

# 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, with annual designed gas transmission capacity of 15 billion cubic meters. The line starts from Zhongwei 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 drops [2].

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The operation of Zhongwei station as follow [3]: the air intake of Zhongwei station mainly includes the west section of west to east first line, west to east second line and west to east third line, with a total design gas transmission capacity of about 21 million cubic meters per day; The gas output of Zhongwei station mainly includes the east section of of west to east first line, west to east second line and west to east third 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 can be seen from the data that the air intake of Zhongwei station is obviously insufficient, and once the reverse transmission of Zhonggui line occurs, the inflow and outflow of Zhongwei station will be basically balanced, so it is necessary to study the reverse transmission of Zhonggui line.

## 2 Analyze the problem

In view of the above problems, the model of Zhonggui line is established by SPS simulation software, and the simulation data are analyzed under different 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 gas quality (Table 1)

**Table 1.** Composition of simulated natural gas.

Composition	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	iC <sub>4</sub>	nC <sub>4</sub>	iC <sub>5</sub>	CO <sub>2</sub>	N <sub>2</sub>
Mol%	99.65	0.065	0.03	0.008	0.002	0.015	0.072	0.158

2) The standard state : pressure  $1.01325 \times 10^5 Pa$  (absolute pressure), temperature  $20 ^\circ C$ .

3) The absolute equivalent roughness of pipe inner wall is  $10 \mu m$ .

## 3 Solve the problem

The research is divided into two working conditions: one is to take Xiangguo gas storage as the gas source, close the upstream valve of the injection point, and send the injected gas to Guiyang station, and then operate in combination with China Myanmar line; Second, China Myanmar gas will be used as the gas source for reverse transmission.

### 3.1 Xiangguosi gas storage as the gas source[6]

The pressure range of Sichuan and Chongqing region injected into Zhonggui line is from 4.5MPa to 5MPa [7], the injection point is the Nanbu station or Jiangjin station, and the maximum injection volume is 15 million m<sup>3</sup> / d. There are two compressor stations in the Nanchong and Zunyi, and the pressure to Guiyang station is set at 6MPa.

Under low throughput (from 3 million to 4 million m<sup>3</sup> / 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 can be seen that Guiyang pressure is always less than the Nanbu pressure without pressurization, so pressurization is needed. Zunyi station is far away from the injection point, so it is not economical, so only Nanchong station pressurization is feasible.

The following analysis is only for Nanchong station compressor operation scheme:

#### 3.1.1 When the injection pressure is 4.5MPa

When the injection volume is 8 million m<sup>3</sup> / D, Nanchong station will start backflow (about 0.2 million m<sup>3</sup> / D), as shown in Table 3. Considering the safe operation of the compressor, the compressor of Nanchong station can be started above 9 million m<sup>3</sup> / d.

**Table 3.** Compressor operating conditions from Nanchong station at 9 million m<sup>3</sup> / d.

station	Entrance pressure	Exit pressure	Number of compressor operation	power	speed	efficiency
Nanbu	4.5					
Nanhong	4.433	7	1	5166	9945	0.825
Guizhou	6.058					

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

**Table 4.** Compressor operating conditions from Nanchong station at 12 million m<sup>3</sup> / d.

station	Entrance pressure	Exit pressure	Number of compressor operation	power	speed	efficiency
Nanbu	4.5					
Nanhong	4.355	7.5	1	8716	11366	0.86
Guizhou	6.011					

When the injection volume is more than 1200W×10<sup>4</sup>m<sup>3</sup> / D, the pressure ratio of a single compressor is too large to guarantee 6MPa at Guiyang station. Therefore, when the injection pressure is 4.5MPa, the flow range required compressor operation in Nanchong is from 9 million m<sup>3</sup> / D to 12 million m<sup>3</sup> / d.

#### 3.1.2 When the injection pressure is 5 MPa

When the injection volume is 7 million m<sup>3</sup> / D, Nanchong station will start backflow (about 0.2 million m<sup>3</sup> / D), as shown in Table 5. Considering the safe operation of the compressor, the compressor of Nanchong station can be started above 8 million m<sup>3</sup> / d.

**Table 5.** Compressor operating conditions from Nanchong station at 7 million m<sup>3</sup> / d.

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

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

**Table 6.** Compressor operating conditions from Nanchong station at 15 million m<sup>3</sup> / d.

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

Therefore, when the injection pressure is 5MPa, the flow range required compressor operation in Nanchong is from 8 million m<sup>3</sup> / d to 15 million m<sup>3</sup> / d.

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

The gas volume from China-Myanmar line is 10 million m<sup>3</sup> / D, the pressure is 8 MPa. Zhonggui line injection flow is 10 million m<sup>3</sup> / d. Download 2.5 million m<sup>3</sup> / d in Nanning, 0.5 million m<sup>3</sup> / d. in Lufeng, 1 million m<sup>3</sup> / d. in Guigang, surplus in Guangzhou, and make sure the download pressure is no less than 5MPa , as shown in Table 7.

**Table 7.** The pipeline condition from 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					
Guizhou	+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, it is suggested that the injected gas should be between 9 million m<sup>3</sup> / D and 13 million m<sup>3</sup> / D, and Nanchong compressor station should be operated; 2. Guiyang compressor station should be operated when China-Myanmar line and zhonggui line joint operation.

### 3.2 China-Myanmar gas as gas source reversed

Guizhou station is the first station when reverse transmission, and set the exit pressure of Guizhou station is 9.8MPa. while the upper limit of the download pressure at Tongliang is 7.5MPa, and the guaranteed pressure at Zhongwei station is 6MPa. The download volume at Tongliang is 10 million m<sup>3</sup> / d, and the rest is transported to Zhongwei station.

According to the above conditions, the output range to Zhongwei station and the compressor station which need reform.

The simulation results show that the pressure of Tongliang station is less than 7.5MPa without pressurization at Guizhou-Tongliang section, and transportation capacity of this section should not be less than 27 million m<sup>3</sup> / d.

**3.2.1 The download capacity of Tongliangstaion is 10 million m<sup>3</sup> / d, and that of Zhongwei station is 20 million m<sup>3</sup> / 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
Guizhou	+3000		9.8				
Tongliang	-1000	6.938					
Nanchong		6.48	9.8	2			
Zhongwei	-2000	5.96			12109	9069	0.822

**3.2.2 The download capacity of Tongliangstaion is 10 million m<sup>3</sup> / d, and that of Zhongwei station is 30 million m<sup>3</sup> / 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
Guizhou	+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<sup>3</sup> / 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<sup>3</sup> / D and 13 million m<sup>3</sup> / 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<sup>3</sup> / d, whichbasicallyensuring the balance of gas flow in and out of Zhongwei station.

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