ISSN: 2414-1895 DOI: 10.6919/ICJE.201908_5(9).0046

Study on Operation Optimization of TEG Dehydration System in WS Gas Field

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Abstract

According to the deviation caused by the external factors such as gas field production and sales situation in the gas field in the WS gas field, and the problem that the dehydration equipment is not up to standard and energy consumption during the design conditions, the HYSYS model is established. The optimization study on the operation of the TEG dehydration system in the WS gas field. The results show that the temperature and pressure of natural gas are sensitive fluctuation factors affecting the dehydration effect, but the regulation of TEG circulation is the basic means to control the water dew point. Under different temperature conditions in spring, autumn, summer and winter, different blocks in the WS gas field, The pressure level of TEG should be adjusted to the corresponding level in different pressure level areas to make the water dew point reach the standard.

Keywords

Natural gas; TEG dehydration; Water dew point; HYSYS; Optimization.

1. Introduction

After the natural gas is produced from the wellhead, it needs to be treated after dehydration to enter the long-distance pipeline[1-4]. Natural gas dehydration method can be divided into: 1) low temperature separation method 2) solvent absorption method 3) solid adsorption method 4) membrane separation method 5) supersonic separation method, etc[5-6]. At present, solvent absorption based on triethylene glycol solvent is the most widely used in actual dehydration compared to other methods[7].

The gas source pressure in the WS gas field is low, no pressure difference is available, and the dehydration process such as throttling refrigeration, low temperature method and membrane separation method is excluded. Combined with the dehydration depth requirement, there are eight dehydration stations in the planned nine dewatering stations. However, with the changes in production conditions, sales situation, and the deviation of dehydration engineering construction, the processing load of some TEG dehydration equipment in the gas field is expected to decrease, and the dehydration temperament is not up to standard and the operation schedule occurs under the design conditions. In order to improve the overall dewatering effect of the dewatering station and to form a scheduling operation plan under the deviation condition, the author determines the key influencing factors of the TEG dehydration system and optimizes the dehydration of TEG through theoretical analysis and HYSYS software simulation, combined with the actual operation of the WS gas field.

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2. A brief to TEG dehydration process

TEG dehydration is a physical process that utilizes the strong water absorption of TEG to absorb the moisture in natural gas, thereby reducing the dew point of the aqueous natural gas, thereby achieving the conditions of external transportation. The TEG which absorbs the water becomes a rich liquid, and the rich liquid enters the reboiler to evaporate the water under normal pressure and high temperature conditions to complete the cycle regeneration, and the process flow is shown, see Fig.1.

