Discussion on operation flexibility of Zhonggui natural gas pipeline

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Abstract. Zhongwei station of West to east natural gas pipeline is connected to the north of Zhonggui line, and Guiyang station of China-Myanmar natural gas pipeline is connected to the south, which has important strategic significance in Southwest China. At present, the tie line mainly carries out gas transmission from Zhongwei to Guiyang. Only some pipeline sections and offload stations have reverse transmission function, while all compressor stations have no reverse transmission and pressurization function. In order to evaluate the flexibility of the operation of the Zhonggui line and give some suggestions for the preliminary reconstruction, this paper uses the SPS software to establish the pipeline model and simulate the specific working conditions, focusing on the two working conditions of the intermediate station injection forward transmission and the whole line reverse transmission. Through the simulation, we can get the following conclusions: 1. When the intermediate station injects forward gas transmission, which compressor station, gas transmission range and joint operation condition with China-Myanmar line need to be started for Zhonggui line; 2. When the whole tie line is reversed, it is necessary to change the location of the compressor station with the function of reverse transmission and pressurization. Through this study, we can give some reference and evaluation opinions on the lack of flexibility of the current tie line, and also give some reference opinions on the specific implementation of the improvement of the tie line operation flexibility in the future.

Keywords: Zhonggui natural gas pipeline; Operation; Flexibility; Judgment; SPS software.

1 Introduction

The total length of Zhonggui line is 1613km, withannualdesignedgas transmission capacity of 15 billion cubicmeters. The line startsfromZhongwei City in Ningxia, passes through six provinces and cities in Ningxia, Gansu, Shaanxi, Sichuan, Chongqing and Guizhou, and ends at Guiyang City in Guizhou[1]. There are 6 compressor stations, 14 gas transmission stations and 73 valve chambers in the pipeline. The pipeline section has poor conditions, complicated terrain and many large drop [2].

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The operation of Zhongwei station as follow [3]: the air intake of Zhongwei station mainlyincludes the west section of west to east first line, west to east second line and west to eastthird line, with a total design gas transmission capacity of about 21 million cubicmeters per day; The gas output of Zhongwei station mainlyincludes the east section of ofwest to east first line, west to east second line and west to eastthird line, the Zhonggui line and the Zhongjing line of west to east second line, with a total design capacity of about 290 million m^3 / d. It canbeseenfrom the data that the air intake of Zhongwei station isobviouslyinsufficient, and once the reverse transmission of Zhonggui line occurs, the inflow and outflow of Zhongwei station willbebasicallybalanced, soitisnecessary to study the reverse transmission of Zhonggui line.

2 Analyze the problem

In view of the aboveproblems, the model of Zhonggui line isestablished by SPS simulation software, and the simulation data are analyzedunderdifferent setting conditions.

2.1 Introduction of SPS software [4-5]

SPS simulation software can simulate single fluid, single-phase mixed fluid or batch fluid. SPS software obtains pipeline information from Inprep text file, including all information of physical components. SPS software can not only simulate the normal operation conditions of most pipelines, but also simulate and control the pipeline accident conditions, such as pipeline fracture, equipment failure, etc. SPS software can calculate the flow, pressure, density, temperature and other parameters along the pipeline, and output them in the form of graph or report.

The simulation function of SPS software can be realized in two forms: control sequence operation or interactive operation (boundary conditions can be changed during operation). The initial state can be zero flow state, stored steady state or user-defined steady state.

2.2 Basic parameters

1) Natural gasquality (Table 1)

Table 1. Composition of simulatednaturalgas.

Composition	C_1	C_2	C_3	iC_4	nC_4	iC_5	CO_2	N_2
Mol%	99.65	0.065	0.03	0.008	0.002	0.015	0.072	0.158

2) The standard state : pressure 1.01325 × 105Pa (absolute pressure), temperature 20 °C.
3) The absoluteequivalentroughness of pipe innerwallis 10μm.

