The Common Faults and Analysis of Hydrogen Compressor

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Abstract. The hydrogen compressor plays an important role in the process of petrochemical gasoline hydrofining, coal chemical methanol syngas transmission. Once the hydrogen compressor breakdown, it will cause all the plant stopped and even lead to gas leakage, fire, explosion and other accidents which causing significant economic losses. In this paper, the hydrogen compressor is taken as a research object. We enumerate some common faults that which often occurs in the compressor operation, a detailed analysis is carried out and corresponding maintenance suggestions are put forward. We provide reference for the safety person in charge of chemical enterprises and equipment operators.

1. Introduction
In the chemical industry, in order to promote the normal chemical reaction with hydrogen as raw material, the hydrogen is usually compressed to a high pressure, which requires the use of the hydrogen as the main conveying medium piston compressor, commonly known as "hydrogen compressor." For example, in the synthetic ammonia industry, the inlet pressure of the hydrogen-nitrogen mixed gas is 0.03 MPa, and the final exhaust pressure reaches 31.4 MPa after 6~7 stages of compression. In the process of synthesizing methanol from coal chemical synthesis gas, the inlet pressure of hydrogen and carbon dioxide is 2.5 MPa. After multistage compression, the final exhaust pressure reaches 5~10 MPa (low pressure method) or 35 MPa (high pressure method) [1, 2].

2. Working principle and classification of hydrogen compressor

2.1. Working principle
The hydrogen compressors structure is complex. The most important components are cast iron cylinders, cast iron cylinder liners, cast iron cylinder heads, cast iron crankshafts, connecting rods, crossheads (including crosshead slides), padding, pistons (including piston rings), oil scraping rings, stainless steel piston connecting rods, stainless steel valves, etc. In addition to some auxiliary equipment, gas filters, buffers, lubricant lines and so on [2]. Like other reciprocating compressors, the hydrogen compressor consists of three processes: suction, compression, and exhaust. Under the motor drive, the crankshaft drives the crosshead, the piston connecting rod and the piston to move back and forth in the cylinder, and the gas is finally discharged through the air valve under the compression of the piston.
2.2. Classification
According to the range of exhaust volume and exhaust pressure, the specific classification is shown in Table 1.

| According to the range of gas displacement | According to the range of exhaust pressure |
|-------------------------------------------|------------------------------------------|
| Name                                      | Gas displacement (m³/min) | Name                        | Exhaust pressure (MPa) |
| Micro compressor                          | ≤1                         | Blower                      | ≤0.2                    |
| Miniature compressor                      | 1~10                       | Low pressure compressor     | 0.2~1.0                 |
| Medium compressor                         | 10~100                     | Medium pressure compressor  | 1.0~10.0                |
| Large compressor                          | ≥100                       | High pressure compressor    | 10.0~100.0              |

According to the basic ground plane and the relative position of the center line, the hydrogen compressor can be further divided into: horizontal compressor (the ground plane is parallel to the cylinder center line direction, mainly has contraposition type, single side type, symmetric balance type), vertical type compressor (the ground plane is perpendicular to the cylinder centerline direction), angle compressor (the ground plane is at an angle to the cylinder centerline direction) [3]. The vertical compressor and the horizontal compressor on the crankshaft side of the cylinder are suitable for small air volume conditions. In horizontal compressors, symmetrical balanced compressors are widely used and are one of the best choices for large and medium reciprocating compressors. Several cylinders of the compressor are evenly distributed on both sides of the crankshaft, with a 180 degrees angle with the direction of the cylinder centerline. The opposed compressor is suitable for compressing high pressure gas, while the angle compressor is suitable for small and medium compressors. According to the angle, the angle compressor can be divided into W type (60°), L type (90°) and V fan type (40°) and other types [3,4].