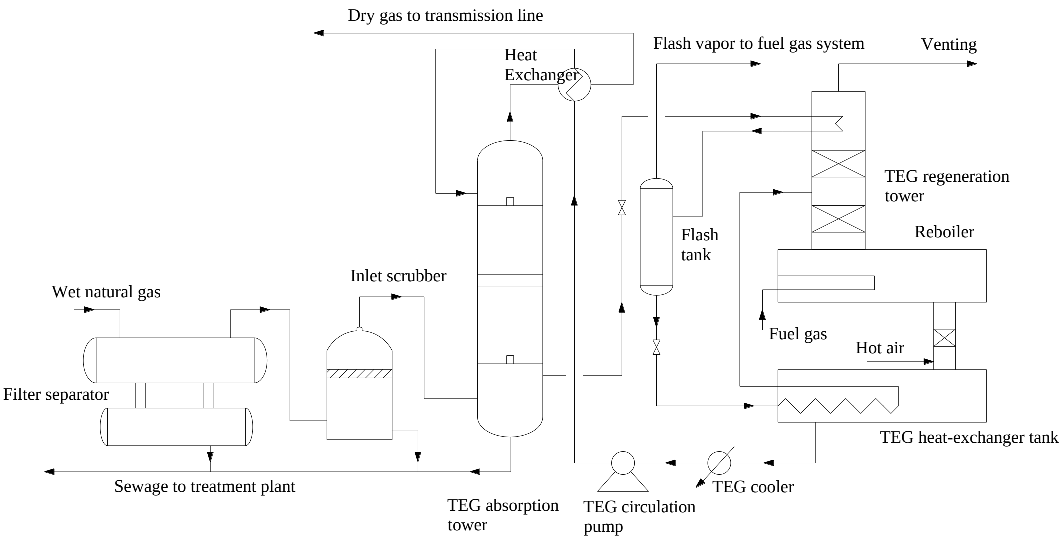

Fig.1 TEG dehydration process flow chart

3. Dewatering planning and deviation analysis of WS gas field

The WS Gas Field plans to construct 9 dehydration stations, including CX246, X21, X301, CX156, L2, CM600, MP53, QBJ, and YJ. In addition to the molecular sieve dehydration process at CX 246 Station The remaining stations use a TEG dehydration process. The dewatering treatment scale of the gas field is 6.8 million square meters per day, and the total dehydration by the TEG process is 6 million cubic meters per day. However, due to changes in gas production and market conditions, the dehydration station's inlet pressure, temperature, natural gas dehydration treatment and other parameters are deviated from the design conditions during normal operation. The details are shown in Tab.1 (CX 246 station is not included), see Table.1.

Tab.1 Dehydration planning and operating parameter deviation of TEG process

Block	Dehydration station	Intake pressure/MPa		Intake temperature/°C		Capacity/ ×104m3/d	
		planning	actual	planning	actual	planning	actual
XC-XQ	X21	2.3-3.5	1.7-2.1	Summer: 30-40 Winter: 25-35	10-30	150	28
	X301	2.2-3.5	1.8-2.2	25-40	10-30	50	17
	CX156	2.2-3.5	1.7-2.1	25-40	10-30	80	33
	L2	1.6-2.3		15-20	10-30	20	11
MJ-SF	CM600	2.2-3.5	1.3-2.0	25-40	10-30	50	15
	MP53	2.2-3.5	1.3-2.1	25-40	35-45	80	29
	QBJ	1.1-1.5	1.4-1.46	25-40	10-30	70	47

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ZJ-GM	YJ	2.2-3.5	1.65-2.3	25-40	10-30	100	80
Total	——	——	——	——	——	600	260

It can be seen that the operating conditions of the dewatering system in the WS gas field are quite different from those in the design working conditions. The main performances are as follows: 1) The inlet pressure of the dehydration tank is not included in the design range of the QBJ dewatering station, and the inlet pressure of the other stations is lower than the design pressure. 0.5-1.5MPa; 2) In winter, the dehydration enthalpy intake temperature is lower than the design temperature by about 5-20℃; 3) natural gas dehydration treatment is lower than the planned treatment. Due to the deviation of the above three aspects, the temperament is not up to standard after dehydration. Therefore, it is necessary to form a new operating parameter and scheduling scheme for the TEG dehydration system in the WS gas field for the new operating conditions, improving the quality of the external gas transmission, and saving operating costs.

4. Analysis of key influencing factors of TEG dehydration

The dehydration effect of TEG is mainly reflected by the dew point value of natural gas after dehydration. Through theoretical analysis, combined with the literature, the factors affecting the absorption dehydration process are intake flow rate, intake air temperature, intake pressure, TEG circulation, TEG temperature, and TEG concentration. In actual operation, the water dew point often does not completely conform to the theoretical curve with the above parameters.

Based on the various operating parameters of the TEG dehydration system in the WS gas field, the HYSYS software was used to simulate and change the individual influence parameters within the technical scope, and the relationship between the change trend and the degree of influence of the water dew point value was obtained.

