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JUSTIFICATION FOR USE OF ENERGETIC SEPARATORS FOR GAS DISTRIBUTIVE STATIONS

This paper shows the efficiency of energetic separators for gas distributive stations and ustified the necessity of replacing existing types of heaters by gas energetic separators.

Key words: gas distributive station, natural gas, gas preheater, energetic separator.

Показано ефективність роботи енергетичних роздільників на газорозподільних станціях та обґрунтовано необхідність заміни існуючих типів підігрівників газу на енергетичні роздільники.

Ключові слова: газорозподільна станція, природний газ, підігрівники газу, енергетичний роздільник.

Introduction

The energy resources saving, including natural gas, is a priority, which the government of Ukraine puts before to all sectors of the economy.

Significant reserves for gas savings are at the transportation of natural gas, including gas distribution stations (GDS). To prevent the formation of hydrates that formed during the lowering the pressure at GDS, natural gas is heated in the preheater different types, which differ according to the type of heat carrier and a heat transfer surfaces [1]. However, they all have drawbacks: their work is related to additional consumption of fuel gas, they have great size and weight and, therefore, require high capital and operating costs, and some of them are dangerous to use.

Today the Ukrainian gas transportation system uses preheater types:

- preheaters of direct heating – PGA-1, PGA-1/3, PGA-2, PGA-3, PGA-5, PGA-10, PGA-20, PGA-15, PGA-100, PGA-200, PGTA-200, PGTA -375, PGTA -1000, PGTA -1600;
- preheaters with intercooler heat carrier – PG-10, PG-30, PTPG-5, PTPG-10, PTPG-15, PTPG-30, PNG-025, PNG-050, PNG-100, PGTT, BPG.

Most of the Ukrainian GDS were built in the 60's – early 80's. That is why today equipments of GDS, including gas preheaters, have a large degree of depreciation, they are physically and morally outdated. Approximately 84% of preheaters have term of exploitation more than 10 years, 40% preheaters been used for over 20 years, 20% exploitated for more than 30 years.

The aim of the study

is a justification of perspective replacement of existing types of preheaters on energetic separator in the gas distributive stations, thus you can achieve significant savings in natural gas and material costs.

Today, the actual productivity of the GDS, much less than the project productivity (only in 2012 reducing of receipts of gas to the gas transport system of Ukraine compared to 2011 amounts to 13% [2]). Arguably, the thermal capacity installed preheaters exceed the real needs of GDS. As a result – 75% preheaters operate with a load of less than 50%, 51% – with a load of less than 30%, 15% – with a load of less than 10%. In this regard preheaters operate in modes that are 8-10 times lower than the project values what a negatively impact on efficiency of their work (there are significant formation of condensate, unreliable burners operation, malfunction of automation systems). Projecting and operating organizations are forced to use the mixing method at the preheating gas. This method is based on heating part of the natural gas to a high temperature (to preheater working in nominal conditions), after which a hot gas is mixed with the cold in such a ratio that the mixture had a temperature that would prevent hydrate formation. [3]

The average temperature of the gas at the outlet of GDS 2-3oC higher than normative is an another factor of overrun of natural gas. Management systems that are used today have a number of shortcomings that prevent fully solve the problem of maintaining the temperature of the gas at the outlet of GDS within the prescribed limits. First, the preheaters haven't smooth regulation mode of combustion that may not accurately maintain the required temperature of the gas at the outlet GDS. Second, the use of two or more heaters in pipes GDS don't takes into account their mutual influence on the general thermal regime. Used control units don't have control systems of top-level that could provide cascade control preheater and make choices of optimal regime combustion for each of them [4].

Thermal productivity of preheaters decreases as due to the formation of deposits on heat transfer surfaces of the preheater and due to the deterioration quality of the heat carrier, which is lowering its thermalphysical properties, primarily in reducing the heat capacity [5].

To date, there are no official figures on the number of natural gas, that is burned at GDS "Ukrtransgas", but the value of gas consumption by industrial and technological needs is given [6]. The main consumers of gas to industrial and technological needs are the installations of compressor stations, preheaters of natural gas at GDS and systems heat supply, gas supply and ventilation of the manufacturing and administrative facilities. The main component of these costs is a natural gas of compressor units, its flow rate is about 2% of the volume of gas delivered to the gas transmission system.

Table 1

Gas consumption in the industrial and technological needs "Ukrtransgas" in 2011 and 2012 [22]

Consumption of natural gas	12 months in 2011, million m^3	12 months in 2012, million m^3
Revenues to the gas transmission system	155124,2	134590,1
Industrial and technological needs, including	3357,8	2107,8
– fuel gas	2594,4	1682,4
– other costs of operation of the GTS	288,4	257,0
– "unbalancing"	475,0	168,4

The specific data on the consumption of fuel gas at GDS is not given. Therefore, to assess the this value we used value of specific gas consumption for the most common types of gas heaters (consumption fuel gas for $1m^3$ throttling gas), Table 2.

