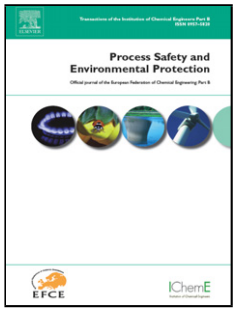

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Effect of one obstacle on methane-air explosion in linked vessels

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ABSTRACT: The effect of one obstacle on the explosion intensity of a methane-air mixture in connected vessels was studied. The experimental results suggested that the blockage ratio and the position of obstacles played a great role in this intensity. The obstacles could increase the reaction speed. When the blockage ratio reaches a certain value, the disturbance effect on the flame is at its highest, and the turbulence intensity and explosion intensity are at their strongest. If the obstacle's blockage ratio is greater than or less than this value, the explosion intensity is weaker. If the obstacles are closer to the initiating container, the combustion pressure will rise earlier both in the initiating container and in the connecting pipe. However, the effect of the obstacle position on the peak combustion pressure is limited. The conclusions provided an important reference for the safety design of explosion venting and explosion resistance.

Keywords: Linked vessels; Obstacle position; Explosion intensity; Blockage ratio

1. Introduction

In the modern industrial production process, pipe blockage occurs frequently and becomes a common phenomenon as a result of material crystallization, pipe corrosion and so on. Obstacles have a significant influence on the induction, reflection, and superposition rules of explosion waves. Scholars have studied the effects rules of obstacles on characteristics of gas explosions in pipes (Na'Inna et al., 2014; Na'Inna et al., 2013; Yang et al., 2011; Naamansen et al., 2002; Wang et al., 2013; Wang et al., 2010). These practices prove that obstacle is one of the most important influence factors affecting gas explosions (Naamansen et al., 2002; Wang et al., 2013; Wang et al., 2010). The influence factors mainly focused on the shape, blockage ratio, quantities, position and spacing of obstacles. The blockage ratio refers to the ratio of the maximum cross-sectional area of the obstacle to the cross-sectional area of the pipe (Zhang et al., 2014; Zhang et al., 2014; Yang et al., 2014; Ibrahim et al., 2001). Local structures of vessels or pipes are changed considering the exits of obstacle. The obstacle has an effect on the development laws of flame and explosion wave propagation. The reflection and superposition of an explosion wave and the turbulent flow will occur in the local area of vessels and pipes (Oh et al., 2001; Razus et al., 2007). Linked vessels were used in this paper for studying the influence of one obstacle on gas explosion characteristics. The aim of this paper is to demonstrate the existence of a proper blockage ratio for explosion suppression. The results can provide a foundation for the further understanding of explosion venting or resistance in linked vessels.

2. Experimental and methods

2.1. Experimental apparatus

A test apparatus was built to measure the explosion pressure of methane-air mixtures. The measurement system consists of an ignition device, a gas distribution system, a pressure measuring unit, a data acquisition and analysis system, and two linked vessels.

As illustrated in Fig. 1, the linked vessels are made up of a large spherical vessel, a pipe, and a smaller spherical vessel. The large spherical vessel is 600 mm in diameter and 113 liters in volume. The smaller spherical vessel is 350 mm in diameter and 22 liters in volume. The cylindrical pipe is 6450 mm in length and 60 mm in internal diameter. The wall thicknesses of the pipe, the large vessel, and the smaller vessel are 15 mm, 22mm, and 16mm respectively. All these three components are connected by flanges. Besides, the top of each spherical vessel has a closed end with a blind flange. Nozzles in the spherical vessels are used to install pressure transmitters, vacuum manometers, spark plugs, a gas inlet, and a gas outlet.

A premixed methane-air gas mixture of 10% concentration is used. An XDH-6 storage battery is used as an electrical ignition source for the high-voltage spark plugs, which ignite the flammable methane-air mixture. The ignition energy is 6 J. Waste gases in the linked vessels are replaced with fresh air by a vacuum circulating pump named (MPV 02) before each test. A distribution instrument named (SY-9506) is used to get the mixture of methane and air of the desired concentration. Five minutes are needed for each test to prepare the gas mixture. CYG1401MF is a of the pressure transmitter which is used to measure explosion pressure. Explosion pressure is

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