The Study on Noise in the Natural Gas Manifolds

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Abstract

In order to make fluid flow stable, manifolds are set among separation, measurement and pressure regulator during the long-distance gas pipeline stations design. Although manifolds are commonly used in gas transmission system, there exists a serious noise pollution problem. Currently, there is little research on manifolds noise. The influence factors and characteristics of manifold noise are studied to reduce the harm to people's health. The mechanism of manifold aerodynamic noise is investigated and noise reduction methods and suggestions are proposed.

Keywords

Natural gas station, Manifolds, Aerodynamic noise, Pollution.

1. Introduction

With the rapid development of urbanization process, the natural gas stations located in remote areas are surrounded by emerging towns[1]. However, noise pollution is prevalent in the natural gas station, which will affect the lives and health of the residents and workers. The noise mainly focus on pressure regulator, manifolds, valves, flow meters and bents. In particularly, the noise pollution is relatively more serious due to the larger pressure difference, the greater flow rate and the higher velocity in the middle and high pressure stage manifolds. Thus, the noise reduction measures are adopted to achieve the corresponding environmental requirements, including external sound insulation materials, soundproof room and noise Isolation Hoods. However, the noise superposition effect will lead to the greater noise due to many noise sources in the gas station. If outsourcing sound insulation method is adopted, the pipelines and meters will be wrapped up. There is not only the higher cost, but also affect the monitoring, dismounting and maintenance of pipes. Meanwhile, improper package of sound insulation material will lead to pipeline corrosion and safety accidents due to a large number of irregular equipment in the gas transmission system. If soundproof room is built to reduce noise, there will be a serious security risk. This is due to the fact that natural gas leaked in the gas station is not easily diffused into the environment. Therefore, there is need to study the noises of manifolds in the gas transmission and transportation system.

Based on air flow noise in a typical cylinder, the methods and various empirical formulas of hydrodynamic and noise source characteristics are mainly focused on valves, variable cross-section pipe and regulating valve of the natural gas pipeline[2]. However, the hydrodynamic characteristics, noise source characteristics and noise impact factors for the manifolds are few investigated. In this paper, the flow field distribution of manifolds is analyzed to study noise based on hydrodynamics, acoustics and gas dynamics. In addition, the mechanism of manifold noise is generated[4]. Furthermore, the suggestions for optimizing the manifolds are proposed from the flow parameters, structure and sound-absorbing materials.

2. Manifold noise

There is a shorter distance between the primary pressure regulation and bypass inlet line and manifolds due to site restrictions in the gas distribution station. The noise generated in the regulating valves or bents is transmitted into the manifold, which is a combination of jet noise and airflow turbulence noise in the manifold. The strong noises are generated by radiating outward with much larger than the surface area of the regulator unit. The manifold noises are particularly prominent in the large-scale gas distribution stations with more equipment and inlet distribution lines. The manifold noise mainly consists of the vibration noise and the aerodynamic noise. According to field investigation, the vibration parameters are small and meet the relevant provisions when the manifolds are in normal operation. Thus, the main noise in the manifold is aerodynamic noise. The sound source type should be considered during the research on the aerodynamic noise of the manifold. The sound source types mainly consist of monopole sound source, dipole source and quadrupole sound source. The study of aerodynamic noise mainly concentrates on judging the noise source correctly and taking effective measures to reduce noise. The total sound power of the dipole is proportional to the six power of the flow velocity, whereas the total sound power of the quadrupole is proportional to the octave of the velocity. Therefore, the quadrupole sound source can be ignored when the fluid Mach number is small. The horizontal velocity of rigid surface of manifold can be neglected due to the intensity of monopole sound source is related to the horizontal velocity of rigid surface of manifold for the aerodynamic noise problem. Therefore, the monopole sound source cannot be considered. Due to the ratio of the intensity of the quadrupole sound source to the intensity of the dipole sound source is proportional to the square of the Mach number and smaller Mach number, the quadrupole sound source can also be ignored. Therefore, the sound source of aerodynamic noise in the manifold is mainly dipole source.