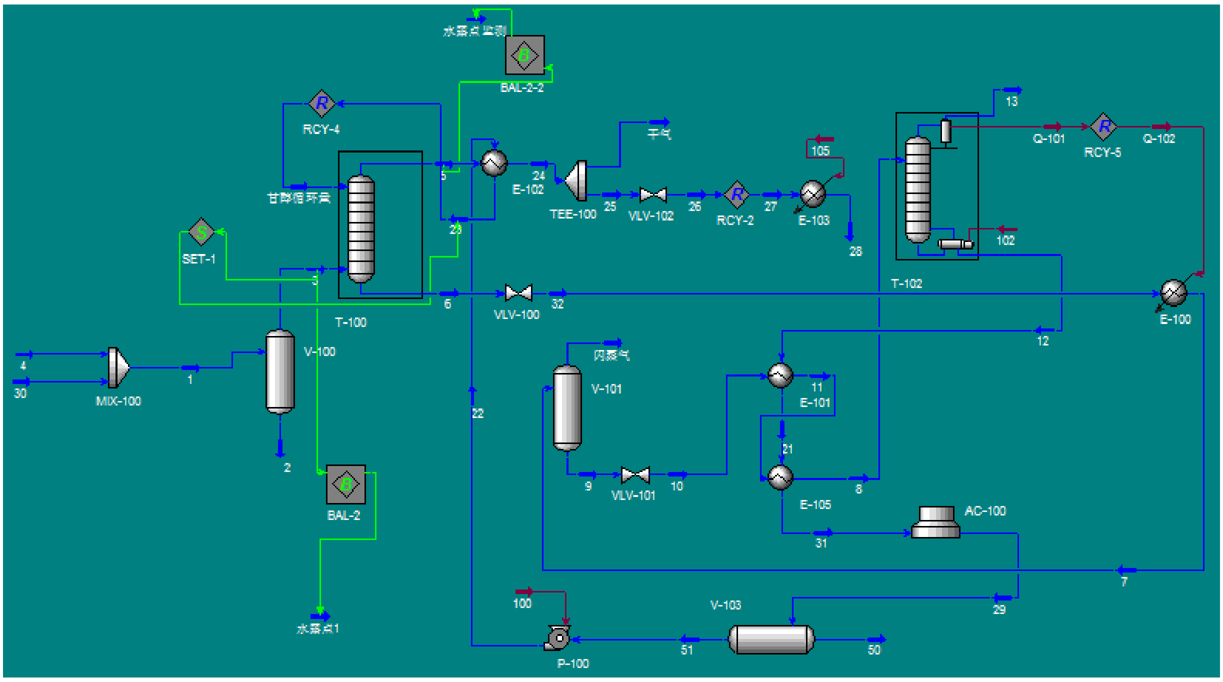

Fig.2 Model of HYSYS

4.1 Intake flow

For the actual working conditions of the dehydration stations in the WS gas field, the current treatment gas volume technology can be adjusted from 0 to 800 kgmol/h (about 0 to $40\times10^4 m^3/d$). After HYSYS simulation, it is found that the water dew point value varies from -6.44 to -3.60℃. It can be seen that

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within the technically adjustable range, the larger the natural gas treatment volume, the higher the dew point value of the natural gas after adsorption treatment, and the worse the dehydration effect is.

4.2 Intake temperature

The current allowable natural gas temperature range is 0-40 ° C. After HYSYS simulation, the water dew point range is from 18.71 to 14.45℃. It can be found from Fig. 3b that the higher the temperature of the natural gas, the larger the dew point value after dehydration and the worse the dewatering effect.

4.3 Intake pressure

At present, the intake pressure technology of the WS gas field dehydration station can be adjusted from 0.8MPa to 3.6MPa. After HYSYS simulation, the water dew point value varies from -0.72 to -6.13℃. It can be seen from Fig. 3c that the higher the pressure of the natural gas entering the dehydration absorption tower, the lower the dew point value of the natural gas water after the absorption and dehydration treatment, and the better the dehydration effect.

4.4 TEG circulation

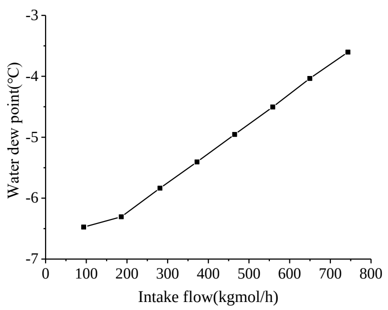
According to the nameplate information of the dehydration equipment used in the WS gas field, the technical specifications recommend that the TEG circulation amount is 0.5-3.5 m^3/h. After HYSYS simulation, the water dew point fluctuated between -2.29 and -6.45℃. As can be seen from Fig. 3d, the larger the amount of glycol circulation, the lower the water dew point value, and the better the dehydration effect. The effect of TEG circulation is most obvious between 0.5 and 2.5 m^3/h, but as the circulation increases, the effect on the water dew point will become smaller and smaller.

