액화석유가스 용기용 과류차단밸브의 개발에 관한 연구

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A Study on the Development of Overflow Cutoff Valve for Liquefied Petroleum Gas Cylinders

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Abstract : This research is about overflow cutoff valve for liquefied petroleum gas cylinders. This valve was developed based on Bernoulli's equation and Newton's equation. The structure of overflow cutoff valve was made by insert module instead of the ordinary valve that is used at present. Recently, the increase in use of gas for fuel in houses has resulted to more frequent occurrences of gas related accidents. In Korea, the government has made a law for the obligatory use of the cutoff valves. This cutoff valve is not yet developed. This research focuses on the use of over flow cutoff valve for LPG cylinders. If this valve is adapted, many accidents can be prevented.

초록 : 액화석유가스 용기용 과류차단 밸브의 개발에 관한 연구이다. 이 밸브는 베르누이 방정식과 뉴턴의 법칙을 응용하여 개발하였다. 이것은 기존의 밸브 하단에 모듈을 삽입함으로써 과류가 발생하면 모듈이 상승하여 모듈상단의 헤드에 부착된 차단변이 가스의 통로를 폐쇄함으로써 작동된다. 최근 가스 사용이 증가됨으로써 이에 따라 가스사고가 많이 발생되고 있다. 따라서 한국에서는 과류밸브의 사용을 의무화 하고 있지만 아직 개발되지 않고 있다. 본 연구는 LP가스 용기용 밸브의 과류 발생시 자동 차단 되는 밸브이다. 본 밸브가 채택 된다면 많은 가스 사고로부터 벗어 날 수 있을 것이다.
Key Words : overflow cutoff valve, LPG cylinder, gases valve, safety valve

1. Introduction

Liquefied petroleum gases (LPG) are now widely used in various branches of the industry and also in many households. LPG are stored and transported in special tanks, which are high fire hazard technological processes. Many accidents with fires and explosions have involved LPG vessels[1-3]. Recently, because of the increasing use of gas for fuel in homes, there are more occurrences of gas related accidents. More accidents involving liquefied petroleum gases (LPG) are occurring in comparison to the number of accidents involving liquefied natural gases.

This is because LP gases are heavier than liquefied natural gases. Furthermore, LP gases are transferred into cylinders, which increase their probability of being used for terrorism/ demonstration or causing self-injury.

In Korea, the government made a law for the obligatory use of cut-off valves[4,5]. Because of its harmful use, Korean government required the use of over flow cutoff valves for the cylinder valves in LP gases. However, this over-flow cutoff valve was not yet developed, thus the decision was deferred until the completion of its development. This research will study on the use of over-flow cutoff valves for LP gas cylinders[6,7].

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2. Research Backgrounds

2.1. A law of high-pressure safety control

According to the law of high-pressure safety control, cutoff range is from 2 to 2.7m/h at 1kgf/cm^2 of vessel pressure, and from 4.3 to 6.3m^3/h at 10 kgf/cm^2 of vessel pressure. The leak amount after operation of valve must be below 5l/h.

2.2. Shape and operating principle of overflow cutoff valve

The structure of overflow cutoff valve was made by insert module instead of the ordinary valve that is used at present. This module consists of a head that is installed in the cut-off sheet, a vertical bar with metal spring and a fixed body, which includes a suspending ring for return gas. Fig.1 shows the ordinary valve that is used nowadays.

Fig. 2 shows the overflow cutoff valve that was developed in this study. The head makes the principle of this valve. A clearance is maintained between the head and valve body. This clearance creates a difference in the velocity of the fluid, thus making a difference in pressure according to Bernoulli's equation. If the amount of fluid is bigger, the difference in pressure is also bigger. This power can move the module upward, causing the cut-off sheet to close the gas pathway thus making the gas flow stop.