Eddy motion leads to aerodynamic noise in the manifold. The reason of this phenomenon lies in that the vortex movement produces pulsating pressure acting on the manifold walls[5]. However, the movement of vortex is difficult to be intuitively reflected during CFD simulations using Fluent, while it can be shown by pressure cloud and velocity vector pictures indirectly. This numerical simulations are performed using a 20m/s inlet speed and a 0.8 MPa outlet pressure. The pressure cloud picture is shown in Fig. 1 and the velocity cloud picture is shown in Fig. 2. The pulsating pressure is larger in the strong vortex movement. A minimum velocity is generated at both ends of the manifold, whereas a greater velocity is produced at the inlet pipe, outlet pipe, and manifold center. Vortex is commonly generated at a higher speed. When the gas enters manifolds from the inlet pipes, the gas is difficult to expand due to larger velocity. When the gas touches the rear edge of manifold center, the movement direction is changed and the flow cannot be steady and smooth transition due to the blocking effect of the manifold walls. Thus, there will be a strong vortex. The pulsating pressure of manifold wall will be changed in this process, leading to aerodynamic noise. According to the analysis of manifold flow field and sound pressure level at other parts, a maximum noise will be produced at near the middle of manifolds. The pulsating pressure decreases with the increase of diffusion distance; thus leading to a smaller pressure level.

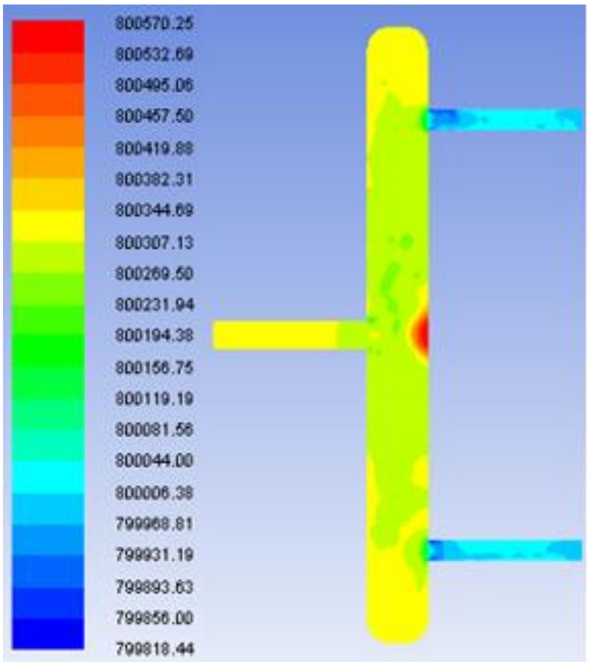

Fig .1 Simulated pressure development

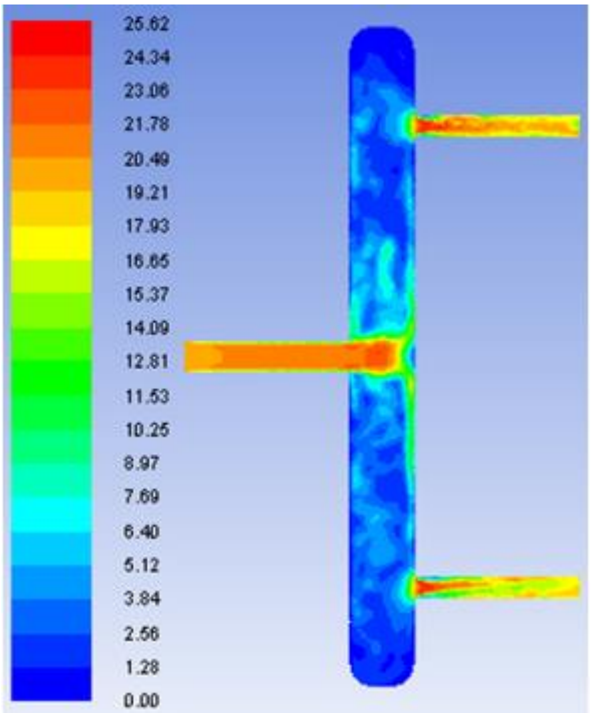

Fig .2 Simulated velocity development

3. Noise reduction measures

Noise reduction measures includes passive noise reduction and active noise reduction. The passive noise reduction measures are usually used in engineering considering the economic applicability and specific operation[3]. The sound absorption widely used in the passive noise reduction is the most effective method. There are many types of sound-absorbing materials, including fiber material, foam material and particle type sound-absorbing material. The fiber porous sound-absorbing material mainly includes glass fiber, glass wool, slag cotton, rock wool, cotton, linen and cotton. However, the glass wool is the commonly used sound-absorbing material. The foam materials mainly include foam glass and foamed plastic. However, the common foamed plastics are the urethane and miboluo.