4.5 TEG temperature

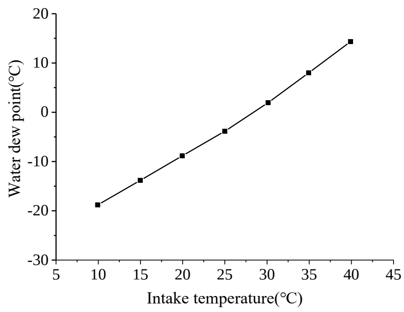
According to the nameplate information of the dehydration equipment used in the WS gas field, the technical specifications recommend that the working temperature of TEG is 25℃ ~ 50℃. After HYSYS simulation, the water dew point value is basically no fluctuation, indicating that the TEG temperature has no effect on the dewatering effect, as shown in Fig.3e.

4.6 TEG concentration

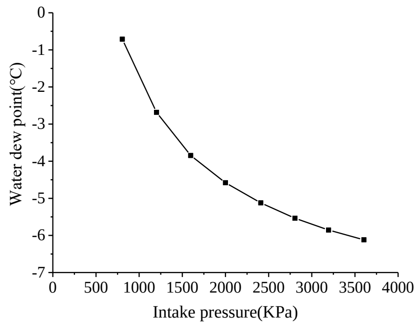
According to the nameplate information of the dehydration equipment used in the WS gas field, the technical specifications recommend a concentration of TEG of 98.9% to 99.9% (mass fraction). After HYSYS simulation, the water dew point ranged from -3.40 to -8.91℃. It can be seen from Fig. 3f that the higher the TEG mass fraction, the lower the water dew point value, indicating that the dehydration effect is better.



a) Intake flow

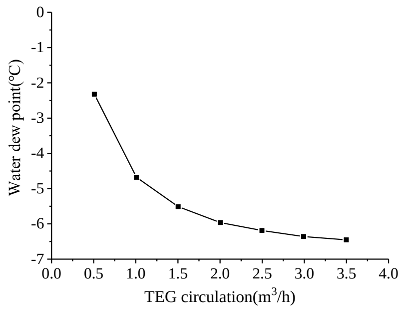


b) Intake temperature

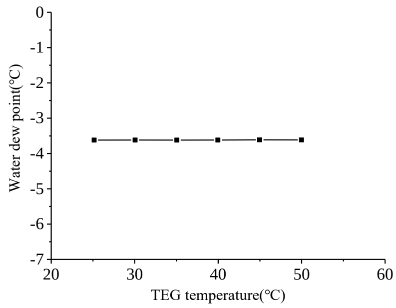


c) Intake pressure

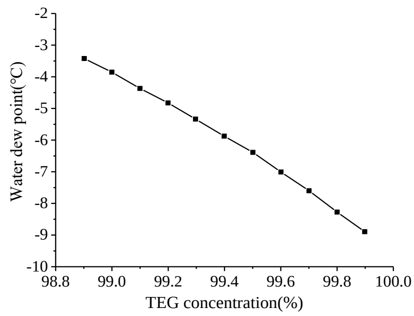
ISSN: 2414-1895 DOI: 10.6919/ICJE.201908_5(9).0046



d）TEG circulation



e）TEG temperature



f）TEG concentration

Fig.3 Univariate analysis simulation results

From the above analysis, the natural gas temperature has the greatest influence on the dehydration effect during the absorption process, followed by the TEG concentration (mass fraction), the TEG cycle and the natural gas pressure, the natural gas treatment volume and the TEG temperature.

According to the analysis results, although the influence of natural gas temperature is the most sensitive, the natural gas temperature is close to the ground temperature, and there is no temperature regulating equipment in the dewatering equipment. Temperature control in the field operation is not the most effective adjustment method; similarly, the natural gas pressure management network The pressure changes fluctuate and it is difficult to control stably. Therefore, the parameters determining the effect of the TEG dehydration system in the WS gas field should be determined as the amount of TEG and the concentration of TEG. See Table. 2 for details.

