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Experimental Study on Fire Extinguishing Properties of Compound Superfine Powder

De-xu DU[a,b,c], Xu-hai PAN[a,b,c], Min HUA[a,b,c,*]

[a]*College of Safety Scienceand Engineering, Nanjing Tech University, Nanjing 210009, China*
[b]*Institute of Fire Science and Engineering, Nanjing Tech University, Nanjing 210009, China*
[c]*Jiangsu Key Laboratory of Urban and Industrial Safety, Nanjing 210009, China*

Abstract

In this paper, the existing fire extinguishing powder was improved with magnesium hydroxide as additive to prepare the compound superfine powder. And the fire extinguishing performance of the compound powder was tested by the modified cup-burner, being compared with the commercial dry powder and the superfine powder. The advantages of the compound superfine powder were explained from the aspects of minimum extinguishing concentration, temperature and extinguishing time. The experimental results showed that the minimum extinguishing concentration of compound superfine powder was much lower than the other two, and the temperature drop rate was greater in the process of suppressing flame. Although the compound superfine powder was slightly lower than the superfine powder in the average extinguishing time, the standard deviation results showed that the composite powder had better stability. In addition, the experimental results showed that the fray-out of flame was very fast and the time only accounted for 17.5% in the fire extinguishing process.

Keywords:compound, fire extinguishing powder, magnesium hydroxide, minimum extinguishing concentration, temperature, fire-extinguishing time

Nomenclature

C	concentration of fire extinguishing powder(g/m³)
m	mass flow of fire extinguishing powder (g/s)
V	the flow rate of air(m³/h)

1. Introduction

With the exit of Halon, fire extinguishing powder has obvious advantage in Halon substitutes with its low toxicity, environmental protection, cheap and outstanding fire extinguishing efficiency [1-3]. As the large-scale use of fire extinguishing powders, demands of improving the efficiency of the fire extinguishing powders is becoming higher and higher, and relevant scholars have done a lot of research to make it. Researchers found that the commercial dry powder being further refined into ultra-fine powder (particle size ≤20μm) could have better fluidity and dispersion [4], which resulted that the refined particles would have greater specific surface area, and the interaction with the flame could be greatly improved, and as a result the powders could play a better role in fire extinguishing progress. However, if the powder was further refined, although the fire extinguishing performance could be improved to a certain extent, the problem of

* Corresponding author. Tel.: +86-25-8323-9951; fax: +86-25-8323-9949
E-mail address: huamin@njtech.edu.cn

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agglomeration and preservation of powder was more prominent, which made the preparation process and cost increase greatly. Therefore, the relevant scholars had done some further researches, and made breakthrough in other technical aspects.

Xiaomin et al wrapped the nanometer superfine sodium bicarbonate powder in the pore structure of zeolite through a new type of fruit core structure, to solve the agglomeration problem of powder, so that the powders could penetrate the flame effectively and achieve better fire extinguishing performance [5]. Kuang K et al. found that the fire extinguishing performance of superfine powder was not only related to the size of the surface structure of the powder, but also to the main components of the fire extinguishing agent, and the experiment showed that the ultrafine magnesium hydroxide powder had higher extinguishing efficacy than the commercial dry powder of ammonium bicarbonate [6]. Koshiba et al through the experimental study of combustion inhibition found that the metallocene powder had a higher firefighting advantages, the minimum extinguishing concentration of ferrocene was 11 times smaller than that of ammonium dihydrogen phosphate, which indicated that the metallocene, represented by ferrocene, was a more efficient agent than that of ammonium dihydrogen phosphate [7].The effects of manganese-containing compounds and zinc-containing compounds on the combustion rate of methane-air flame were studied experimentally by Linteris G T et al, and compared with $Fe(CO)_5$ and CF_3Br, it was found that the inhibition effect of the compounds containing manganese or zinc was more obvious, and the inhibition efficiency of zinc compounds was twice times of CF_3Br [8].

Now the extinguishing efficiency promotion of fire extinguishing powder is mainly aimed at the improvement of the single material, and the research on the compound fire extinguishing powder is less. B. G. Mchale combined dry powder and gas fire extinguishing agent, using halogenated alkanes as the driving gas, to drive the powder from the fire extinguisher, and the effectiveness of extinguishing had a large increase [9]. Skaggs et al combined use of sodium bicarbonate and heptafluoropropane, and found that the fire extinguishing time was shorter than that of the separate use [10]. However, the choice of the driving gas and the powder was limited, the nature of the driving gas required by different powders must be adapted to it, which restricted the popularization of this method.

In this paper, the compound superfine powder with magnesium hydroxide was adopted, to look forward to developing a new high-performance compound fire extinguishing powder, and the effectiveness of the powder was studied by the small-scale device-cup burner.

2. Experiment

2.1. Chemicals and materials

Magnesium hydroxide was purchased from Shanghai No.4 Reagent & H.V. Chemical Limited Company, which was chemical pure (> 98%), commercial dry powders produced by Nanjing Fire Extinction Agents Ltd. The magnesium hydroxide and the commercial dry powder were refined by horizontal planetary ball mill respectively, then mixed into the compound superfine powder by 15:85 proportion. And the experiment was conducted to compare it with the commercial dry powder and the superfine powder.

2.2. Fire extinguishing experiment

As a coaxial flow flame device, the flame property of the cup burner is very similar to the flame burning condition under the same natural condition, and the oxidant in the device can keep the flame burning stably [11]. The addition of the fire extinguishing powder is achieved by the air of the oxidizer which can drive the powders to the burning area, and under the entrainment the powders get into flame, in the end, achieving the role of extinguishing. The device structure of the cup burner used in this experiment is shown in Fig. 1.