The advantages of foamed plastics are soft material, small thermal conductivity and small density, whereas the disadvantages are poor fire resistance and easy aging. The sound energy is incident to the porous sound-absorbing material and enters porous hole, causing material and air vibration. The acoustic vibration energy is converted into heat energy due to the friction and viscous force. The sound absorption coefficient of porous sound-absorbing material increases with the frequency, which indicates that the low-frequency absorption is not better than high-frequency absorption. However, the low-frequency absorption increase with increase of the material thickness, while the high-frequency absorption is barely affected by the material thickness. The muffler is a noise elimination device and makes the air flow open. The noise elimination technology is adopted to noise reduction for the outlet and ventilation pipes. A good muffler can reduce the noise by 20 ~ 40dB. The muffler can only reduce the propagation noise s in the tuyere or pipes, while it cannot reduce the sound of noise source equipment. According to the field research, the noise reduction technology in the natural gas station and long-distance system mainly includes sound-absorbing material package, building acoustic enclosures, muffler technology and ear protector. Currently, the muffler technology is widely used in the gas station. The muffle is installed in the sophisticated voltage regulator equipment to reduce noise. However, the sound-absorbing materials and acoustic enclosure are commonly adopted to decrease manifold noise. The effect of using passive noise reduction method as Fig. 3.

The active noise reduction technology is mainly from the design aspects of transformation, including the optimization of working parameters and the optimization of inlet pipe diameter, outlet pipe diameter and two outlet pipe distance, whereas the passive noise reduction technology uses the external structure of sound absorption. The flow velocity will lead to noise based on the noise reduction principle. In addition, the appropriate reduction in flow velocity can significantly reduce noise[6]. First, the length of the straight pipe section after the regulator is increased to make turbulent natural gas stable in the pipes. In addition, the airflow velocity is reduced, leading to a reduction in the air flow disturbance; thus the aerodynamic noise is decreased in the manifolds. Then,the outlet diameter of manifold is increased and the ratio of manifold diameter to the diameter of outlet pipes to decrease airflow disturbance, causing a reduction in noise. Finally, the inlet diameter of manifold is increased and the jet-flow caused by fluid entering the manifold is decreased to reduce eddy disturbance; thus leading to a reduction in noise. The effect of using active noise reduction method as Fig.4.

