Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 211 (2018) 590–598

Procedia Engineering

www.elsevier.com/locate/procedia

2017 8th International Conference on Fire Science and Fire Protection Engineering (on the Development of Performance-based Fire Code)

Study of Downward Flame Spread and Fire Risk Evaluation of the Thermoplastic Materials

Ruo-wen ZONG[a,b,*], Jie REN[a], Xi-ping LIU[a], You-ran ZHI[c]

[a]*University of Science and Technology of China, Heifei 230027, China*
[b]*Suzhou Institute for Advanced Study, University of Science and Technology of China,Suzhou 215123, China*
[c]*Nanjing Institute of Technology, Nanjing 211167,China*

Abstract

This paper focuses its attention on the combustion characteristics and fire risk evaluation on the downward flame spread of polypropylene (PP) and polymethyl methacrylate (PMMA). Many characteristic parameters have been measured under different widths of samples, including flame spread rate, flame height etc. It is shown that the flame spread of PP and PMMA are diversed for different pyrolysis mechanism. The width of test sample has different impact on the fire spread rate, flame height and CO emissions during the burning period. As the width increases, the fire spread rate and flame height of PP decreases first, and then increases, while that of PPMA increases monotonically. The volume fraction of CO of PP and PPMA increases, but the effect of the width on sample PP can be neglected. Based on the Analytic Hierarchy Process (AHP), the evaluation of fire risk has been conducted. The flame height, flame spread rate and toxic gas generation rate are selected as the basic evaluation index parameters to establish a comprehensive evaluation model of fire risk. The evaluation results indicates that the fire risk of PP is greater than PMMA.

© 2018 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the organizing committee of ICFSFPE 2017.

Keywords: thermoplastic materials, downward flame spread, melting,comprehensive evaluation, the analytic hierarchy process

Nomenclature

A	judgment matrix
CI	consistency index
CR	random consistency ratio
F	view factor from flame to unburned area
Fr	Froude number
g	acceleration of gravity
H	flame height
hc	convective heat transfer coefficient
I	comprehensive evaluation index
q_c''	convective heat transfer
$q_{f,loss}$	heat loss to the environment
q_g	heat transfer from flame front to unburned area
q_p	heat transfer from pyrolysis area to unburned area
q_r''	radiant heat transfer
$q_{s,loss}$	heat loss to the wall

* Corresponding author. Tel.: +86-551-63606439; fax: +86-551-63601669.
E-mail address: zongrw@ustc.edu.cn

1877-7058 © 2018 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the organizing committee of ICFSFPE 2017
10.1016/j.proeng.2017.12.052

RI	random consistency index
T_g	the temperature of pyrolysis of samples
TR	experimental values
Ts	the temperature of surface of samples
u_0	characteristic velocity
V_f	flame spread rate
W	sample width
$\boldsymbol{X}$	matrix eigenvector
Greek symbols	
σ	Stefan-Boltzmann constant
ε	flame emissivity
κ	emission coefficient
λ_{max}	the largest eigenvalue

1. Introduction

The thermoplastic materials have been widely used for the high performance in transportation, automotive and other fields[1]. But their characteristic of ease to melt and burn, accelerating the fire spread, and generating a large amount of toxic gases, have seriously affected people's life, property and social stability.

Many studies have been studied the thermoplastic material for its fire hazards. Ohlemiller et al[2-4] studied the effect of viscosity of thermoplastic materials on the combustion. Butler et al[5,6]analyzed the melting behavior of PP without pyrolysis by computer simulation. It was shown that there is a uniform high temperature mixing layer between the solid and liquid state in the combustion process. Xie et al[7-9] investigated the upward flame spread of thermoplastic materials including PP and PMMA in the ISO9705 room. They pointed that PMMA combustion is mainly influenced by the fire spread on surface, and PP combustion is mainly controlled by the oil pool fire. Kashiwagi[10] analyzed the downward flame spread and flame stability of carbide material under constant radiation heat flux. Based on the downward flame spread experiments of PMMA, Ayani[11] noted that fire spread rate is inversely proportional to the thickness of the material. Gong[12] studied the effect of angle and thickness on the downward flame spread of PMMA. Current researches have focused on the upward flame spread of thermoplastic materials, but downward flame spread is an important pattern of flame spread[13]. Mechanism of downward flame spread of thermoplastic materials and its influence factors have not been clarified. In this paper, based on downward flame spread experiments of typical thermoplastic material, the evaluation of thermoplastic material in the downward flame spread process has been conducted, which aims at evaluating the fire risk in downward flame spread.

2. Experiment

2.1. Experimental system

The schematic illustration of the experimental system for downward flame spread is shown in Fig.1, which consists of combustion system and data collection system. A gypsum board of 30cm*15cm is fixed on the insulation board. A ruler is set on one side to record the experimental parameters. Samples of different widths are tied closely on the center of gypsum board. The whole system has been placed on a horizontal insulation board of 30cm*30cm. A smoke analyzer (Testo340) is placed around 15cm over the top edge of sample. The smoke analyzer mainly collects the volume fraction of CO, at the frequency of one data per second. The combustion process is recorded with a digital video camera.

Download English Version:

https://daneshyari.com/en/article/7226361

Download Persian Version:

https://daneshyari.com/article/7226361

Daneshyari.com