If the average value of the specific gas consumption for heating is 3.3 10-3 nm3/m3 and the amount of gas supplied to consumers in Ukraine amounts to 36.3% gas, then consumption gas for heating reached 185.8 million m3 in 2011 and will reach 161.2 million m3 in 2013. This is a very large overhead of gas, which in monetary terms can be estimated 681,855 thous. grn. /year, and therefore a significant decrease in consumption of fuel gas at GDS is feasible both technically and economically.

The preheating of natural gas in the energetic separator is most advanced and cost effective method of heating natural gas before the throttling at GDS. [7] This method allows you to heat the gas without using any kind of extra energy (including electricity) and moving parts. In addition, energetic separator allow you to offload pressure regulator gas during the heating season.

The energetic separator works as follows. [8] Compressed gas is supplied through a tangential nozzle channel to the pipe where installed an intense circular motion. The non-uniform temperature field arises. Layers of gas near the axis are colder than inlet gas and peripheral layers of swirling flow are heating. This phenomenon is called the effect of Ranque. Part of a cold gas stream is discharged through the diaphragm, the heated gas is discharged through the throttle valve in the other part of tube. With the gradual closing of the throttle overall pressure is increases in energetic separator and consumption of cold flow through the aperture increases with a corresponding decrease in consumption of hot flow. The temperatures of the cold and heated flows are also changing.

Table 2

Specifications of the most common gas heaters.

The type of equipment	Brand of equipment	Productivity of heater nm3/hour		Gas consumption for heating, nm^3/hour	Specific gas consumption for heating, nm^3/m^3	The note
		The maximum	The nominal			
The preheaters of direct heating	PGA-200		10000	33	$3{,}3 \cdot 10^{-3}$	Fakel
	PGA -100		3000	13	$4{,}33 \cdot 10^{-3}$	Fakel
	PGA -1		10000	30	$3{,}0 \cdot 10^{-3}$	Fakel
The preheaters with intercooler heat carrier	PGPT-SN-5		5000	19	$3{,}8 \cdot 10^{-3}$	S and N – gas
	PGPT-SN -10		10000	30	$3{,}0 \cdot 10^{-3}$	S and N – gas
	PGPT-SN -30		30000	110	$3{,}6 \cdot 10^{-3}$	S and N – gas
	PGPT-SN -100		1000	315	$3{,}15 \cdot 10^{-3}$	S and N – gas
	GPM-PGPT-5		5000	22	$4{,}4 \cdot 10^{-3}$	Gazprommash
	Mark 5	5000		12	$2{,}4 \cdot 10^{-3}$	
	Mark 10	10000		24	$2{,}4 \cdot 10^{-3}$	
	Mark 30	30000		66	$2{,}2 \cdot 10^{-3}$	Fakel
	Fakel- PG-5		5000	12,3	$2{,}5 \cdot 10^{-3}$	Fakel
	PG-10		10000	41	$4{,}1 \cdot 10^{-3}$	
Block GDS	«Energia-3»	6000	3500	12	$3{,}4 \cdot 10^{-3}$	
	«Energia -1»	40000	25000	115	$4{,}6 \cdot 10^{-3}$	

The energetic separator with optimal sizes was manufactured and was installed on the existing gas distribution station using a patented scheme [9]. Simplified schematic diagram of GDS with energetic separator at technological part and additional lines of warm flow with regulating crane is shown in Fig. 1.

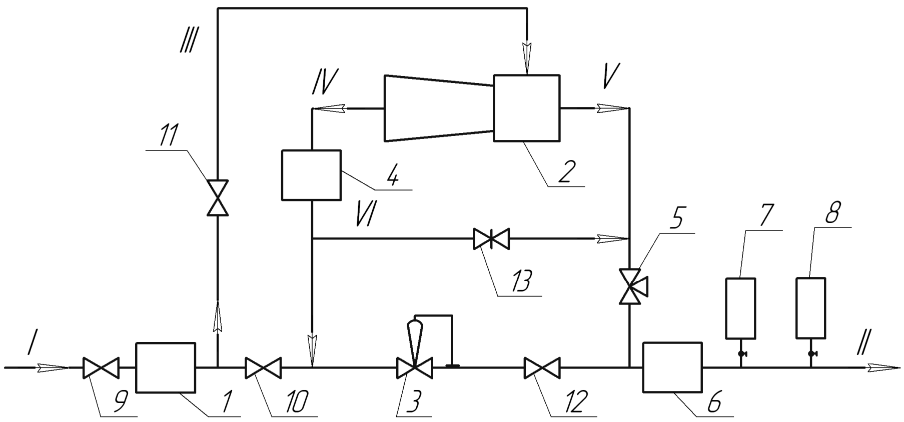

Fig. 1. Scheme of technological part gas distribution station with energetic separator and an additional line of heat flow: I – the main gas pipeline, II – the distribution pipeline, III – input gas pipeline, IV – gas pipeline of warm flow, V – gas pipeline of cold flow, VI – additional line of warm flow. 1 – cleaning unit, 2 – energetic separator, 3 – gas pressure regulator, 4 – separator 5 – avert-stop valve, 6 – block of measurement of gas flow, 7 – odorizer, 8 – device for feeding methanol, 9,10,11,12 – cranes, 13 – regulating crane.

