The research of compressibility of compressed air foam

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Abstract. The compressibility of compressed air foam was an important mechanical parameter in hydrodynamic calculations. The compression coefficient was set by the theoretical model in the current study of foam computational fluid mechanics. There are many types of fire foam and each of them is different with different compressible performance. The compression coefficient obtained by theoretical calculation has a certain error and the experimental method test is needed. In this study, the equipment for measuring the foam compressibility was designed and developed. The compressibility of compressed air foam was preliminary studied in this article.

1. Introduction
Compressed air foam system (CAFS) was a fire fighting technique that foam was produced with positive pressure and transfer in pipeline. Compressed air foam had advantages of exquisite structure, uniform size and high stability compared with the traditional foam extinguishing system[1]. Compressed air foam could stay and accumulate on the surface of protected objects for a long time, so it could obviously increase the performance of fire extinguishing system[2]. In the fixed compressed air foam system, the foam in pipeline was fully foamed, which had obvious advantages in engineering. However, the flow model of compressed air foam in the pipeline was different from water, as the foam was gas-liquid two phase flow with non-Newtonian fluid properties and compressibility[3,4]. The compressibility of compressed air foam was an important mechanical parameter in hydrodynamic calculations.

The compressibility factor is the relative increase rate of the fluid density when the pressure is increased one unit at certain temperature[5]. The compression coefficient was set by the theoretical model in the current study of foam computational fluid mechanics. There are many types of fire foam and each of them is different with different compressible performance. The compression coefficient obtained by theoretical calculation has a certain error and the experimental method test is needed.

At present, most of research about foam compressibility focused on theoretical calculation, and the experiment research that the foam compressibility could be measured by devices directly was not studied. In this study, the equipment for measuring the foam compressibility was designed and developed. The compressibility of compressed air foam was preliminary studied in this article.

2. Experimental

2.1 Materials
Aqueous film forming foams extinguishing agent (3% AFFF and 1% Class A foam) were generated.
2.2 Experimental setup and procedure

The fixed compressed air foam fire extinguishing system developed by the research group is used in the system diagram is shown in Fig 1. The system is mainly composed of centrifugal pump, screw air compressor, foam proportional mixer, foam generator and related measuring equipment.

![Figure 1. Fixed compressed air foam system.](image1)

The research group independently developed the compression coefficient test device of compressed air foam as shown in Fig 2. The device comprises a chamber, a servo motor, a touch control screen, a pressure sensor, a piston, a feed valve, a planetary reducer, a safety relief valve, a wire rod lift, a sealing ring, a foam, and the wire rod lift comprises a wire rod and a turbine box, one end of which is meshed with the turbine inner teeth inside the turbine box. The other end of the wire rod lift wire rod is arranged in the chamber through the chamber cover and is fixed with the piston, the sealing ring is arranged on the piston and is close to the inner wall of the chamber, the pressure sensor is arranged on the piston, the foam reducer is arranged in the chamber under the piston, the servo motor is connected with the planetary reducer, the screw of the planetary reducer is meshed with the turbine outer teeth in the wire rod lift turbine box, the servo motor rotates clockwise or counterclockwise, the screw of the planetary reducer is matched with the turbine outer teeth and the turbine inner teeth and the wire rod through the planetary reducer screw, drive the piston up and down in the chamber.

![Figure 2 Compressed air foam compression coefficient testing device](image2)
3. Result and discussion
In this study, 1% Class A foam was chose to study the compressibility of compressed air foam with
different expansion. Calculate the mass of the foam solution and measure its compression performance
without foaming, as shown in Fig 3.

![Figure 3 Comparison of compression characteristics](image)

The expansion ratio is 6

The expansion ratio is 15

It can be seen from the diagram that when the same volume is compressed, the pressure of the foam
is smaller, that is, the foam is more easily compressed than the stratified gas-liquid two-phase state,
which is mainly due to the large contact area between the gas and liquid in the foam. Air can quickly
dissolve into foam solution.

The compression characteristics of the gas-liquid two-phase separation mixture of aqueous
film-forming foam and foam are compared, as shown in Fig 4. It can be seen that it is difficult to
maintain the structure of water film foam when compressed to a certain volume under 25 times
expansion ratio, and the compression performance of water film foam tends to gas-liquid two-phase
separation mixture. This is due to the poor stability of water film foam and the short time of liquid
evolution.

![Figure 4 Comparison of compression characteristics](image)

The expansion ratio is 6

The expansion ratio is 25

Figure 4 Comparison of compression characteristics
For the comparison of the compression characteristics of Class A foam solution with air gas-liquid two-phase, aqueous film-forming foam solution with air gas-liquid two-phase, as shown in Fig 5. It can be seen from the diagram that the compression performance curves of the two stratified gas-liquid phases basically coincide.

4. Conclusion
In this study, the equipment for measuring the foam compressibility was designed and developed. The compressibility of compressed air foam was preliminary studied in this article. It can be seen that when the same volume is compressed, the pressure of the foam is smaller, that is, the foam is more easily compressed than the stratified gas-liquid two-phase state.

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