3 Solve the problem

The researchisdividedintotwoworking conditions: one is to takeXiangguosigasstorage as the gas source, close the upstream valve of the injection point, and send the injectedgas to Guiyang station, and thenoperate in combinationwith China Myanmar line; Second, China Myanmar gaswillbeused as the gas source for reverse transmission.

3.1 Xiangguosi gas storage as the gas source[6]

The pressure range of Sichuan and Chongqing regioninjectedintoZhonggui line isfrom 4.5MPa to 5Mpa[7] , the injection point is the Nanbu station or Jiangjin station, and the maximum injection volume is 15 million m^3 / d. There are twocompressor stations in the Nanchong and Zunyi, and the pressure to Guiyang station is set at 6Mpa.

Under lowthroughput (from 3 million to 4 million m^3 / D), the simulation results are shown in Table 2.

Table 2. The simulation results of pressure.

Throughput	The pressure of Nanbu station	The pressure of Zunyi station	The pressure of Guiyang station
300	4.5	4.501	4.083
400	4.5	4.484	3.998
300	5	5.01	4.559
400	5	4.975	4.484

It canbeseenthat Guiyang pressure isalwayslessthan the Nanbu pressure withoutpressurization, sopressurizationisneeded. Zunyi station is far awayfrom the injection point, soitis not economical, soonly Nanchong station pressurizationisfeasible.

The followinganalysisisonlyfor Nanchong station compressoroperationscheme:

3.1.1 When the injection pressure is 4.5MPa

When the injection volume is 8 million m^3 / D, Nanchong station willstartbackflow (about 0.2 million m^3 / D), as shown in Table 3. Considering the safeoperation of the compressor, the compressor of Nanchong station canbestartedabove 9 million m^3 / d.

Table 3. Compressor operating conditions fromNanchong station at 9 million m^3 / d.

station	Entrance pressure	Exit pressure	Number of compressoroperation	power	speed	efficiency
Nanbu	4.5					
Nanhong	4.433	7	1	5166	9945	0.825
Guiyang	6.058					

When the injection volume is 12 million m^3 / D, as shown in Table 4

Table 4. Compressor operating conditions from Nanchong station at 12 million m^3 / d.

station	Entrance pressure	Exit pressure	Number of compressoroperation	power	speed	efficiency
Nanbu	4.5					
Nanhong	4.355	7.5	1	8716	11366	0.86
Guiyang	6.011					

When the injection volume is more than $1200W\times10^4m^3$ / D, the pressure ratio of a single compressoristoo large to guarantee 6Mpa at Guiyang station. Therefore, when the injection pressure is 4.5MPa, the flow range requiredcompressoroperation in Nanchong isfrom 9 million m^3 / D to 12 million m^3 / d.

3.1.2 When the injection pressure is 5 MPa

When the injection volume is 7 million m^3 / D, Nanchong station willstartbackflow (about 0.2 million m^3 / D), as shown in Table 5. Considering the safeoperation of the compressor, the compressor of Nanchong station canbestartedabove 8 million m^3 / d.

Table 5. Compressor operating conditions from Nanchong station at 7 million m^3 / d.

station	Entrance pressure	Exit pressure	Number of compressoroperation	power	speed	efficiency
Nanbu	5					
Nanhong	4.953	6.9	1	334	8338	0.82
Guiyang	6.071					

When the injection volume is 15 million m^3 / D, as shown in Table 6 :

Table 6. Compressor operating conditions from Nanchong station at 15 million m^3 / d.

station	Entrance pressure	Exit pressure	Number of compressoroperation	power	speed	efficiency
Nanbu	5					
Nanhong	4.801	8	1	10147	11399	0.857
Guiyang	6.018					

Therefore, when the injection pressure is 5MPa, the flow range requiredcompressoroperation in Nanchong isfrom 8 million m^3 / d to 15 million m^3 / d.

3.1.3 China-Myanmar line and zhonggui line joint operation[8]

The gas volume from China-Myanmar line is 10 million m3 / D, the pressure is 8 MPa. Zhonggui line injection flow is 10 million m3 / d. Download 2.5 million m^3 / d in Nanning, 0.5 million m^3 / d. in Lufeng, 1 million m^3 / d. in Guigang, surplus in Guangzhou,andmake sure the download pressure is no lessthan 5MPa , as shown in Table 7.

