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Study on structure optimization and noise reduction of filling nipple and elbow of natural gas wellhead

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Abstract:
Noise control is very important for the safe production of natural gas wellhead. After natural gas goes through the throttle valve then must travel through the filling nipple (which connect secondary throttle valve and the elbow), and get in the exchange tube, there will be the production of noise due to internal flow field changes caused by sudden change of structure. This paper aimed at the natural gas field in Sichuan basin, and optimized the structure of the filling nipple, and numerical simulation of the flow field before and after the optimization was carried out. The simulation results show that the vortexes of the internal flow field are reduced, the velocity distribution of each section of pipeline is uniform, and the optimized structure is conducive to reducing noise.

Key words: noise pollution, filling nipple, natural gas, flow field simulation

1 Introduction

The environment consist of sound is called the sound environment [1]. When the sound of the environment has no adverse effects on human beings, animals and nature, it is a normal physical phenomenon [2]. On the contrary, the sound which has a bad influence on people's life and work is called noise. In this paper, the gas field is located in the Sichuan Basin in the central; the gas pool has characteristics such as large reserves, high pressure, high single well production. Since the gas field was put into production, more than 20 wellhead had appeared excessive noise, some had reaches 110 dB, far more than the limit value of 70 dB provided by GB12348-2008 (the industrial enterprise factory environmental noise emission standards). A number of domestic and foreign research institutes experts and scholars were hired, and together with the gas field construction technology research, they have proposed a number of solutions and construction to the noise reduction program, but the noise reduction effect still remained poor. Therefore, the analysis of mechanism of noise and noise reduction of filling nipple and elbow on the wellhead is necessary for safe production. In this paper, the noise reduction is studied by analyzing the internal flow field of the pipeline.

2 The flow field analysis of the original structure

The gas production process of the single well station is: the gas production tree – first step throttle – second step throttle - manifold - separator. For the diameter of the outlet of the throttle valve and set pipe diameter big difference is bigger, so the natural gas through the throttle valve throttle and need to after filling nipple (connected secondary throttle valve and pipe) into the manifold. There are two functions of filling nipple, one function is the change of the diameter, another function is adding corrosion inhibitor and anti ice blocking agent. The position of filling nipple is shown in Figure 1.

filling nipple

Figure 1 The position of the filling nipple

The structure of filling nipple is shown in Figure 2, the diameter of the pipeline increased dramatically in the very short distance (48mm) in the exit of the filling nipple, the rapid decrease of velocity of gas flow will cause great disturbance, which causes the vortexes. At the same time, the fluid kinetic energy is reduced, according to the law of conservation of energy, the loss of kinetic energy may be converted to heat energy and vibration energy. The composition of vibration wave and sound wave will expand the noise.

