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Safety Analysis and Fault Automatic Recognition Technology of Regenerative Adsorption Dryer

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Abstract. In oil and gas processing station, the regenerative adsorption dryer absorbs the compressed air moisture to ensure the dew point of the gas. Once the dryer fails, it will cause the water dew point to rise, which will affect the operation parameters of the device in winter when the automatic control valves freeze. Control valves freezing can lead to serious consequences such as release, gas-Migration, and unqualified product quality and so on, which are difficult to deal with. The pressure of dryer and regenerative pressure are characterized by a certain periodic change when dryer is working. This paper introduces the automatic identification technology of the dryer fault. Logic analysis through DCS system can identify faults by analyzing the time curve of regenerative pressure, catching abnormal changes of the curve during the failure of dryer. The automatic identification technology of the dryer fault will be achieved in a short time and send out alarm signal to ensure the safe operation of the oil and gas treatment station. It is highly valuable for wide extension and application.

1. Introduction
Compressed air is widely used as power source in oil and gas processing stations, which provides power for automatic control valves and raw materials for nitrogen production. The main equipment is air compressor and regenerative adsorption dryer. The former is to manufacture compressed air and the latter is to dry compressed air to reduce dew point and provide users with compressed air of standard dew point requirements.

2. The principle of regenerative adsorption dryer
Pressure swing adsorption (PSA) is a mature technology, which is widely used in regenerative adsorption dryer. PSA uses aluminium oxide as molecular sieve to adsorb moisture.

Molecular sieve is a porous solid material with different sizes of pores. Aluminum trioxide is a kind of molecular sieve. Its pore diameter is similar to that of water molecule. Under certain pressure, water molecule can be absorbed into the pore of adsorbent, with the increasing amount of water molecules, water droplets are formed. During regeneration, low pressure dry air blows water molecules out of the molecular sieve. The adsorption principle is shown in Figure 1.
Fig.1 Principle of molecular sieve adsorbing water molecules

The regenerative adsorption dryer consists of two towers, of which one is drying while the other tower is regenerated. The two towers work continuously under the controller. The compressed air manufactured by the air compressor enters from the bottom of the tower, passes through the molecular sieve in the tower, absorbs moisture, and then discharges from the top to enter the tank. Regeneration can be divided into two ways: thermal regeneration and non-thermal regeneration. After partial compressed air is reduced to atmospheric pressure by throttling, the molecular sieve adsorbed moisture is blown back and discharged through the exhaust port to prepare for the next drying process. The regenerative adsorption dryer control principle is shown in Figure 2.

3. Safety analysis and failure types of regenerative adsorption dryer

According to the Instrument Gas Supply Design Code, the dew point under the operating pressure of the gas source in the gas supply system should be at least 10 degrees lower than the extreme minimum temperature in the working environment or in the history of the local year (season). In the north of Xinjiang and other areas, it is extremely cold in winter, and the dew point requirement of oil and gas treatment stations is -40, which poses a great challenge to the regenerative adsorption dryer. When the dryer absorbs moisture, if the dryer fails, the dew point will rise, and the automatic control valve will lose control during winter operation, which will seriously affect the control of field and station parameters, and may cause serious consequences such as release, pressure channelling, and unqualified product quality and so on.

In 2009 and 2010, two unqualified dew point incidents occurred in a certain oil and gas treatment station. The parameters of the production plant were out of control, the valve core of the automatic control valve was seriously frozen, hundreds of automatic control valves were out of control and could only be controlled manually. After troubleshooting, unqualified gas is discharged at the gas supply end of each valve for more than ten days.