3. Hydrogen compressor model and letter meaning
In order to quickly identify the structural characteristics of the compressor, volume flow, working pressure and other information, the hydrogen compressor and other common chemical equipment, there is a specified model, and each letter has a different meaning.
The "difference" at the end of the model in Figure 2 is mainly to distinguish the type of compressor, which is generally expressed as a combination of letters and numbers. "Pressure" refers to the nominal exhaust pressure indicated by the air suction at standard atmospheric pressure after compression by the compressor. “Nominal volume flow” refers to the flow rate obtained by converting the exhaust gas flow of the compressor according to the working conditions (pressure, temperature, gas composition) at the standard suction position [4]. The structure and characteristics of the hydrogen compressor are shown in Table 2, and which represent the structure and specific characteristics of the compressor.

**Table 2. Various letter meanings of hydrogen compressor.**

| Structural letter (1) | Meaning of letter | Structural letter (2) | Meaning of letter | Characteristic letter | Meaning of letter |
|----------------------|-------------------|----------------------|-------------------|----------------------|-------------------|
| V                    | V-type            | P                    |                   | W                    | No lubrication    |
|                      |                   |                      | Horizontal (the cylinder center lines are parallel to the horizontal plane and the cylinder is on the same side of the crankshaft) |
| W                    | W-type            | M                    | M-type            | WJ                   | No basis          |
|                      |                   |                      |                   |                      | Low noise mask type |
|                      |                   |                      |                   | D                    | Direct connection |
|                      |                   |                      |                   |                      | Portable          |
| L                    | L-type            | H                    | H-type            |                      |                  |
|                      |                   |                      | Two columns symmetric and balanced |
| S                    | Fan type          | D                    | Contraposition type |
|                      |                   |                      |                   | B                    |                  |
| X                    | The star          | DZ                   | Contraposition type |
|                      | Vertical (the center line of the cylinder is perpendicular to the horizontal plane) |
| Z                    |                    | ZH                   | Free piston type  |
|                      |                    |                      |                   | ZT                   | Integral motor compressor |

Such as 4M80-50/11.5-93-BX type compressor, according to the above letter code, numerical classification, the specific meaning is:

4: Represent the number of compressor columns (2, 4, 6).
M: Represent the form of compressor (D, M, L, P, DZ).
80: Represent the carrying capacity of the compressor (80 T).
50: Represent the discharge capacity m³/min under the condition of import.
11.5: Represent intake pressure bar (g).
93: Represent exhaust pressure bar (g).
BX: Represent the introduction of technology.

4. Common faults of hydrogen compressor

The manufacturing accuracy and maintenance requirements of the hydrogen compressor are high. When the hydrogen compressor runs under the motor drive, the crankshaft rotates rapidly and reciprocates. One end of the crankshaft and the connecting rod is connected with the crosshead member, and the crosshead parts also reciprocates in the chute under the action of the crankshaft connecting rod, and finally drive the reciprocating movement of the piston, so as to realize the compression of hydrogen (or mixed gas containing hydrogen). However, in the long-term reciprocating motion of the crankshaft, connecting rod and crosshead parts, these parts are prone to wear. Once the serious wear will affect the running quality, it needs to be discovered and stopped for maintenance in time to ensure the safety and stability of the hydrogen compressor.

4.1. Analysis of lubricating oil system faults and causes

The most common problem with hydrogen compressor oil systems is the low lubricant pressure. When the hydrogen compressor is in normal operation, the lubricating oil is pumped to the primary filter through the oil pump, and then passes through the external lubricating oil cooler and the secondary filter in turn, and is divided into three channels, the first passage to the compressor oil pressure gauge (including remote transmission instruments and field instruments), the second road reaches the small section of the large head tile bushing to provide lubrication, and the third road reaches the compensation pump to prevent the oil pressure limiter from leaking oil.

