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New energy-saving temperature controller for heater at natural gas gate station

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ABSTRACT

Some stations in the gas transportation system experience a decrease in natural gas (NG) pressure. The drop in pressure occurs in the regulators and causes the temperature to drop so that the gas must be preheated to prevent it from freezing. The present study investigated this phenomenon at Akand City Gate Station, which has a nominal flow rate of 120,000 SCMH. Preheating of the NG in the station regulator was shown to consume excessive fuel to run heater. A new temperature controller was installed where the NG line leaves the second regulator of the station to decrease heater gas consumption. The station was simulated in HYSYS software to calculate the amount of possible decrease in usage. The real temperature of NG stream measured at the second regulator and the results of two state equations to reach minimum deviation were compared. The results showed the new NG temperature controller decreased heater gas consumption more than 431,000 SCM, which resulted in a cost savings of over $43000 annually. It is predicted that the implementation of this controller at all of the more than 50 stations city gate stations belonging to Mazandaran Gas Company will result in significant savings for the company of up to $1 million annually.

1. Introduction

Countries must devise plans to preserve the energy supply for the future. Decreasing energy consumption and recovery of lost energy sources are the main methods of saving energy. Natural gas, as an important source of energy, supplies domestic, commercial and industrial consumers. The transfer of natural gas from refineries to the consumer also consumes energy, which is provided at compressor stations. Pressure reduction stations decrease the gas pressure to that required for consumers. Gas discharged from a compressor station passes through underground pipes and enters city gate stations (CGSs) to initially decrease pressure. The stations under study decrease inlet gas pressure to the station (2.7 MPa–5.5 MPa) to 1.7 MPa using regulator. When the gas pressure drops, the temperature of the gas falls and can cause hydrate formation and freezing. The natural gas first passes through a heater for preheating before it enters the regulators. Because the CGS heaters consume large amounts of gas, any decrease in gas consumption provides substantial economic benefit for gas companies.

Azizi et al. (Azizi et al., 2014) studied the energy lost from heater flue gas to decrease heater gas consumption. They suggested the use of a heat exchanger to preheat the gas before it enters the heater. They found an 11% improvement in heater thermal efficiency with a payback period of 1.2 years for heater exchanger installation. Farzaneh-Gord et al. (Farzaneh-Gord et al., 2011) investigated the feasibility of using a solar system with uncontrolled linear heaters. They concluded that the savings from solar energy was 100 kWh, which amounts to a savings of $27000. Pozivil (Poživil, 2004) simulated a CGS regulator using HYSYS software. He showed a temperature drop of about 4.5–6 °C for each 1 MPa drop in gas pressure in the regulator, depending on gas composition. He simulated installation of a turboexpander in parallel with the CGS regulator to recover energy lost from the gas pressure drop and concluded that gas temperature was 15–20 °C. This was significantly higher than that of the regulator.

Ashouri et al. (Ashouri et al., 2014) computed the Joule–-Thomson coefficient of NG entering a CGS. They found that utilizing a controller to set the temperature of the inlet gas entering the

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station decreased energy consumption of the heater by 43% with a payback period of less than 1 year. Khalili et al. (Khalili et al., 2011) calculated the efficiency of the Shahrekord station heater using the data for NG flow, inlet and outlet NG temperature, fuel consumption by the heater and temperature of inlet and outlet combustion product through the stack. He then calculated an efficiency of less than 47%.

Mirandola and Macor (Mirandola and Macor, 1988) concluded that, if the pressure of gas entering is 1.13–5.1 MPa and leaving the station regulator is 0.15–0.6 MPa, the design flow changes from 5000 to 30,000 SCMH and 300 to 1400 kWh of energy will be recovered. In a study of the Shahrekord city gate station (Ardali and Heybatian, 2009) having a nominal capacity of 120,000 SCMH with a gas inlet pressure of 4.9–5.5 MPa and outlet pressure of 1.8 MPa, it was calculated that the fuel gas consumption by the heater is 0.32% of total gas flow. The power recovery was about 0.18–1.8 GWh/mo from the station regulators.

The present study examined the effect of installation of a new temperature controller on the heater to adjust the fixed temperature of NG leaving the regulator and decrease heater gas consumption. The cost savings can be easily calculated. The line to Akand CGS having a nominal capacity of 120,000 SCMH was simulated and the results were compared with real values to determine the cost savings.