Faults affecting dew point in regenerative adsorption dryer include: power supply line fault; dryer not started; instrument air pipeline damage; power supply insurance burning; programme fault; part of the valve out of control because of electromagnetic valve fault; part of the valve out of control because of relay fault; pneumatic butterfly valve closure is not strict or stuck and not thorough regeneration.
The common problems in oil and gas treatment stations are: many types of regenerative adsorption dryer faults, ordinary inspection personnel do not have the relevant knowledge; regenerative adsorption dryer operation cycle is long and intermittent operation, patrol inspection is difficult; instrument dew point measured once a few days. There are only a few patrols every day, but the failure occurs at any time. Consequently, the regenerative adsorption dryer failure cannot be timely, which is identified as one of the major hidden dangers of the station. According to the failures of regenerative adsorption dryer in Tarim Oilfield in recent years, valve leakage and blocking faults occurred frequently. Besides, insurance burning, electrical faults, butterfly valve supply pipeline damage and dryer not started also happen sometimes. There is a certain time gap between the fault recognition and the fault occurrence, and the fault occurs every year, so it is meaningful to develop the automatic fault recognition technology for regenerative adsorption dryer.

4. The principle of automatic fault recognition of regenerative adsorption dryer

When one tower is drying, the other is regenerated. When one tower is boosted, the other is ready to unload and switch at the same time. The regeneration pressure only rises before switching. It rises to the pipe network pressure, and then falls to the regeneration pressure again after a certain switching success. Regeneration pressure shows a certain periodicity. The pressure time curve of normal operation is shown in Figure 3.

![Fig.3 Pressure time curve of normal periodic operation of regenerative adsorption dryer](image)

The time pressure curve of the left tower and the right tower is just the opposite. The cycle time of regeneration pressure time curve is half of the two tower pressure time curve.

When the regenerative adsorption dryer fails, the regeneration pressure time curve changes. The automatic fault recognition technology of regenerative adsorption dryer analyses regeneration pressure time curve by DCS system logic, catches abnormal change of curve, automatically identifies and sends out alarm. The time curve of regeneration pressure during failure is shown in Figure 4.

![Fig.4 Regenerative pressure time curve at fault operation of regenerative adsorption dryer](image)

The first curve is normal running curve. The time curve of regeneration pressure changes periodically.

The second curve represents that the regenerative adsorption dryer does not start; the circuit and control system fail. Under these circumstances, the time curve of regeneration pressure will remain uniformly as pipe network pressure. Even if the air compressor stops running, the pressure value remains unchanged.
The third curve represents the failure of valves and pipelines. Under these circumstances, the time curve of regeneration pressure still shows periodic change, but the curve pattern and the period changes. The regeneration pressure time curve is no longer just a short-term increase. It is to maintain regular high pressure over a certain period of time.

These two situations are extremely dangerous. It will cause the dew point of compressed air water to rise and cause accidents in a very short time.

The fourth curve represents the valve leakage. When the valve is leaking, the pressure of the regeneration tower is no longer zero. It will have a higher pressure than normal. When this case happens, the regeneration of the dryer will not be thorough. The dew point of compressed air will rise.

The fifth curve represents low regeneration pressure. Although this happens, the time curve of regeneration pressure still shows periodic change. The result is the same as the previous curve.

5. **Automatic recognition technology for regenerative adsorption dryer fault.**

5.1. **Automatic fault recognition method**

The regeneration pressure time curve can reflect the failure of regenerative adsorption dryer. Therefore, Curve analysis will be used as the basis of fault recognition.

A pressure sensor should be added before the orifice plate of regeneration gas throttle, and the regeneration pressure is transmitted to the central control room. The fault recognition logic is added to the DCS of the central control room, and the sound and light alarm is issued after the fault is recognised. Method description is shown in Figure 5.

![Fig.5 Schematic diagram of automatic fault recognition of regenerative adsorption dryer](image)

5.2. **The condition for fault recognition of regenerative adsorption dryer**

To distinguish whether the regenerative adsorption dryer fails or not, three conditions should be satisfied:

- The air compressor must be in operation because it is unidentified zone when the air compressor is not running;
- The regeneration pressure is greater than the set value and the duration is greater than the set value; either or, The regeneration pressure is less than the set value and the duration is greater than the set value;
- The regenerative adsorption dryer is in non-evacuation zone. In addition, if the dryer is not linked to the air compressor, there is no need to identify the state of the air compressor, and there is no blind zone.