Table.2 The degree of influence of the main parameters on the water dew point

Parameter	Effect	Feasibility	Priority
TEG circulation	sensitive	simple	1
TEG concentration	sensitive	relatively complex	2
TEG temperature	insensitive	simple	——
Intake temperature	sensitive	unadjustable	——
Intake pressure	relatively sensitive	unadjustable	——
Processing capacity	relatively sensitive	unadjustable	——

5. Optimization of operating parameters of TEG dehydration system

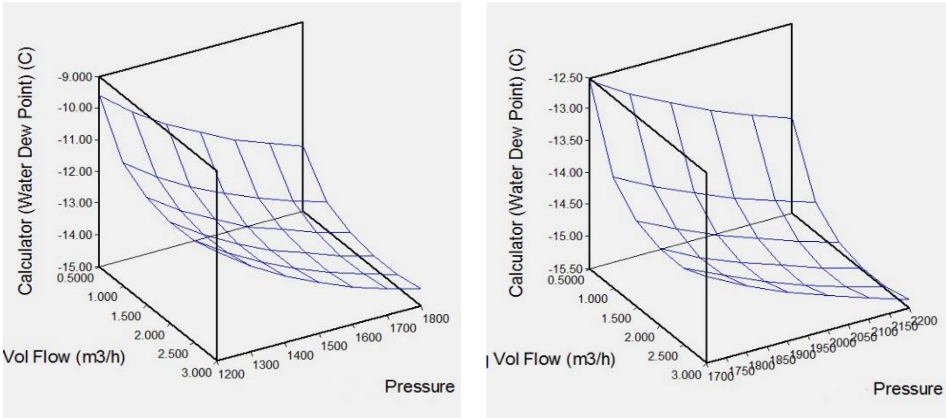
According to the above analysis, it can be seen that the parameters affecting the effect of the TEG dehydration system in the WS gas field should be the amount of TEG and the concentration of TEG, and the concentration of TEG is mainly from the reboiling temperature, the reboiling pressure, the distillation column temperature, The stripping gas control is more complicated than the circulation amount adjustment. Considering the convenience of actual operation on site, in order to effectively guide the economical and efficient operation of dewatering equipment, this section only optimizes the circulation of TEG dehydration system under different seasons and different pressures.

5.1 Spring and autumn conditions

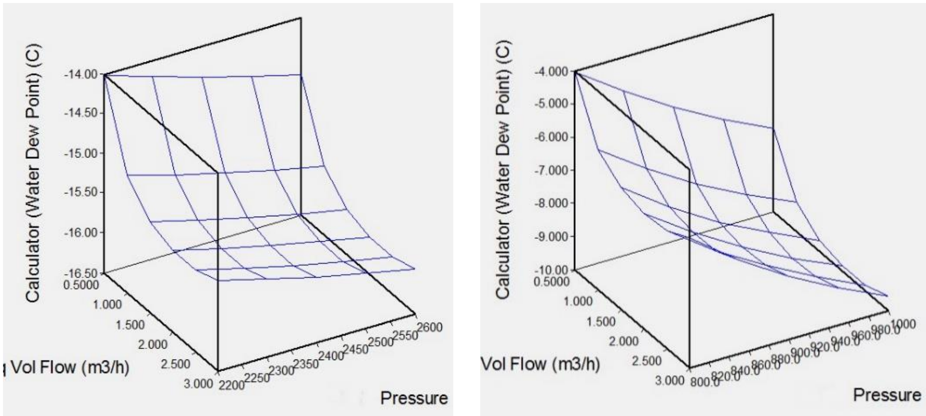
At present, there are both low-pressure and medium-pressure areas in the XC-XQ block of the WS gas field. The two blocks of MJ-SF and ZJ-GM are medium-pressure areas. In the spring and autumn working conditions, the intake pressure of the XC-XQ medium pressure area is 1.7-2.2MPa, the inlet pressure of MJ-SF is 1.2-1.8MPa, and the inlet pressure of ZJ- GM is 2.2-2.6MPa. The inlet pressure of the low-pressure zone is 0.8-1.0Mpa, the natural gas temperature in spring and autumn is 15-20℃, and the natural gas processing range is 10-100×$10^4$$m^3$/d.

ISSN: 2414-1895 DOI: 10.6919/ICJE.201908_5(9).0046

According to the above analysis, temperature is the main controlling factor affecting the water dew point. In the fluctuation range, the influence of high temperature should be mainly considered. Therefore, the high value (up to 20℃ in spring and autumn) is taken as the simulation parameter. The same HYSYS dehydration model as in Fig. 2 was established. Under different conditions, the optimal circulation amount was calculated by the influence of pressure fluctuation and TEG circulation on the water dew point value.



a）XC-XQ block medium pressure area　　b）MJ-SF block



c）ZJ-GM Block　　d）XC-XQ block low pressure area

Fig.4 Simulation of operating parameters in spring and autumn

It can be seen that under the spring and autumn conditions, if the water dew point is to be kept at -10℃, the amount of TEG should be set in the medium pressure area of the XC-XQ block, the MJ-SF block, and the ZJ-GM block. It is about 0.5m^3/h, and the circulation of TEG should be set at 2.0m^3/h in the low pressure area of XC-XQ block.