2. City gate stations

2.1. Sari-Akand gate station

Sari-Akand CGS consists of two lines with capacities of 120,000 and 200,000 SCMH. The first second station consists of two lines with a capacity of 60,000 SCMH. Each line operates in the same manner. Fig. 1 shows that NG first passes through three filters to remove impurities. It is next sent to the heater for preheating to prevent hydrate formation and freezing in the regulators. It is then transferred to three pipes, each having two regulators in which NG pressure is reduced. It is ultimately sent to the town boundary station (TBS) for another pressure reduction (NIGC.MZ engineering department, 2011).

2.2. Heater operation

The CGS heater is used to preheat gas before it enters the station regulators. The NG is not heated directly by burner flame to preserve safety. Fig. 1 shows that water is used as a medium to transfer thermal energy. The heater with this design is called an indirect water bath heater. Fuel gas is burnt in the heater burner and is then sent to the combustion chamber and the stack. Water around the combustion chamber is heated and transfers thermal energy to the NG tubes. Fig. 2 is a schematic of the NG temperature controller installed on the gas line that controls the NG temperature by means of a valve.

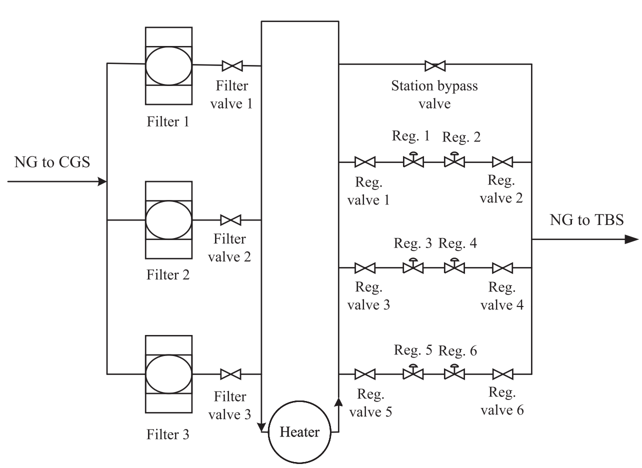

Fig. 1. Flow diagram of NG city gate station.

2.3. New temperature controller

The new temperature controller can significantly decrease heater gas consumption. The change in NG pressure upon entering the station was from 2.7 MPa to 5.5 MPa per year and the fixed pressure of the NG stream leaving the station was 1.7 MPa. Pozivil (Poživil, 2004) found that the gas pressure and gas temperature drop in regulators will differ; thus, the need for preheating will vary. The current operation of Akand station indicates that the temperature of the NG stream after leaving the heater is around 40 °C.

The drop in gas temperature was examined in two modes. In the first mode, if the pressure of gas entering to station is 5.2 MPa, then the pressure drop will be 3.5 MPa. This means that the temperature of the gas leaving the station will be 25 °C. In the second mode, the pressure on gas entering the station is 4.5 MPa, which indicates a decreased in pressure of only 2.7 MPa. Because the NG stream temperature after leaving the heater is 40 °C, the temperature of gas at the outlet line of the station will be at 30 °C. In the second mode, the temperature of gas leaving the station is 5 °C greater than it is in the first mode. This illustrates the increased energy consumption caused by operation of the heater. If the new gas temperature controller is set at to 25 °C, then the inlet gas at a pressure of 4.5 MPa heats to a temperature of 35 °C, not 40 °C. Fig. 3 is a schematic of the new temperature controller. This temperature controller on the NG stream leaving the station decreases heater energy consumption and can significantly decrease costs for the operating company. Fig. 3 shows that the new controller displaces the NG stream leaving the heater (Fig. 2) to the NG stream to the TBS.

Because gas leaving the station passes through underground pipes, its temperature will equal the ground temperature; heating it to a temperature above ground temperature is not necessary and wastes energy. The new temperature controller was set at 15 °C, which prevented hydrate formation because the hydration temperature of Akand station NG at 0.75 specific gravity is −2.2 °C (NIGC.MZ engineering department, 2011). Heater burner gas consumption should be calculated before and after use of the new temperature controller to demonstrate its effect.

3. Calculation of heater gas consumption

3.1. Heater gas consumption before installation of new temperature controller

The station was simulated using HYSYS software to calculate heater gas consumption before installation of the new temperature controller. Prior to entering the HYSYS simulation environment, the composition and physical specifications of the NG entering the station and the state equation for thermodynamic calculation must be entered. Table 1 shows the composition and physical specifications of the NG at Akand CGS (Data Sheets, 2013).

There are different equations of state for thermodynamic calculation in HYSYS that could be suitable for computing the results with minimum error. In the present study, the Peng–Robinson (Peng and Robinson, 1976) and Soave modification of Redlich-Kwong (SRK) (Redlich and Kwong, 1949) were selected. For