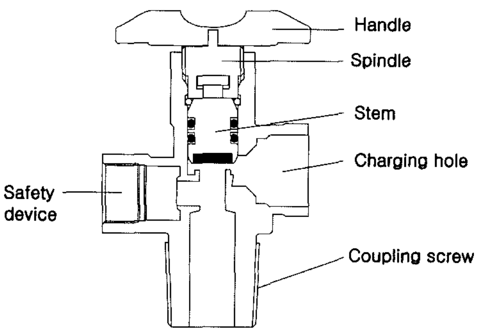

Fig. 1. LP Gases cylinder valve of present use

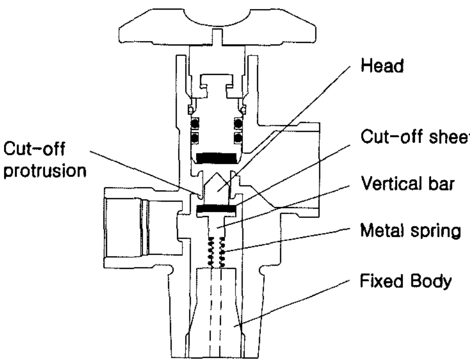

Fig. 2. The overflow cutoff valve for this study

In this study, we developed a useful valve which is safe and can prevent deaths due to self-injury. This valve uses the principle of Bernoulli's equation and Newton's equation. We changed the volume of gas flow. Fig. 3(1) shows the closed stem, where the flow of gas occurs. In Fig. 3(2), even if the valve is open, flow of gas can not occur because velocity of the gas flow moves the module upward, causing the cutoff sheet to close and adhere to the valve body. Thus this allows only a small amount of gas to flow.

In the case of Fig. 3(3), the connection of a gas regulator or high pressure tube while the valve is open, causes a small amount of gas to flow. The difference in pressure before and after the module disappears make the consumption of gas regulated. If the gas hose is suddenly cut and pulled-off, a difference in pressure makes the module moves upward and the gas pathway be closed.

3. Experiment and Results

The quantity of fluid gas moving the module in the overflow cutoff valve was decided by three kinds of variables. First is the height between the cutoff sheet and cutoff protrusion. This is shown in Fig. 4. Second is the difference between the head diameter and valve main body diameter. The difference of

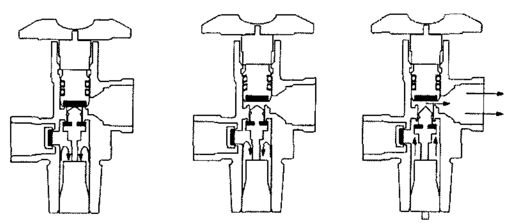

Fig. 3. Operation of overflow cutoff valve of LP gases cylinders.

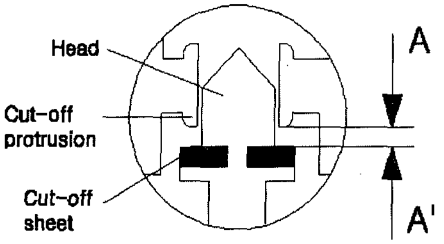

Fig. 4. The intervals of cutoff protrusion and cutoff sheet (A-A' showed head height)

which can make gases more fluid. And third is the weight of the module. The heavier this weight is, the more difficult it will be to move the module.

This experiments were conducted by air according the law of high pressure safety management in Korea. Then cutoff fluid was measured by Sierra 820 Top-Trak mass flow meter. In case of high pressure, experiments use nitrogen gas together.

3.1. The measurement of cutoff fluid quantity with variation in cutoff sheet height

In this section, we did not change the module weight and the head diameter. Only the height between the cutoff sheet and the cutoff protrusion was changed. Afterwards, the fluid variation was measured. In Fig. 5, we showed that the cutoff fluid quantity is proportional to the height between the cutoff sheet and the cutoff protrusion. The result of this research shows that the height must be approximately 1.20-1.60mm in order to comply with the law of high-pressure safety management.

3.2. Fluid flow quantity with variation in head diameter

In this section, the inner diameter of the valve

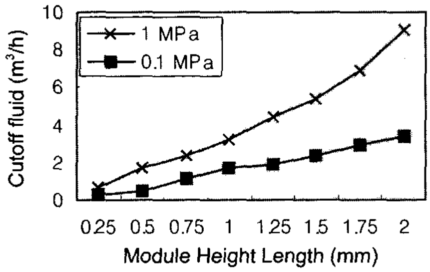

Fig. 5. The relation for module height and cutoff fluid.