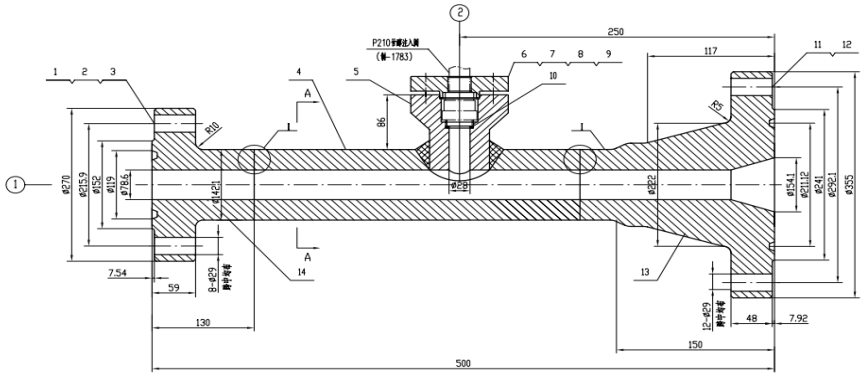


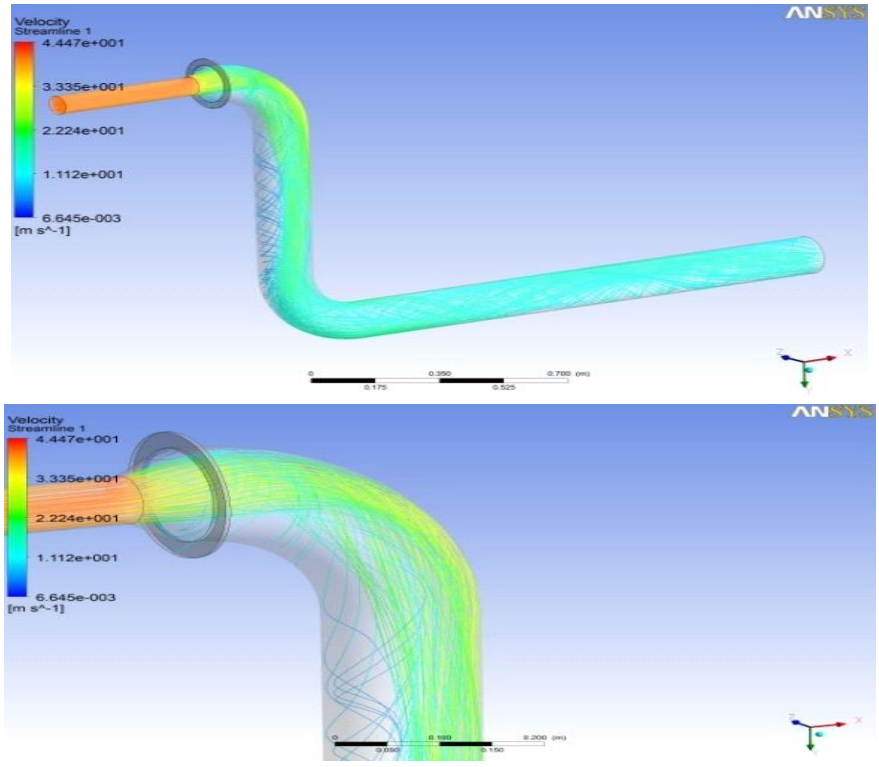
Figure 2 The structure of the original used filling nipple

The results of the flow field analysis of the original structure are shown in Figure 3 and Figure 4. Figure 3 shows that the fluid near the exit of the filling nipple especially near the elbow contains serious uneven distribution of velocity, severe turbulence, and vortex they are likely to become

part of the noise source. Under the action of centrifugal force, the flow direction of the elbow is suddenly changed, and the medium is flowing to the outside wall in the middle of the elbow, so that the effective cross-sectional area of the main flow is reduced, and the fluid flow on the unit cross section is not uniform. At the same time, due to the impact of the fluid on the lateral wall surface, the pipe will vibrate, and there will be a certain impact noise.

In addition, when the fluid flows through the elbow, the outer wall of the elbow is blocked to form the boundary layer[3], and the partial kinetic energy is converted into static pressure energy. With the increase of the distance of the flow, the blocking effect is spread in the direction perpendicular to the flow, and the boundary layer is continuously thickened[4]. Also due to the conversion of kinetic energy into pressure energy, making the flow direction in the boundary layer on contrary to the pressure drop direction, resulting in the formation of inverse pressure gradient, and because of this gradient and wall friction, the kinetic energy of the fluid decreased rapidly[5]. After some flow distance of the fluid of the boundary layer, the fluid will stagnate and in the inverse pressure gradient driven by backflow, eventually formats eddy region near wall.

In the backward or eddy current area, the natural gas in the tube is heated by mixing or collision, which causes the vibration of the pipe, and the vibration energy is converted to sound wave.