5.3. **Blind zone**

When it comes to the regenerative adsorption dryer connected with the air compressor, regeneration pauses. Because when the air compressor shuts down, the program controller pauses the timing, the regeneration exhaust valve of the dryer is closed and the remaining valves remain in the original state.
If a tower is in a boost state when the dryer stops, when the pipe network pressure is lower than the set value of the air compressor and starts, the dryer will maintain the pipe network pressure and delay pressure relief, and there is a "minefield". Therefore, in order to avoid the false alarm of "minefield" during the first pressure relief of the dryer, the identification logic is compiled. The failure of dryer is repeatable, and the appearance of blind zone will not affect the identification of faults. The fault recognition zone is shown in Figure 6.

![Regenerative Adsorption Dryer Failure](image)

**Fig.6 Pressure running curve and zoning of regenerative adsorption dryer**

5.4. **Parameter setting**
Because different regenerative adsorption dryers run in different Control schematic diagram, parameter setting must match dryer.

- The lubricating oil pressure of air compressor should be less than the normal operation pressure. If the minimum pressure is 280 KPa, the value of 250 KPa can be selected to distinguish whether the air compressor is running.
- The identification value of dryer regeneration pressure: If there is regeneration pressure value on the nameplate of dryer, the identification value is 0.02-0.05 MPa higher than that of regeneration pressure; if there is no regeneration pressure on the nameplate of dryer, first make the pressure-dew point curve, then determine the best regeneration pressure according to regeneration flow rate and dew point, and the identification value should be 0.02-0.05 MPa higher on the basis of the best pressure.
- Blind zone time. Taking Ingersoll Rand regenerative adsorption dryer as an example, the blind zone time should be 10 second higher on the basis of switching time;
- Regeneration pressure identification time. It should be 5-10 seconds higher on the basis of switching time.

6. **Automatic recognition test of regenerative adsorption dryer failure**
There are many types of failures in regenerative adsorption dryer. But only the boost valve fault can not be identified. Boost valve can ensure that the pressure of the two towers is the same when switching. Because the boost time is set for a long time, the pressure of the regeneration tower can basically rise to the pipe network pressure in this period, and there will be no sudden change of pressure when switching the two towers. This fault will not affect the dew point and is easy to find, so the risk is small.

According to the theoretical calculation, the time that the regenerative adsorption dryer can give an alarm ranges from 35 seconds to 6 minutes and 15 seconds. After testing, the alarm is normal. The test record is shown in Table 1.

| Test item | Test time | Alarm or not | Alarm time | Remarks |
|-----------|-----------|--------------|------------|---------|
|           |           |              |            |         |

Table 1 Automatic fault recognition and alarm test of regenerative adsorption dryer
Fault automatic recognition technology of regenerative adsorption dryer can identify most of the faults and alarm. The successful implementation of fault identification technology can improve the automatic control valve power source quality assurance, thus ensuring the precise control of the parameters of oil and gas processing stations and avoiding the occurrence of accidents. It is a technology that can be widely used in various occasions using compressed air as power source.

References

[1] Zhonghui Luo. (1999) Compressed Heat Dryer. Compressor Technology.05:19-25.
[2] Yushan Lu. (1994) Compression Heat Regeneration Method - Compressed Gas Drying Process. Energy Saving.5:25-26.
[3] Difei Yan. (2011) Energy Saving Potential of Dryer. Energy Saving technology.06:564-565
[4] Xueping Zhan. (2004) Energy Saving Air Compressor Station. Energy Saving Technology.04:50-51.
[5] Jianhua Qiu. (2002) Efficiency and Energy Saving of Compressed Hot Regenerative Air dryer and Its Application. Energy Research and Utilization.04:45-46.
[6] Renmin Zhang,Lianbao Li. (2012) Improvement of Compressed Air Drying Method for Instruments. Standards and Quality of PetroChina and Chemical Industry. s1:250-250.
[7] Jianming Ma. (2001) Using Programmable Logic Controller to Control The Dryer of Air Compressor. Cement 01:40-40.