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An investigation on the static electrification of dimethyl ether

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Abstract

Static electrification characteristics of dimethyl ether (DME) were studied considering accidents during unloading (discharging) operations. Producing mist flow, static electrification by the mist was studied as a first step. Influences of flow velocity on the charge generation, produced potential, charge generation ratio, electrostatic energy, etc. were investigated experimentally. Although the produced charge is not too big, it will be requested to pay full attention during the handling process, considering the igniting characteristics of DME.

Keywords: Dimethyl ether; Electrification; Mist; Charge generation; Accident

1. Introduction

Combustion exhaust is regarded as one of the sources of air pollution. Particularly, suspended particulate matter, soot, etc. are regarded as the major cause of the problem. For this problem, dimethyl ether (DME) will be recommended to be one of the substitutes for liquefied petroleum gas. However, its details for safety are not fully known. DME may produce static electricity easily during the handling, like gasoline. In gasoline filing operation for car, at least four cases of electrostatic ignition accidents were reported in 2002 in Japan [1]. Since flash point of DME is −41 °C and boiling point is −23.7 °C [2], DME is highly flammable. And ignition energy of DME is small (0.29 [3] or 0.45 mJ [4]). Therefore, great attention must be paid and detailed safety study must be carried out.

Based on these backgrounds, the authors are studying the static electrification phenomena of DME, particularly in the handling process. A closed circulation piping system was prepared and the static electrification characteristics were studied, considering accidents in the DME unloading (discharging) operations. Producing mist flow, static electrification by the mist was studied as the first step. Influence of flow velocity and DME concentration on the electrostatic charge generation, charge generation ratio, electrostatic energy, etc. were investigated experimentally.

2. Experimental

As the first step to study the static electrification phenomena of DME, it is tried to investigate the electrification by DME mist, anticipating DME leakage in the handling system. If the piping system is broken or some DME is left in the pipeline, mist ejection is possible and this will lead to the static electrification easily. The experimental system is described in Fig. 1. Liquid DME is introduced to the measuring section through a nozzle. The detail of nozzle is shown in Fig. 2. The average diameter of the mist droplet is about 70 μm. The mist is transported through measuring section, relaxation tank, circulation pump, mass flow meter, second relaxation tank, etc. The mist concentration is regulated to keep certain value even for different DME flow velocity. The flow velocity is controlled by a mass flow meter. The pressure in the piping system is regulated by a back pressure regulating valve and

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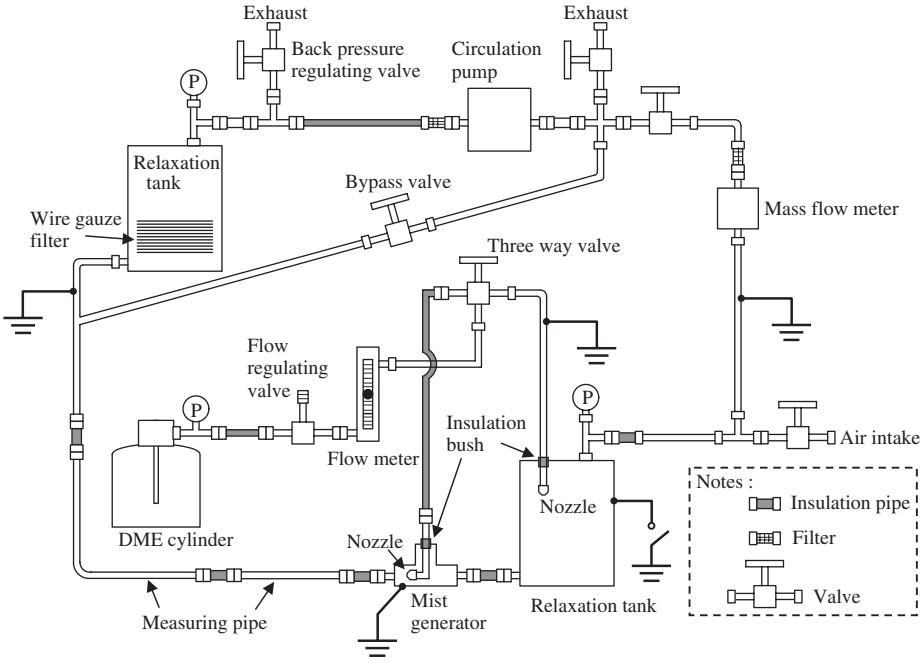

Fig. 1. Static electrification system by DME mist.

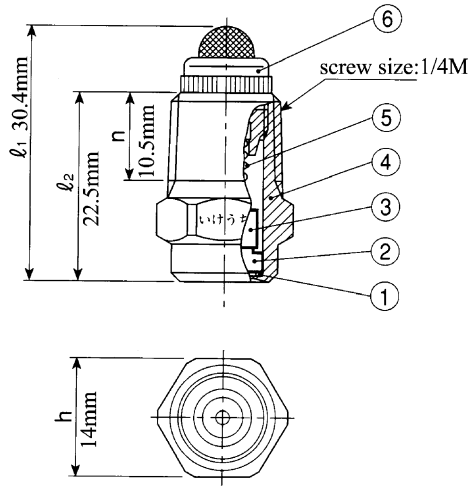

Fig. 2. Spray nozzle.

excessive evaporated DME is discharged through the valve to outdoor.

The inside diameter of the measuring section is 4.35 mm and the length is 556 mm. The metal pipe is made of stainless steel and the insulation material is made of polytetrafluoroethylene (PTFE). The capacitances of both the measuring section and the nozzle are 9 and 9.5 pF, respectively. Additional capacitors are connected to regulate the voltage.

3. Results and discussions

3.1. Static electrification on the nozzle

The static electrification characteristics on the nozzle by DME mist are described in the following sections.

3.1.1. Electrostatic charge on the nozzle

Electrostatic charge generated on the nozzle is shown in Fig. 3. The graph shows the influence of DME flow velocity on the electrostatic charge generation. The flow velocity means the one in the experimental piping system (inside diameter: 4.35 mm). As mentioned earlier, the mist concentration in the measuring pipe is kept constant even with the increase of flow velocity during an experiment (in other words, DME supply is increased with the increase of flow velocity). The nozzle was negatively charged and the charge decreased with the increase of the DME mist flow velocity. The maximum value was in the order of 10^{-6} C. Since no charge will be produced when there is no mist supply, it is indicated that the electrostatic charge increases with the increase of flow velocity and that the charge peaks. Then the charge decreases with the increase of flow velocity. A similar relationship was also observed during static electrification of powder transportation [5]. When the velocity is increased, factors which influence the charge generation, such as the formation of charge double layer, contact and separation charge generations, etc., will become more inactive. Therefore, it would be necessary to reduce the flow velocity or to make the velocity very high in order to avoid the electrostatic charge accumulation.