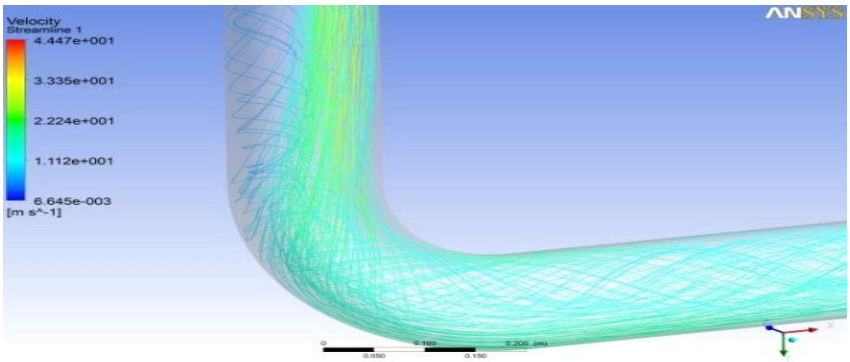


Figure 3 Internal velocity streamlines of the filling nipple and elbow

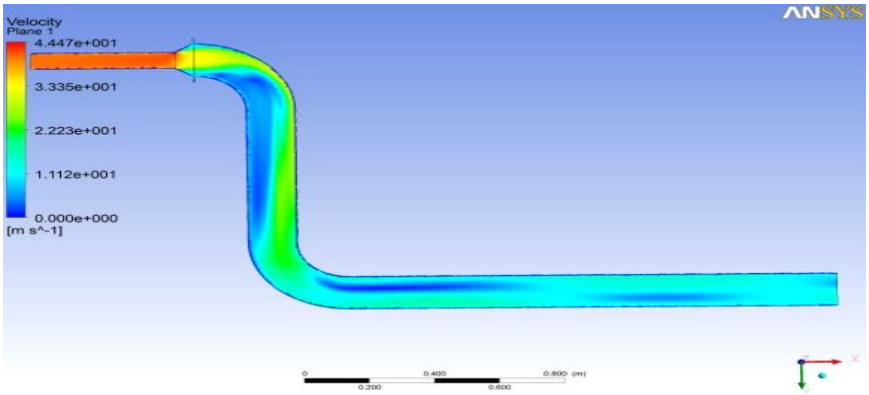


Figure 4 Internal velocity contour of the filling nipple and elbow

3 Analysis of the filling nipple

The original structure was changed into overall transition pipe in order to slow down the transition of fluids, the appropriate taper was selected so that the flow rate from the throttle valve outlet to the elbow becomes slow, the vortex phenomenon is weakened, thus the noise source strength from the throttle valve outlet to the original elbow will be weakened.

ANSYS was used to analysis the stress of the optimized filling nipple as shown in Figure 5.

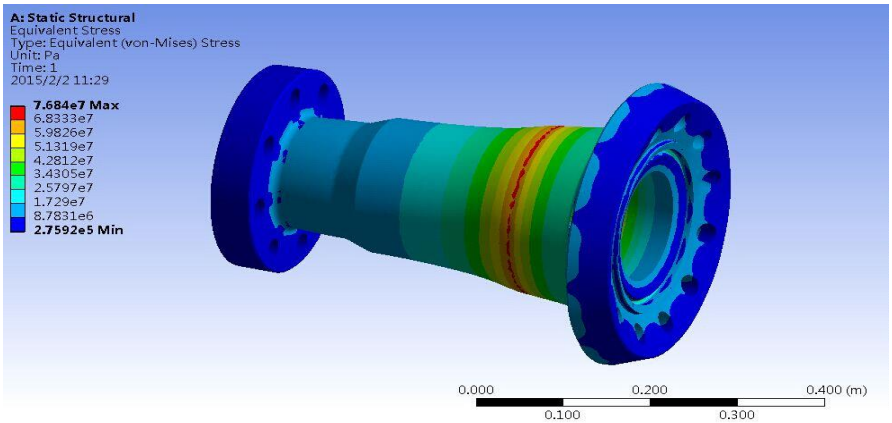


Figure 5 stress contour of the optimized filling nipple(internal pressure 10MPa, internal tension 13299.8KG)

4 Flow field analysis of optimized structure

The results of the flow field analysis of the optimized structure are shown in Figure 6 and Figure 7. Compare with the flow field analysis of the original structure(Figure 3, Figure 4), the optimized filling nipple has little impact on the header, and the vortexes are reduced, the velocity distribution of each section and axial line is more uniform. This analysis can help the reduction of the generation of noise theoretically.