5.2 Summer condition

According to the statistical data, the summer temperature is higher than that in spring and autumn, generally 20 to 30 ° C, and the other parameters are the same. The HYSYS modeling process and analysis method are the same as above. The simulation results are shown in Table.3.

Table.3 Summer operating parameter optimization

Intake pressure（MPa）	Processing capacity（104m3/d）	TEG circulation（m3/h）	Block
0.8～1.0	10	2.5	XC-XQ district low
	20	2.5	
	30	2.5	

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	40	3	pressure area
	50	3	
	60	3	
	70	3	
	80	3	
	90	3	
	100	3	
1.2～1.8	10	1	MJ-SF block
	20	1.2	
	30	1.2	
	40	1.5	
	50	1.5	
	60	1.5	
	70	1.5	
	80	1.5	
	90	1.5	
	100	1.5	

5.3 Winter condition

According to the statistical data, the winter temperature is lower than that in spring and autumn, generally around 10℃, and the flow rate varies from 10 to $80\times10^4 m^3/d$. The remaining parameters and analytical methods are consistent with the above. The simulation results are shown in Table. 4.

Table.4 Winter working condition parameter optimization

Intake pressure （MPa）	Processing capacity （104m3/d）	TEG circulation （m3/h）	Block
0.8～2.6	10	0.5	All
	20	0.5	
	30	0.5	
	40	0.5	
	50	0.5	
	60	0.5	
	70	0.5	
	80	0.5	
	90	0.5	
	100	0.5	

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5.4 Analysis and discussion of results

(1) It can be seen from Fig.4 that under the moderate temperature conditions in spring and autumn, with the increase of natural gas treatment volume, it is necessary to ensure that the water dew point reaches -10℃, and the low pressure production area needs to increase the glycol circulation amount, while the medium pressure production area. Only the higher pressure of the self is enough to achieve the dehydration effect, without increasing the amount of glycol circulation. This is because the intake pressure in the lower pressure region of the medium pressure region is high, which can reduce the natural gas water dew point after dehydration.

(2) It can be seen from Table.3 that under the condition of high temperature in summer, with the increase of natural gas treatment volume, it is necessary to ensure that the water dew point reaches -10℃, and the amount of TEG should be adjusted in both medium and low pressure areas. The amount of TEG treated in the low pressure region is greater than that in the medium pressure region. This is because the intake air temperature is high, and the water dew point after the natural gas is dehydrated is greatly increased. The increase of the pressure alone is not enough to lower the water dew point, and it is necessary to increase the amount of TEG.

(3) It can be seen from Table.4 that under the condition of low temperature in winter, with the increase of natural gas treatment volume, it is necessary to ensure that the water dew point reaches -10℃, no need to adjust the TEG cycle in medium or low pressure areas. This is because the intake air temperature is lower, and the water dew point after the dehydration of the natural gas is lowered compared with the spring, autumn and summer, so the temperament is satisfied for the standard.

6. Conclusions and suggestions

After the above analysis and research, combined with the current situation of the WS gas field and the existing TEG dehydration equipment operation tracking and simulation debugging experience, the following conclusions and recommendations can be obtained.

(1) During the operation of the TEG dehydration unit in the WS gas field, the temperature and pressure of natural gas are sensitive fluctuation factors affecting the dehydration effect, but adjusting the TEG circulation amount is the basic mean to control the water dew point.

(2) During spring and autumn production, the amount of TEG in the medium-pressure region of the WS gas field can be adjusted down to $0.5m^3/h$. In low-pressure areas, it should be controlled at 1.0 m^3/h.

(3) During summer production, the amount of TEG in the XC-XQ area and ZJ-GM block can be adjusted down to $1.0m^3/h$. In the medium-pressure area, the MJ-SF block can be adjusted down to $1.5m^3/h$.

(4) During winter production, the amount of TEG in all areas of the WS gas field can be adjusted down to 0.5 m^3/h.

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