Prediction of the Flow Characteristics of Relief Valve

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Abstract: - This paper investigates the flow characteristics of the relief valve attached to engine crankcase. As a practical safeguard against crankcase explosion, relief valves are fitted. The fluid analysis for the explosion and the operation of the relief valve was performed by using ANSYS CFX.

Key-Words: - Crankcase, Relief valve, Fluid analysis

1 Introduction

The valve is core components of industrial facilities, it used all industry that using fluid, like oil refining, petrochemistry, piping, power generation. Especially, vessel industry using valve in various techniques[1]. The valve is composition of parts that control the fluid and body that keep safety to the structural components of the control.

The valve investigated in this study is a safety relief valve which is attached to a crankcase. First, the crankcase refers to a body surrounding the space which is used for the rotation of the lower part of the internal combustion engine cylinder. Safety relief valve is attached to outside the crankcase, which works to prevent the destruction of the crankcase and the spread of fire caused unpredictably by an internal explosion.

An explosion by oil mist in the crankcase causes a rapid temperature and pressure rise, along with a moment of rising energy. The installation of a protrusive valve and oil mist detection/monitoring and alarm arrangements is to protect people from such an explosion and reduce the damage caused by a second explosion. However, in the recent five to six years many large institutions suffered human casualty and damage of equipment from explosions of crankcase. As a result, it became inevitable to revise the current standard which had been established after the Reina del Pacifico accident in 1947. The IACS(International Association of Classification Societies) newly established UR(Unified requirements) M66 and M67 as a formal approval testing producer of crankcase explosion relief valves and crankcase oil mist detection/monitoring and alarm arrangements in January 2005.

For domestic production of the crankcase relief valve, it is required to pass the formal approval mentioned above. This study analyzed the flow characteristics of the crankcase relief valve in order to succeed in passing the explosion proof test of the formal approval. We used solidworks for CAD modeling and ANSYS CFX 11.0 for flow analysis.

2 Flow analysis of Crankcase relief valve

Fig. 1 A relief valve for crankcase

2.1 Structure of Crankcase relief valve
The crankcase relief valve is composed of disc, seat, cover, flame arrester, trap and spring as is shown in Fig. 1 and Fig. 2. Fig. 3 shows the operating principles of the crankcases relief valve. The seat, as a part contacted with the crankcase, serves as an entrance for gas to flow into the relief valve when there is an explosion. The disc, connected with spring, is operated when the pressure rises to 0.5bar±15% inside the crankcase within the crankcase, because of an explosion. At this time, the disc is opened, resulting in the gas flowing into the valve. And the pressure falling blow 0.5bar, the disc goes down and pressure return to normal. The flame arrester and the trap lower the temperature of the gas into the relief valve and absorb the flames and the result, emit only smokes out.

This study simplified the modeling to 1/36 model as is shown in Fig. 4 after considering the time taken to conduct flow analysis of crankcase relief valve and the specifications of the workstation. This study showed the flow field model for the flow analysis in Fig. 5 and used ANSYS CFX 11.0 which common software. The flow field model generated 277669 panel points and 1025022 elements. Air Idea Gas was used as fluid and SST(shear-stress transport) was adopted as a turbulence model. For an inlet condition, the explosion pressure of 8bar and the normal speed of 340 m/s were fed as mixed condition. For an outlet condition, opening condition was used and the both sides symmetry planes were made to allow exchange of fluids using interface.

Flow analysis of this model, analysis time took an average of 48 hours, using a computer with specifications similar to workstation.

**Fig. 2** A structure of a relief valve for crankcase

**Fig. 3** Operation of a relief valve for crankcase

**2.2 Flow analysis of Crankcase relief valve**

2.3 Results and analysis of flow analysis

This study, the shape of the flame arrester is not disclosed as it is currently applied for a patent by a company. It is assumed that it would not affect the analysis of the overall flow
characteristics of the crankcase relief valve. The results of the flow analysis of the crankcase relief valve are illustrated in Fig.6

![Fig. 6 Analysis results](image)

First, take a look at the pressure distribution of (a), the inlet pressure over 8bar is evenly distributed. It is understood that the supersonic-speed flow phenomenon caused by the difference in pressures between the inlet pressure of 8bar and the outlet pressure of atmospheric pressure leads to the pressure leads to the pressure distribution over 9bar. When combustion gas and flame were pass through the flame arrester which made up of four panels, result in a rapid decline of pressure. And this moment, the flame contained in combustion gas is absorbed into the flame arrester. The speed distribution illustrated in (b) reveals the maximum speed of 1184 m/s at the top of the flame arrester. Because the fluid is concentrated in the top of the flame arrester by the vortex created in the upper part of the disc. Thus, the explosion of the crankcase relief valve causes the maximum pressure at the cover. And the resulting pressure of the flow analysis may be used as load data for the structural analysis of the crankcase relief valve.

3 Conclusion

This study drew a conclusion after analyzing the flow characteristics of the crankcase relief valve in the explosion proof test.

1. This study generated basic data for the following structural analysis using successful results of the flow analysis of the crankcase relief valve.
2. This study helped set a guideline for designing the shape of flame arresters based on the analysis of fluid flow in the explosion proof test.
3. This results and analysis methods in the study are thought to be used as good reference for designing a relief valve.

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References