Gas distribution station operates as follows. Gas from the gas main pipeline I with pressure 7.5-3MPa after cleaning unit 1 and valves 9 and 10 enters to the gas pressure regulator 3. The decrease in pressure to 1.2 – 0.1 MPa and its automatic maintenance constant regardless of productivity the takes place in regulator 3. Then through valve 12 after determining the quantity of gas in unit 6, through odorizer 7 and device for feeding methanol 8 gas enters to the distribution gas pipeline II.

With increasing consumption of gas during the heating season and at high pressure drop across the regulator there is a risk of icing pressure regulator. To prevent this, energetic separator 2 is turn on, valve 10 closed and valve 11 opened. The entire flow of gas from the main gas pipeline I through input gas pipeline III is sent to the power divider 2. Thermal separation of compressed input stream of natural gas into two: warm and cold takes place in the energetic separator.

The heated gas flow through the pipeline of warm gas IV enters the separator 4, where a branch of mechanical impurities and condensate takes place. After the separator gas comes to input gas pressure regulator 3, and then to the distribution gas pipeline II. Lowering pressure of warm and drained gas occurs without the formation of hydrates, which is the main purpose of establishing of energetic separator at gas distribution stations. Cold flow through gas pipeline of cold gas V, through avert-stop valve 5 enters to the distribution gas pipeline II.

The temperature of the natural gas before the pressure regulator must be 5-7 oC above the dew point temperature for prevention the formation of hydrates, namely:

$$t_{reg} = t_{cr} + (5-7)^{o}C\,, \qquad (1)$$

where t_{reg} – temperature gas before the pressure regulator, t_{cr} – the critical temperature of formation of hydrates.

If the productivity of gas distribution stations increases, then the energetic separator does not provide the necessary heating of natural gas. This can occur when expanding the settlement, or the construction of additional of large consumer of natural gas. In this case, using additional line of warm flow *VI* with regulating crane *13* is carried by the selection of the warm flow after energetic separator *2* in the distribution gas pipeline. This reduces the load on the gas pressure regulator *3*. As shown by experimental studies on compressed air, decreasing the share of warm flow ε allows increase the degree of heating Δt_h^{air}. Thanks to additional line of warm stream of natural gas that goes to the regulator pressure decreases, thereby increasing the degree of heating of natural gas Δt_h^{air} to the throttling process.

The advantage of this scheme of gas distribution station is the ability regulation the temperature of warm gas stream by changing the amount of warm flow. This lets you change the degree of heating of natural gas in the energetic separator when changing of natural gas consumption during the year.

During the entire time of operation of energetic separator on the existing gas distribution station weren't observed icing pressure regulator. The results of the working of energetic separator in heating period shown in Figure 2.

As shown in Figure 2, during the whole heating season temperature before pressure regulator t_{reg} was higher than the critical temperature of formation of hydrates t_{cr}.

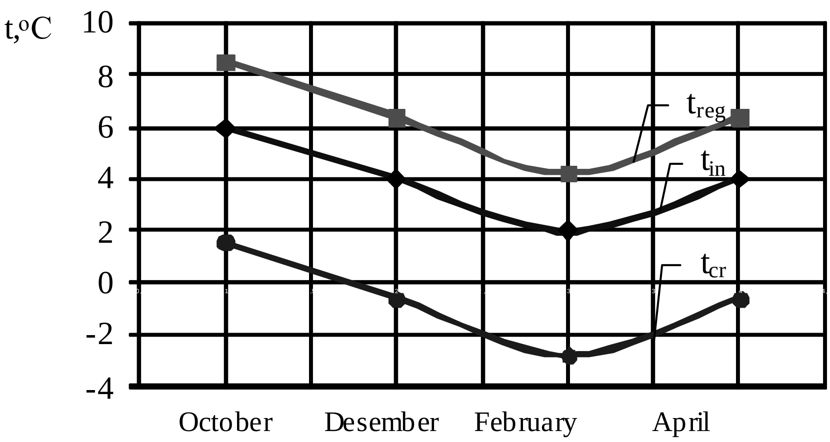

Fig. 2. Temperature regime of energetic separator on the existing AGDS:
t_{cr} – the critical temperature of formation of hydrates,
t_{in} – temperature of the natural gas at the inlet of AGDS,
t_{reg} – temperature gas before the pressure regulator,

The results are given in this article obtained in the performance of contractual work №0054 and the dissertation "Friction heating of natural gas in energetic separator". Potential volume of introduction of power dividers are significant – only UMG "Lvivtransgaz" operates 213 gas distribution stations, and "Ukrtransgaz" – 1450. It is clear that for the mass use of energetic separator at GDS necessary to make a number of works: development of technical documentation for manufacturing (create model range of installation of different performance), conduct certification and acceptance testing. These activities require additional resources, but compared to the cost of repair and reconstruction of the existing GDS they are minor. The reconstruction GDS "Kozova" was worth 22,495.3 thousand grn. (2011) [10], the purchase of gas heaters (52 units) – 25782.8 thousand grn. [11]

Conclusion

Perspective and economy of using of energetic separators for gas distributive stations to heat the gas by a process of reduction has substantiation.

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