4.2. Failure and maintenance analysis of air valve and valve

Usually every 3~6 months of operation of the hydrogen compressor, it is necessary to switch to the standby machine for maintenance or overhaul of the compressor. One of the air valve to focus on inspection, the valve piece easy to deposit carbon, accumulation of sludge or dust, the air valve spring is easy to break. There are several top wires on the top of the air valve gland. During maintenance, loosen the jack screw and place it on a clean induction box or dust-free cloth. Then loosen the bolts and nuts on the top of the air valve gland and keep the two bolts and nuts in the opposite direction from being removed until there is no air escaping from the cylinder. Finally, remove the gland and valve sleeve, and gently pull out the valve to clean up possible oil and mud on the surface for material inspection. All air valves should be nitrogen pressure leak test before installation, and can only be installed after confirming no leakage.

4.3. Cylinder block

The smooth and lubrication of the inner wall of the cylinder is very important. The piston reciprocates in the cylinder at high speed. When the hydrogen contains dust and particles, the inner wall of the cylinder is constantly scraped and fluffed. When the inner wall of the cylinder is slightly scratched or brushed, a semicircle of whetstone can be used to polish it gently until it is smooth and ready to resume use. When the inner wall of the cylinder is scratched or brushed seriously, if the length of the pulled is larger than 1/4 of the circumference of the cylinder, groove exists, and the width of the groove is greater than 3mm and the depth is greater than 0.4mm, the cylinder boring should be carried out. Boring cylinder is the cylinder body serious wear often used treatment method, after boring cylinder diameter will slightly increase, but the increase value should not exceed the original design cylinder diameter of 2%, cylinder wall thickness reduction should not exceed the original wall thickness of 1/12. In order to ensure that the fit gap is close to the original design, the piston and piston ring should be re-selected after boring the cylinder.
4.4. Crankshaft
The conicality and the ellipticity of the main journal and the crankshaft are <0.10 mm. The spindle level is <0.05mm/M (the motor direction is high). Non-destructive testing of the crankshaft neck is required for each inspection.

Replacement of spindle tile: (1) Removing the fuselage side cover and the side cover at both ends, and separate the crankshaft and the motor from the connection, then loosen the lubricating oil pipe and the main bearing upper cover, and take out the main bearing upper tile. (2) Using the jack to place the main Appropriate position under the crankshaft on both sides of the bearing (maintaining the balance position), the crankshaft is lifted by about 0.1 to 0.2 mm, and the main bearing lower bush is turned out from the main bearing seat by a round bar or other suitable tool. The new main bearing lower dam is transferred into the main bearing housing, replacing the old main bearing lower watt. (3) Installing the new main bearing upper tile and main bearing upper cover into the main bearing seat and tighten the bolts of the main bearing as required. (4) If the spindle tile is made in pairs, it must be replaced in pairs. (5) The fit gap between the big head tile and the curved neck, the thick wall tile is usually adjusted by the shim. If the gap of thin wall tile is small, it can be scraped properly. If it is large, it can only be replaced with new tile. The radial clearance is usually measured by press lead method and axial clearance is usually measured by feeler. It is used to measure the clearance, radial clearance can also be obtained by subtracting the diameter of the measuring bush and the size of the axial diameter, and the axial clearance can be obtained by subtracting the size of the axial diameter and the width of the connecting rod bush. The radial clearance is 0.8/1000–1.2/1000 of the turning diameter. If the design value is required, the clearance of the spindle tile should strictly follow the design value of the compressor.

5. Conclusion
Hydrogen compressor is the core equipment of chemical reaction in the chemical production process with hydrogen as raw materials. Therefore, the maintenance plan should be made in operation, the standby machine should be checked regularly, and the maintenance work should be carried out after switching the standby machine according to the requirements of the normal hydrogen compressor manufacturer. In addition, regularly check the lubricating oil system, regularly clean the first and second grade lubricating oil filter, tighten the static sealing point. Patrol inspection, the use of listening stick to check the compressor section sound is normal, to judge whether the cast iron cylinder block, crankshaft, connecting rod, etc. This article through to the hydrogen compressor working principle, classification, common failure analysis, summary. For the chemical industry operators to improve reference ideas, to promote the hydrogen compressor operation, management, maintenance level, guarantee the stability of chemical unit operation, reduce the loss caused by hydrogen compressor fault parking, creating biggest economic benefits for the enterprise.

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