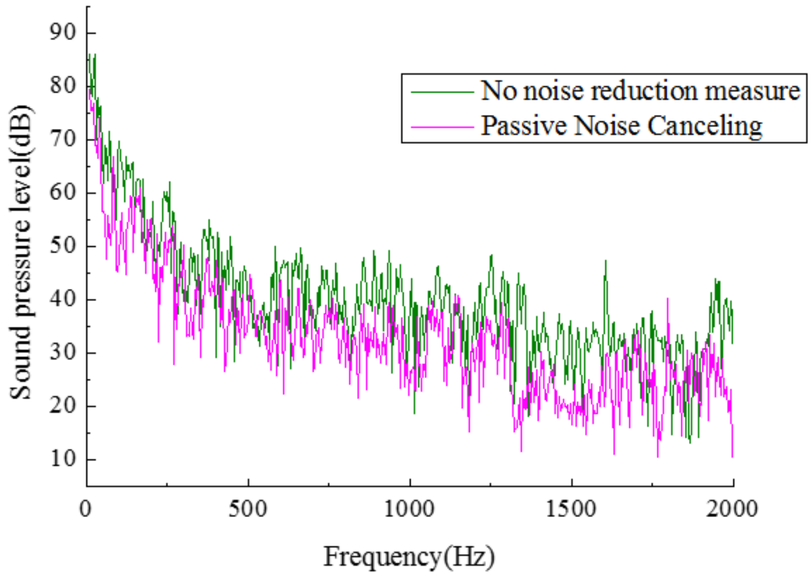

Fig. 3 The effect of using passive noise reduction method

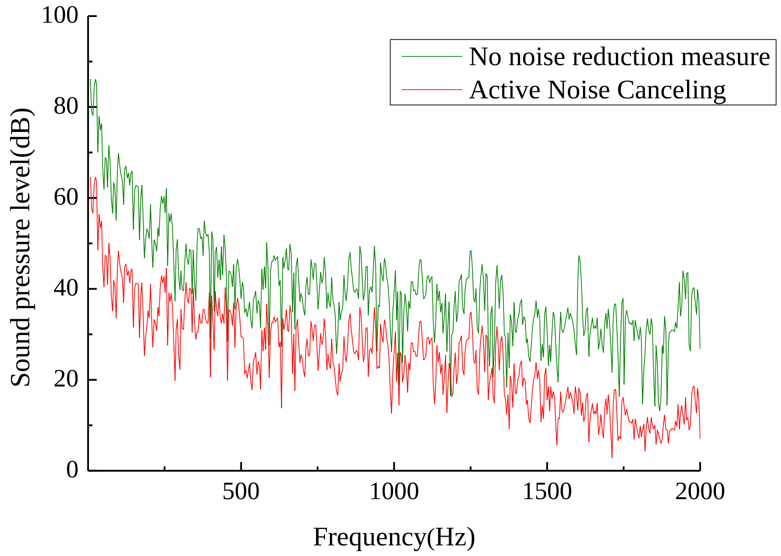

Fig. 4 The effect of using active noise reduction method

4. Conclusion

Manifold noise is mainly aerodynamic noise. The manifold inlet line is optimized to reduce the aerodynamic noise effectively. First, the length of the straight pipe section after the regulator is increased to make turbulent natural gas stable in the pipes. In addition, the airflow velocity is reduced, leading to a reduction in the air flow disturbance; thus the aerodynamic noise is decreased in the manifolds. Then, the inlet pipe diameter of the manifold need to be increased. This is due to the fact that when the natural gas enters the manifold through the straight pipe section, the airflow disturbance will be produced as a result of airflow diffusion caused by pressure difference and a sudden change in space. Thus, the increase of inlet pipe diameter of the manifold can make a smaller airflow disturbance, leading to a reduction in noise. Meanwhile, it is favorable for the expansion capacity. Furthermore, multiple manifolds should be set for a gas distribution station with a large capacity. There are many methods to reduce noise in the manifolds, including set multiple inlet pipes, decrease the air input of single channel, reduce the airflow velocity, decrease the jet flow caused by the high-speed airflow into manifolds, and reduce airflow disturbance. The implementation of technological transformation is the main way to reduce manifold noise. For example, the soundproof sleeves and acoustic enclosures are made of glass wool and other sound-absorbing material. Furthermore, the sound absorption and sound insulation sheds are installed to prevent noise propagation in the out of the station noise sensitive point direction.

References

[1] Danping Yan,Shunli Gao,Qi Zhu etc. Practice of Noise Control in Natural Gas Regulating Station. Gas & Heat, 2008,28(12): 51-54.

[2] Mengling Ya，Liucui Wei，Liyu Xing etc. Aero-acoustics generation mechanism and analysis methods for natural gas pipelines.Journal of China University of Petroleum,2012,36(6):128-136.

[3] Chen Yang.Research on acoustic materials applied in auto noise reduction. Shanghai University of Engineering Science,2015

[4] Taehyung K. Minu J. Soogab Lee.Numerical simulation of flatback airfoil aerodynamic noise. Renewable Energy. 2014.192-201.

[5] Cuiwei Liu,Yuxing Li,Xuejie Li.Simulation of Valve Flow Noise in Gas Pipeline Based on CFD Simulation. Oil & Gas Storage and Transportation, 2012,31(9) :657-662.

[6] Houlin Liu ,Jian Ding, Yong Wang etc. Numerical Simulation of Hydrodynamic Noise in Centrifugal Pump Based on LES. Journal of Mechanical Engineering.2013,49(18):177-182