Table 7. The pipeline conditionfrom China-Myanmar line.

station	volume	Entrance pressure	Exit pressure	Number of compressoroperation	power	speed	efficiency
Ruili	+1000		8				
Baoshan		7.218					
Lufeng	-50	6.873					
Guiyang	+1000	6.54	7.7	1	4358	3585	0.787
Hechi	-100	7.2					
Guigang	-250	6.477					
Guangzhou	-1600	5.046					

The conclusions are as follows: 1. Considering the economy and reliability of the operation of the Zhonggui line, itissuggestedthat the injectedgasshouldbebetween 9 million m^3 / D and 13 million m^3 / D, and Nanchong compressor station shouldbeoperated; 2. Guiyang compressor station shouldbeoperatedwhen China-Myanmar line and zhonggui line joint operation.

3.2 China-Myanmar gas as gas source reversed

Guiyang station is the first station when reverse transmission, and set the exit pressure of Guiyang station is 9.8MPa. while the upperlimit of the download pressure at Tongliangis 7.5MPa, and the guaranteed pressure at Zhongwei station is 6MPa. The download volume at Tongliangis 10 million m^3 / d, and the restistransported to Zhongwei station.

According to the above conditions, the output range to Zhongwei station and the compressor station whichneedreform.

The simulation results show that the pressure of Tongliang station islessthan 7.5MPa withoutpressurization at Guiyang-Tongliang section, and transportation capacity of this section should not belessthan 27 million m^3 / d.

3.2.1 The download capacity of Tongliangstaion is 10 million m^3 / d, and that of Zhongwei station is 20 million m^3 / d, as shown in Table 8

Table 8. The downloadcapacityof Tongliang and Zhongwei.

station	volume	Entrance pressure	Exit pressure	Number of compressoroperation	power	speed	efficiency
Guiyang	+3000		9.8				
Tongliang	-1000	6.938					
Nanchong		6.48	9.8	2	12109	9069	0.822
Zhongwei	-2000	5.96					

3.2.2 The download capacity of Tongliangstaion is 10 million m^3 / d, and that of Zhongwei station is 30 million m^3 / d, as shown in Table 9

Table 9. The downloadcapacityof Tongliang and Zhongwei.

station	volume	Entrance pressure	Exit pressure	Number of compressoroperation	power	speed	efficiency
Guiyang	+4000		9.8				
Zunyi		7.673	9.8	2	11635	7479	0.86
Jiangjin		7.39	9.3	2	11895	7902	0.837
Tongliang	-1000	7.438					
Nanchong		6.437	9.5	2	15198	9565	0.863
Guangyuan		7.544	9.8	2	10542	7844	0.859
Tianshui		6.967	9.8	2	13399	8986	0.863
Zhongwei	-3000	6.26					

The conclusions are as follows: 1. In order to makeZhonggui line have the function of whole line reverse transmission, itisnecessary to reform at Nanchong compressor station for reverse transmission of pressurization transformation; 2. If reform at the compressor stations of Zunyi, Jiangjin, Nanchong, Guangyuan and Tianshui, itcanbeguaranteed the reverse transmission capacity 30 million m^3 / d, whichbasicallyensuring the balance of gas flow in and out of Zhongwei station.

4 Conclusion summary

1) Xiangguosigasstorage as the gas source, itissuggestedthat the injectedgasshouldbebetween 9 million m^3 / D and 13 million m^3 / D, and Nanchong and Guiyang compressor station shouldbeoperated.

2) China-Myanmar gas as gas source reversed, In order to makeZhonggui line have the function of whole line reverse transmission, itisnecessary to reform at Nanchong compressor station for reverse transmission of pressurization transformation. If reform at the compressor stations of Zunyi, Jiangjin, Nanchong, Guangyuan and Tianshui, itcanbeguaranteed the reverse transmission capacity 30 million m^3 / d, whichbasicallyensuring the balance of gas flow in and out of Zhongwei station.

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