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Calorific Value Adjustment System for City Gas Production Process†

1. Introduction

Against the background of heightened environmental awareness in recent years, demand for city gas is increasing year by year, as the main feedstock for city gas is clean natural gas (hereinafter, "NG")[1].

In addition to the main component methane (CH_4), NG also contains ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), etc., and as a result, its density and calorific value vary, depending on the contents of these components. On the other hand, the calorific value range of city gas supplied to customers by the supplier is regulated[2]. Accordingly, a process for adjusting the feedstock gas (NG), which is subject to variations in calorific value, to the specified calorific value range is necessary. In Japan, the calorific value of the feedstock NG is usually lower than that of the product city gas, which means the calorific value is adjusted upward. Recently, calorific value of liquefied natural gas (LNG) tends to be lower, due to increasing demand of LNG in Europe and the United States. Lower calorific value LNG has been distributed to markets in large volume, and is now also imported into Japan. Calorific value adjustment is an essential technology for producing city gas from this low calorific value LNG.

The new calorific value adjustment system introduced in this report is a product that was developed in response to this need.

2. Calorific Value Adjustment Technology and Concept of Developed Product

2.1 Calorific Value Adjustment Technology

The typical process for producing city gas from NG is shown in **Fig. 1**. The calorific value of NG is generally adjusted by addition of liquefied petroleum gas (LPG), which has a higher calorific value than NG. The device used in addition of LPG to NG is called a calorific value adjustment system (hereinafter, "CVAS"). Because demand for city gas varies greatly depending on the season and time of day, a capability (calorific value control performance) of stable calorific value adjustment over a wide flow rate range (turndown ratio = operating flow rate / rated flow rate) is required.

In recent years, the method of adding LPG directly in the liquid state has become the main stream in calorific value adjustment. While this has the merit of not requiring a high temperature heat source to vaporize the LPG, on the other hand, 100% of the LPG which is added in the liquid state must be securely evaporated and vaporized. In the unlikely event that the added LPG is not completely evaporated, a phenomenon called "dripping" will occur, in which the LPG that does not contribute to increasing the calorific value flows out to the downstream side of the CVAS while still in the liquid state, resulting in a condition in which calorific value adjustment does not function.

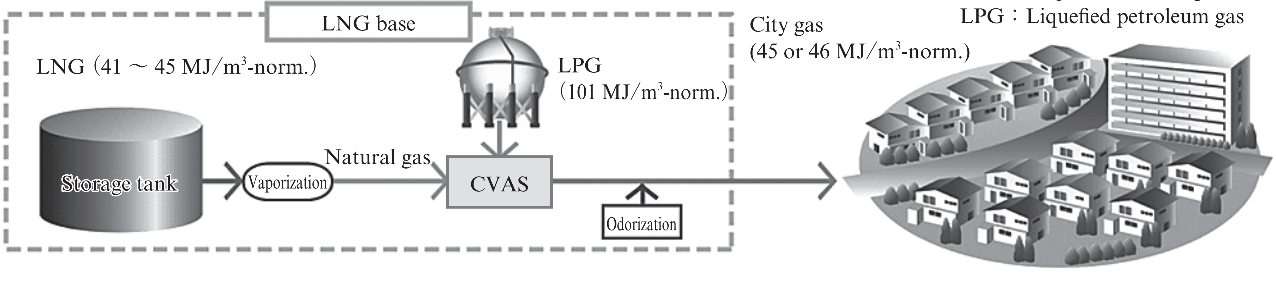

Fig. 1 Typical process of city gas production

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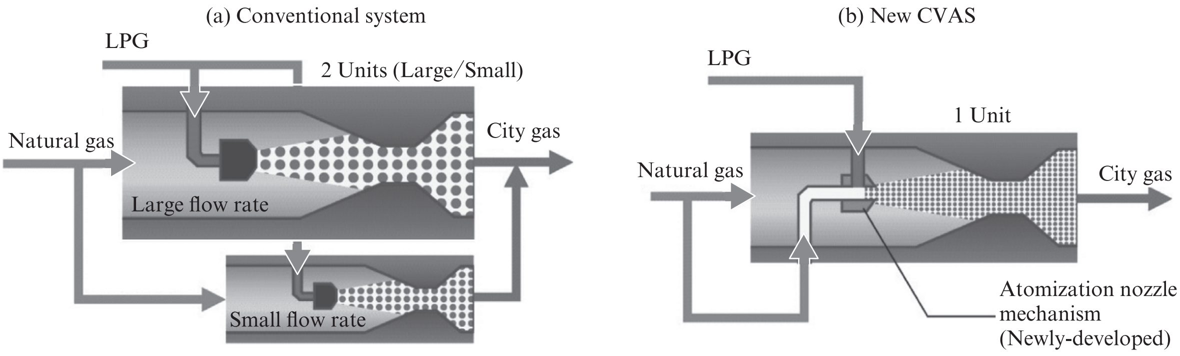

Fig. 2 Schematics of conventional method and developed method

2.2 Concept of Developed Product

In comparison with the conventional CVAS, the newly-developed CVAS greatly expands the operation turndown ratios. **Figure 2** shows a comparison of the Venturi type, which is a conventional CVAS, and the newly-developed CVAS. The Venturi type (hereinafter, conventional system) has the most extensive track record of actual use in high pressure, large volume calorific value adjustment applications.

