INVESTIGATION OF FLAMMABILITY PARAMETERS OF DIFFERENT TYPES OF FABRICS USING DIGITAL IMAGE PROCESSING TECHNIQUE

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Abstract

Fabric flammability is one of the most important criteria for the wearer safety. Apart from apparels, the need for textiles requiring defined flammability behaviour for improved safety spans a range of applications that includes furnishing and bedding, transport, civil engineering, medical and defense. Hence, researchers have been trying to determine the flammability capacity by measuring different flammability parameters like ease of ignition, the rate and extent of flame spread, the duration of flaming, measurement of heat release and heat of combustion. All these flammability parameters required to test in different instruments and also needs manual measurement system which involves human error. So this project aims to determine the key flammability parameters like burning time, burning rate, burning area, char length and the complete thermal profile of the fire by using image processing technique. The measurement has been done by developing a customised vertical flammability tester and capturing the videos of the burning samples and then processing the videos by a customised developed software in MATLAB platform. The flammability parameters have been evaluated for the 100% cotton fabrics, 100% polyester fabrics and blends of the cotton and polyester fabrics. These fabric flammability parameters are compared for safe use in apparels. It is observed that the cotton fabrics are most safe for apparels where as the 100% polyester fabrics are most dangerous in nature.

Key Words: Fabric flammability, image processing analysis, vertical flammability tester, thermal profile

1. Introduction

Flammability is the ability of a substance to burn or ignite, causing fire or combustion. The degree of difficulty required to cause the combustion of a substance is quantified through fire testing. Internationally, a variety of test protocols exist to quantify flammability [1]. Flammability testing is arguably one of the most important testing procedures within the textile industry because it has crucial safety implications in the event of a fire. It has been statistically shown that the major cause of fatalities in fire can be directly attributed to the accidental ignition of upholstery and textiles, so it is only sensible that proper flammability standards should be in place [2]. Flammability performance can be improved by the fabric manufacturer at the design stage to ensure a safer interior environment. Unfortunately, there is no single flammability standard for upholstery or vertical surface fabrics which has been adopted as the norm throughout the world and the plethora of different standards in force internationally reflects the different ways of approaching the whole flammability issue. There are an assortment of clothing flammability and related tests [3, 4]. These test methods attempt to determine how flame-resistant, heat resistant, or injury- resistant a particular fabric and/or garment is. The flammability test is conducted three basic formats such as small scale testing, large scale testing and the instrumented manikin test [5]. Small-scale testing is the backbone of research, as it provides the most cost efficient method to compare different specimens amongst one another. However, protective clothing small-scale test methods provide only a limited analysis of a fabric's performance in a specific scenario; thus several different tests may be required to get a general understanding of a fabric's performance [6]. Currently the large-scale test method for clothing flammability uses a fully dressed manikin to represent a person. This manikin is then subjected to a fire environment and an evaluation of the entire garment assembly is made rather than just a small sample of textiles from the small-scale test methods.

The proposed method to determine the different parameters by using image processing method is a small scale testing procedure in which different flammability parameters are determined accurately by analyzing the captured video of the burning sample.

2. Materials and Methods

2.1 Materials

Apparel grade fabrics are used for this study for the estimation of different flammability parameters. Five samples covering variety of structures are used for this study. The fabric specification is shown in Table 1.

Table: 1: Fabric specification used in this project

Sr. no	Sample	Weave	Areal Density (gm/m^2)
1	100% Cotton	Plain	213
2	100% Cotton	Twill (3/2)	205
3	100% PET	Plain	78
4	Cotton+5% Lycra	Denim	320
5	100% Linen	Plain	202

2.2 Methodology

2.2.1 Design of the Digital Vertical Flammability Tester

To measure the flammability of the fabric using image processing technique, an instrument was fabricated based on the basic idea of Vertical Flammability Tester [7]. It is designed in such a way that it can be used for conventional as well as for image processing technique for accurate results. The specification of the specially developed vertical flammability tester is shown in Figure1. The video capturing is carried out by using a digital video recorder in mp4 format. The standard dimension of the image is 1920 X 1080 and the depth of the image is 36 bit.

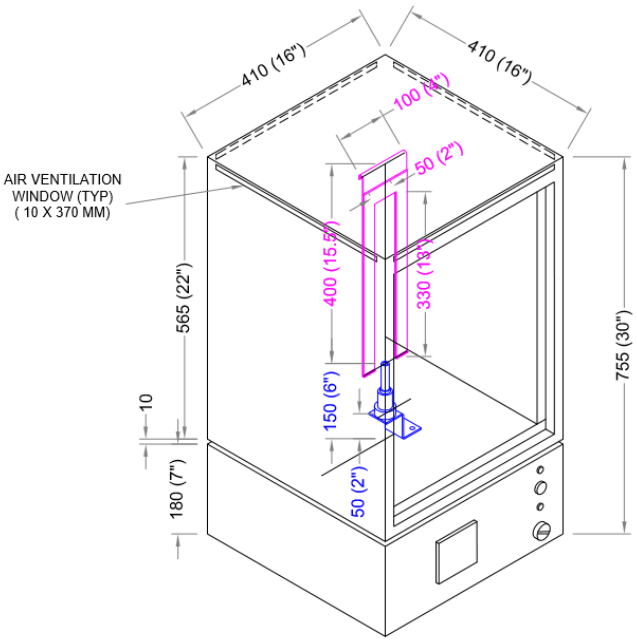

Figure 1: Schematic of vertical flammability tester (Front view)

2.2.2 Video Processing Algorithm

In this measurement technique, first video is grabbed by the CCD camera and that video is processed by the software developed in the MATLAB to calculate various flammability parameters. The

sequence of video processing operations used for determination of drape parameters, are given below in Figure 2.

