common accidents in use. In order to avoid all the dangerous phenomena, the first step is to select a suitable type of valves. Before valves are selected, their features should be analyzed to match the requirements, including the types, components, transmission methods, length and height, connecting methods, form of sealing face and the structure form of stems. After this information is ensured, the operating conditions should also be analyzed, like the work environment, fluid properties, needed space, price and others. According to these two aspects of data, an appropriate type of valves can be chosen. There are three main reasons for using problems, which are poor design and manufacture, wrong installation and debugging and irregular maintenance. The first

mentioned problem can be fixed by using right materials, changing some data as needed and adding auxiliary equipment. The second problem can be solved in installation by following the instructions step by step. The solution to the last problem is regular maintenance. The valves should be checked timely. To summarize, if all these can be paid attention to, accidents can be prevented before they happen. It's beneficial not only for the machines and equipment, but also for operators.

As for the problems in the processing, they could be generalized into the next two main parts: work safety and quality management to ensure the safety and the health of the employees, which is the basic responsibility of any employer. In the workshop, steps like turning or drilling are all dangerous, so a safe workplace is very important. On the other hand, health is the best insurance of the workers. Effective measures to make healthier working environment is also important. As to quality management, this is the key to develop the products and the production line. How to make the production process efficient? This problem relates to many aspects, such as rework, it means JIT (Just in Time), too much motion in the workshop, too much inventory and so on. In this thesis, two parts were discussed: rework in the inspection and transportation between each workshop. These disadvantages are solved, and the processing can be improved.

In a word, the whole industrial process is quite a long and complex process which includes selecting of materials, manufacturing, inspection and a lot of other things, and many details affect the final results. So every small problem should be treated seriously to make the whole chain work smoothly.

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