In the conventional system, NG is passed at high velocity through a constricted flow path (Venturi), and LPG in the liquid state is added to this point. The LPG is atomized by the shear effect of the high speed flow of NG, promoting evaporation, and a “dripping” prevention and calorific value control enhancement effect is obtained. However, when the NG flow rate decreases due to low demand for city gas, the gas flow velocity in the Venturi also decreases. As a result, the LPG atomization effect of the Venturi is reduced. Experience has shown that the lower limit of the turndown ratio at which the LPG atomization effect can be obtained is about 1/5 to 1/7. To respond to turndown ratios corresponding to a wider range of city gas demand, a combination of two Venturis (one large and one small) was installed, and the Venturis were switched depending on the operating flow rate.

The new CVAS was designed so that LPG can be securely atomized, even under reduced flow rate operating conditions, by applying a newly-developed liquid-atomization-nozzle mechanism (hereinafter, “developed atomization nozzle”). LPG and part of the NG are supplied simultaneously to the developed atomization nozzle, and are then mixed and injected into the main stream of NG. The added LPG is reliably atomized by properly controlling the amount of NG feed to the developed atomization nozzle, corresponding to the operating load.

3. Pilot-Scale Test for Performance Assessment

In order to verify the performance of the new CVAS, a pilot-scale test plant was constructed in a city gas production plant, and its performance was assessed[3–5]. Although this was a test plant, its rated flow rate was 14 000 m^3-norm./h. Thus, it was in fact a small actual facility in volume. The pilot plant was installed as a production facility based on Japan's Gas Utility Industry Law, and the calorie-adjusted gas was actually supplied as city gas after confirming its product quality.

The results of the verification test are shown in **Fig. 3**. With a conventional system, which was also manufactured and tested for purposes of relative comparison, “dripping” occurred at turndown ratios of 1/5 to 1/10, which is basically consistent with the empirical knowledge obtained in actual operation. In contrast, the test of the new CVAS confirmed that the calorific value can be adjusted stably to a level far exceeding that possible with the conventional system. Moreover, as the added LPG was completely atomized, calorific value controllability was satisfactory. Pressure loss of the new CVAS could also be controlled to the same level or lower than that of the conventional system. Normally, atomization characteristics and pressure loss display a

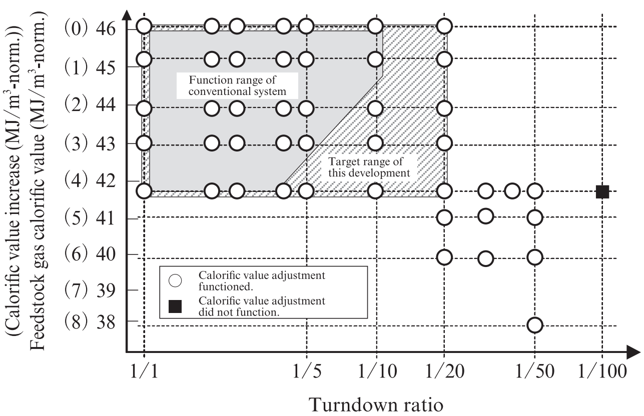

Fig. 3 Results of verification test

tradeoff relationship, which means that pressure loss increases when atomization is improved. However, the developed atomization nozzle showed an excellent balance of atomization properties and pressure loss.

4. Conclusion

A new calorific value adjustment system (CVAS) for city gas production was developed. The new CVAS realized excellent calorific value controllability and a wide possible operating range (turndown ratio range) by completely and reliably atomizing added LPG without increasing pressure loss. As a result, it is possible to respond to turndown ratios corresponding to a wide range of city gas demand with a single unit.

The first commercial unit (rated flow rate: 140 000 m^3-norm./h) is scheduled to begin operation in the autumn of 2013.

JFE Engineering wishes to take this opportunity to express their deep appreciation to Toho Gas Co., Ltd., with which we jointly conducted the pilot-scale verification test for performance assessment, for useful advice and generous cooperation in the development of the new CVAS.

References

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