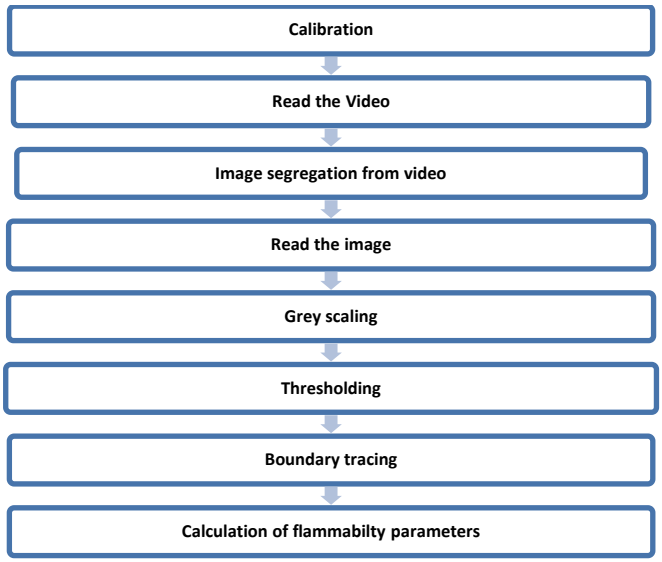

Figure 2: The flow chart of the working principle of the digital flammability tester

2.2.3 Definition flammability Parameters

Burning Time: It is the recorded time taken for the self-extinguish of the sample after ignition.

Propagation rate: Rate of flame spread is calculated by measuring the distance and recording the time taken of the advancing flame front to sever threads

Char Length: It is the maximum length of the burned length of the sample after self-extinguish of the sample.

Heat profile: The heat profile of the burning samples can determined by a thermal camera. The images captured by the thermal camera will help to analyses the severity of the thermal behavior of the fabric samples.

2.2.4 Testing Procedure

The samples are tested as per the following [8]

a) Sample size 330×50 millimeter
b) All fabrics are oven dried for 30min.at 105ºC
c) All fabrics should then be placed in desiccator for at least 15min. before testing
d) samples are secured into frame using two clips on each side

3. Results and Discussion

3.1 Estimation of fabric flammability characteristics

The fabric samples were evaluated for various flammability parameters using the newly developed digital image processing based vertical flammability tester and also the conventional vertical flammability tester. The results for flammability parameters measured by the conventional technique and by digital image processing technique are given in Figure 3.

Figure 3: Thermal image of Sample 2 at different burning time

3.2 Thermal profile of the burning samples

This study also aims to analyze the thermal profile of the samples. This purpose is achieved by capturing the thermal images of the burning samples at different time interval. The maximum temperature is observed at middle of the burning sample area which attains about 280^0C. This temperature is very dangerous for the human skin in case of fire in the garments. The emissivity represents potential heat that can be transmitted to the burning sample to the next layer i.e to skin.

3.3 Comparative Assessment of flammability by Image processing method and conventional method

The flammability assessments of the five samples are estimated by using image processing technique and also with the conventional technique. The results are shown in Figure 4. It is found that both the techniques has the similar burning time and char length. But apart from these two parameters other parameters (char area, centroid of the burning mass) can also be estimated by image processing technique. Hence this method is more useful for the assessment of the complete behavior of the flammability of textile fabrics.

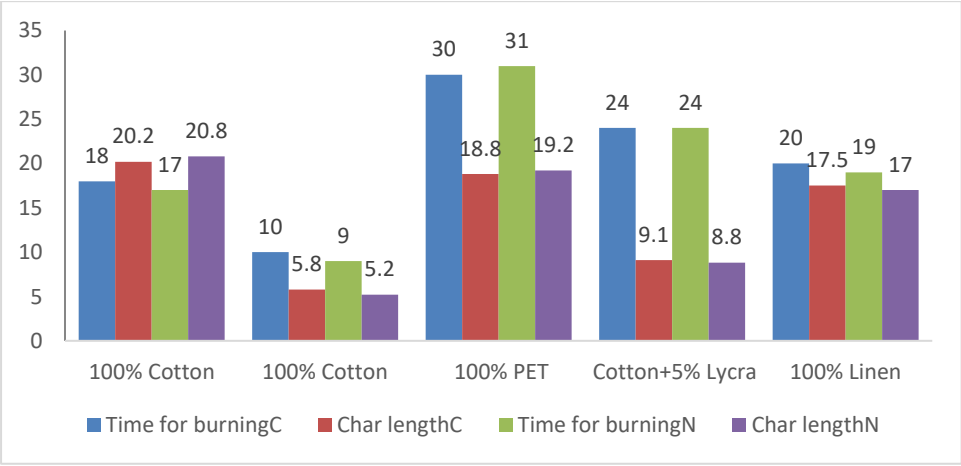

Figure 4: Comparative Assessment of flammability by Image processing method and conventional method (C-conventional and N –New)

4. Conclusion

In this study, a trial has been made to characterize the fabric flammability behavior of different types of fabrics by using image processing technique. This method is also validated by comparing the burning time and char length with the conventional technique. It is observed that both the methods have the similar results. The image processing method is also capable to estimate different flammability parameters like char area, centroid of the burned area for complete understanding of the flammability behavior of the fabrics. So this method can replace the conventional technique for fabric flammability test.

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