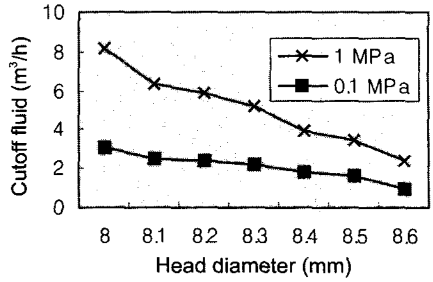

Fig. 6. The relation of head diameter and cutoff fluid

body was fixed at 9mm. Cutoff fluid quantity was measured for every change in head diameter from 8mm to 8.6mm in 0.1mm steps. The cutoff sheet height was fixed at 1.5mm using the same module weight.

This is shown in Fig. 6. The results show that an increase in the head diameter decreases the amount of fluid. Furthermore, the slope at high pressure became sharper. As a result, the range between 8.1-8.3mm is adequate for cutoff ability in accordance with the law.

3.3. Fluid flow quantity with varying insert module weight

In this section, the variation in cutoff fluid quantity with respect to weight change in the insert module was measured. The head diameter was fixed at 8.2 mm while the cutoff sheet height was fixed at 1.5 mm, same as before.

The change in insert module weight was calibrated with the length of the vertical bar. Fig. 7 shows the experimental results of changes from 5 to 8g in

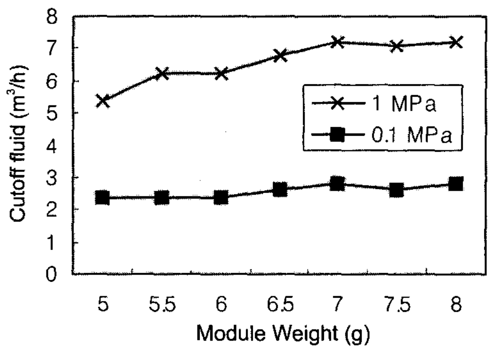

Fig. 7. The relation of module weight and cutoff fluid (cutoff sheet height was fixed at 1.5mm)

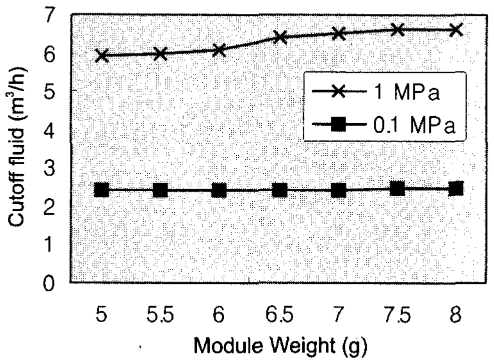

Fig. 8. The relation of module weight and cutoff fluid (head diameter was fixed at 8.2mm)

0.5g step changes. As in Fig. 7, the cutoff fluid quantity varied only slightly with weight changes of the insert module. This was different from previously conducted experiments. There was no observable difference in the low-pressure experiments while the 1.0MPa experiments showed slightly bigger differences its slope was still smaller than those observed with the cutoff height and head diameter experiments.

Fig. 8 shows that the module weight affects the cutoff fluid when the head diameter is fixed. As a result of this experiment, cutoff fluid with weight variation did not change at low pressure (0.1MPa) and high pressure (1.0MPa). This concludes that module weight does not affect the cutoff fluid. As a result, the best choice to control the cut-off fluid is to change the cross-sectional area. This is better than changing the module height.

4. Conclusions

Overflow cutoff valve for liquid petroleum gas cylinders has been developed based on Bernoulli's equation and Newton's law. The experiments have been made with variations in module height, head diameter and module weight.

In the case of varying module heights, longer heights resulted to more cutoff fluid. To follow the law of high-pressure safety management the valve module height must be approximately 1.20-1.60mm. However, in the case of varying head diameters, the higher the increase in head diameter resulted to a decrease in the fluid.

Furthermore, the slope during high-pressure experiments was sharper in comparison to the low-pressure experiments. Adequate ranges have been taken between 8.1-8.3mm. On the other hand, variations in the insert module weight did not make significant changes with only little changes observed in high pressure (1MPa).

If this valve was adapted, the number of accidents will be diminished. And deaths due to self-injuries will be prevented.

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