Research on Countermeasures of Internal fouling in Turbine Flowmeter

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Abstract

Turbine flowmeters are widely used to measure volume flow and total volume of low viscosity gas in closed pipelines due to their advantages of high precision, good repeatability and insensitivity to peak value, especially in natural gas distribution stations and metering institutions are more commonly used. However, there are rotating parts inside them, which are easily affected by factors such as dust, grease, and impurities. Based on flowmeter verification test data and years of experience in standard device management, this paper conducts research from four aspects of fouling source control, fouling blocking, fouling cleaning and fouling prevention, discusses the feasibility scheme to solve the internal fouling problem of turbine flowmeters and forms a complete set of fouling control, treatment, blocking and prevention methods.

1. Introduction

Turbine flowmeter have been widely used in natural gas metering due to their advantages of high precision, good repeatability, no zero drift, high range ratio, simple structure, high pressure resistance, wide measuring range, insensitivity to peak value and high reliability under harsh conditions. Currently, hundreds of turbine flowmeters have been applied to various natural gas long-distance pipelines in China, such as the west-east gas pipeline, Sichuan-east gas pipeline, Yuji pipeline, etc. [1-2].

With the formation of a national pipeline natural gas network, the mixed transmission of various gas sources in the natural gas pipeline network has become a common phenomenon [3]. The gas quality in some pipelines is poor. Even after filtration, there are small impurities, grease, etc., which are easy to adhere to the impellers, thus affecting the performance of the turbine flowmeter. According to statistics, the failure of turbine flowmeter impeller, movement and rotating parts caused by natural gas fouling has accounted for more than 35% of the total failures. Namely, gas fouling has become the main reason for the failure of turbine flowmeters, and it will directly affect the accuracy of trade measurement and value transmission, which is easy to cause huge economic losses. Therefore, it is necessary to carry out research on this problem and formulate targeted preventive and control measures to ensure the accuracy and reliability of turbine flowmeter in the process of field use.

2. Measuring principle of turbine flowmeter

Turbine flowmeter is a velocity-type flowmeter. The measurement principle is that the kinetic energy of the fluid flow drives the turbine blades to rotate, and its rotational speed is approximately proportional to the volume flow. That is, the higher the flow rate, the greater the kinetic energy, and the higher the turbine speed. The rotating speed of the turbine is converted into electric pulses of corresponding frequency by the magnetoelectric induction converter, which is calculated and displayed by the display instrument.

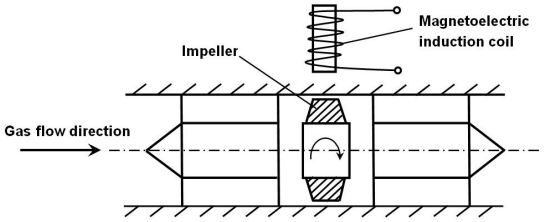

Figure 1: working principle diagram of turbine flowmeter

The turbine flowmeter can display cumulative flow and instantaneous flow respectively through different calculation methods. When the turbine blade cuts the magnetic line of force generated by the permanent magnetic steel in the shell, it will cause the change of the magnetic flux of the sensing coil. The periodic change signal of the magnetic flux is amplified and shaped by the preamplifier to generate a pulse signal proportional to the flow rate. This signal is converted by the flow calculation circuit and displayed as the cumulative flow value. Synchronously, it is converted into the

analog current by the frequency current conversion circuit, and then displayed as the instantaneous flow value [4].

3. Problem sources

3.1 Influence of dust on turbine flowmeter

After the operation, cleaning and internal inspection of the natural gas pipeline, the natural gas in the pipeline is easy to mix with dust. After the dust enters the turbine flowmeter, it is easy to affect the accuracy of the flowmeter. Table 1 shows the comparison of the indication error of a standard turbine flowmeter of a verification technical institution before and after being affected by dust.