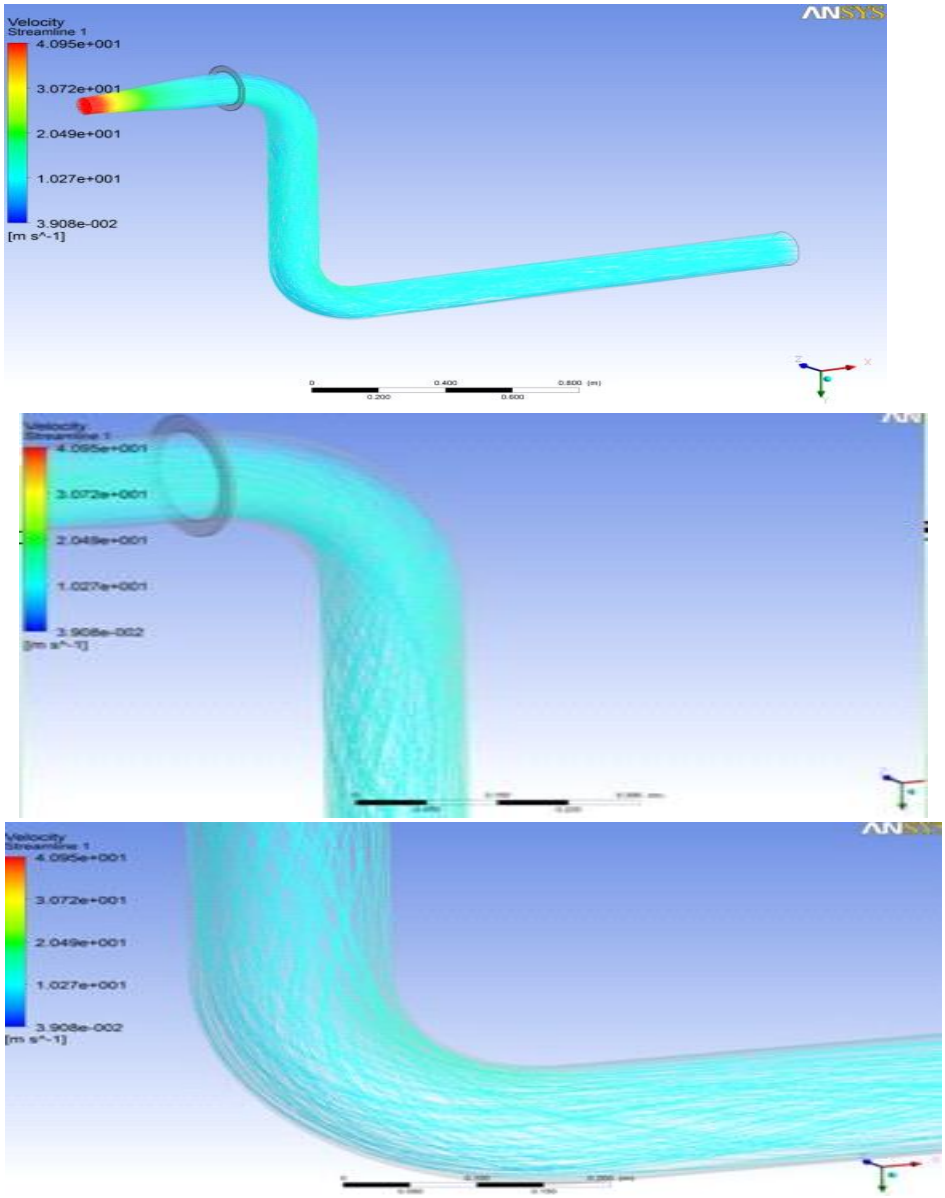


Figure 6 Internal velocity streamlines of the optimized filling nipple and elbow

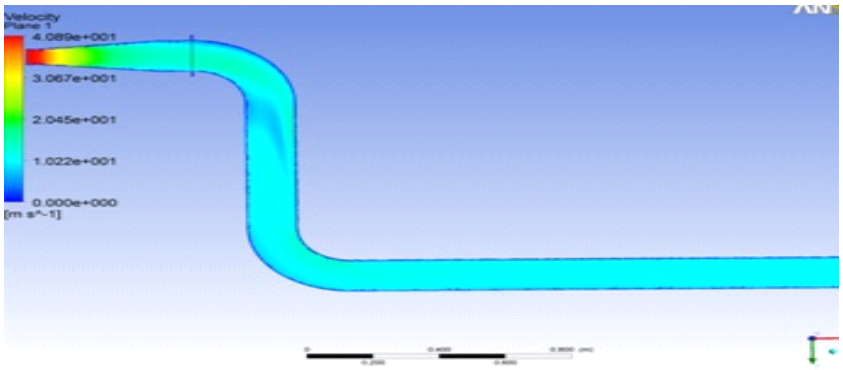


Figure 7 Internal velocity contour of the optimized filling nipple and elbow

5 Conclusion

According to the engineering practice, the structure of the original filling nipple is improved, and the stress of the improved filling nipple was analyzed. The ANSYS software was used to analysis the flow field before and after the improvement of the filling nipple and elbow, the analysis results verified the correctness and feasibility of the structure optimization, providing the theoretical guidance for the noise reduction of the natural gas wellhead.

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