Table 1: Comparison of indication error of standard turbine flowmeter before and after dust influence

Set Point	Flow (m^3/h)	Indication Error before Dust Influence (%)	Indication Error after Dust Influence (%)	Deviation of Indication Error (%)
1	2797.32	-0.08	-0.45	-0.37
2	2396.07	-0.08	-0.47	-0.39
3	1602.58	-0.07	-0.44	-0.36
4	1183.73	-0.05	-0.41	-0.36
5	805.02	-0.12	-0.45	-0.33

It can be seen from Table 1 that the dust entering the turbine flowmeter has a relatively direct impact on its accuracy, with a deviation of more than 0.3%. Therefore, it is suggested that protective measures should be taken to prevent the dirty gas from entering the process pipeline of each metrological verification room to pollute the standard turbine flowmeter when cleaning and internal detection are carried out upstream, which may affect the gas quality.

3.2 Influence of moisture on turbine flowmeter

Before the natural gas pipeline is put into use, if it is not completely dried or effectively sealed after drying, *moisture* is easy to accumulate in the pipeline, and *moisture* entrainment of natural gas into the turbine flowmeter will also affect its measurement accuracy. Table 2 shows the test results of turbine flowmeter in the case of *moisture* in natural gas pipeline.

Table 2: Test results of turbine flowmeter under the influence of moisture

Set Point	Flow (m^3/h)	Pressure (MPa)	Indication Error (%)	Measurement Repeatability (%)
1	79.10	4.3504	-0.55	0.70
2	157.04	4.3418	-0.57	0.49
3	2911.19	4.4517	0.10	0.32
4	3561.47	4.4236	0.08	0.27

As can be seen from Table 2, the poor repeatability of turbine flowmeter test results is caused by the moisture in pipelines. The natural gas in the pipeline is repeatedly purged and monitored, and tested after the pipeline is completely dried. The results are shown in Table 3.

Table 3: Test results of turbine flowmeter after water purging of natural gas

Set Point	Flow (m^3/h)	Pressure (MPa)	Indication Error (%)	Measurement Repeatability (%)
1	65.45	4.7387	0.47	0.01
2	152.54	4.6843	0.63	0.02
3	2911.19	4.4261	0.04	0.01
4	3465.90	4.4205	0.01	0.01

Obviously, moisture has a direct impact on the test results of turbine flowmeterand has an impact on the relative indication error and repeatability of the test results. Therefore, the moisture in the pipeline should be strictly controlled.For pipelines that have not been used for a long time, they should be well protected and sealed with nitrogen. The situation in the pipelines should be confirmed before reuse. If the pipelines do not meet the requirements of gas transmission, they should be dried and purged again.

3.3 Influence of grease on turbine flowmeter

Natural gas pipeline valves need to be regularly filled with lubricating oil. If the added oil spills, the oil will enter the turbine flowmeter with the flow of natural gas and attach to the impeller surface of the turbine flowmeter, resulting in changes in its accuracy. Table 4 shows the comparison of the indication error of the turbine flowmeter before and after the influence of grease.

Table 4: Comparison of indication error of standard turbine flowmeter before and after grease influence

Set Point	Flow (m^3/h)	Indication Error before Grease Influence (%)	Indication Error after Grease Influence (%)	Deviation of Indication Error (%)
1	98.09	0.08	1.38	-1.3
2	68.46	0.22	0.45	-0.23
3	37.61	0.28	0.57	-0.29
4	30.03	0.28	0.52	-0.24
5	22.83	0.19	0.44	-0.25
6	15.22	0.08	0.22	-0.14

As can be seen from Table 4, the turbine flowmeter is obviously affected by grease. Due to the strong adhesion of grease, its influence on large flow points is more obvious, and the influence amount is more than 1%. Therefore,

when greasing and maintaining the upstream valve of the turbine flowmeter, it is recommended to disassemble the standard meter and replace it with a straight pipe section, and then reinstall it after full purging.

4. Solutions

From the above analysis, it can be seen that the performance of turbine flowmeter is susceptible to the influence of moisture, dust and grease in pipeline, leading to the discovery change of its performance and affecting the fairness and justice of trade. Based on flowmeter verification test data and years of experience in standard device management, the research is carried out from four aspects of fouling source control, fouling blocking, fouling cleaning and fouling prevention, and the feasible scheme to solve the internal fouling problems of turbine flowmeter is discussed, and a complete set of fouling control, treatment, blocking and prevention methods is formed.

4.1 Source control

Source control is to analyse the causes of fouling of the turbine flowmeter impellers, find out the fouling sources (Including non-standard construction, impact of gas quality, equipment maintenance and repair, etc.), and formulate targeted control measures to prevent fouling from entering from the source.

4.2 Fouling blocking

Dirt blocking is to develop a high-precision conical filter screen (filter precision up to 100 μm and pressure drop less than 0.15 MPa, as shown in Figure 2) through research and testing (mainly including the influence of pressure difference before and after the filter screen and the adjustment of installation position, etc.), which is installed upstream of the turbine flowmeter to block fouling.

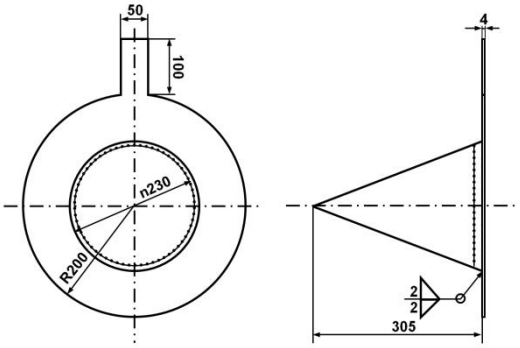

Figure 2: High-precision conical filter screen

4.3 Fouling cleaning

Fouling cleaning is to introduce ultrasonic cleaning technology to clean the standard turbine flowmeter that has been affected by fouling, namely, The disassembled metering core or the whole flowmeter is immersed in turbine lubricating oil and ultrasonic cleaning technology is adopted to eliminate the fine impurities and grease on the impellers. After cleaning, the performance of the turbine flowmeter can be basically restored to that before being affected by dirt, as shown in Figure 3.

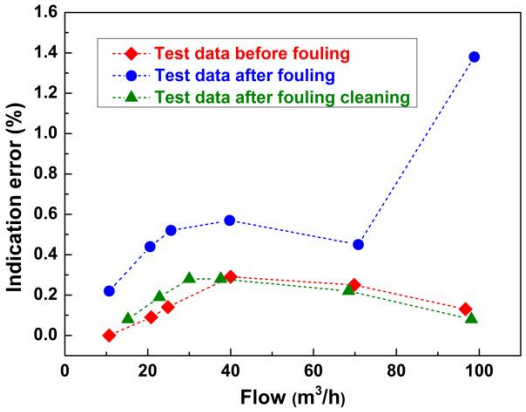

Figure 3: Comparison of test data of turbine flowmeter before and after fouling cleaning

4.3 Fouling prevention

Fouling prevention is to consolidate the existing prevention measures based on the actual operation experience in the field, effectively prevent Fouling sources in the production and operation, ensure the internal cleanliness of the turbine flowmeter and ensure its accuracy and reliability.

5. Conclusions and Recommendations

(1) The performance of the turbine flowmeter is vulnerable to the influence of moisture, dust and grease in the pipeline. It is recommended to add a filter screen in front of the turbine flowmeter, strengthen the monitoring of the dirt and gas quality of the pipeline during daily operation, and regularly check the turbine flowmeter.

(2) For pipelines that have not been used for a long time, they should be well protected and sealed with nitrogen. The situation in the pipelines should be confirmed before reuse. If the pipelines do not meet the requirements of gas transmission, they should be dried and purged again.

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