CHAPTER - 9
CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH WORK

9.1 STUDY ON BURN VICTIMS

The analysis of burn victims statistics shows that on average about 60-80% accidental cases is fatal. Study of 360 fire victims involved in different fire accidents reveled that about 70% of the total accidents occurred in the kitchen. Around 70% victims involved were female of which 48% were wearing saree.

Study on source of fire, shows that kerosene (31%) and gas (29%) altogether accounts for around 60% of the total accidental cases.

Maximum accidents occurred with the cases wearing clothes of polyester material for the age group of 40-45 years, polyester:cotton blends for age group of 30-35 years and cotton for an age group of 20-30 years.

9.2 IGNITION STUDIES

The major objective of the ignition studies is to measure the time required by any particular zone of saree to ignite for a pre-defined height of flame, which determines its chances to ignite if it accidentally caught by flames. the study show that for all saree fabrics (cotton, cotton:polyester blend (50:50), cotton:polyester blend (67:33), cotton:polyester blend (33:67), polyester, silk, viscose, nylon, polyester:viscose blend (67:33) and polyester-:viscose blend (33:67)), the safest combination of blouse is polyester fabric. Polyester blouse fabric takes much higher time to ignite at various zones and provide maximum time for the victim to escape from the ignition as compared to cotton and polyester:cotton blended blouse. Heavy or light cotton petticoat of cotton shows no significant difference in time to ignite.

According to the ignition studies of the saree along with its supporting garments, which ranks the saree on ease to ignite and unsafe to use. Cotton saree ranks first, as ignites earliest followed by polyester:cotton (33:67),

polyester:viscose (33:67), polyester:cotton (67:33), polyester:cotton (50:50), polyester:viscose (50:50), polyester:viscose (67:33), polyester and nylon saree. The studies on ignitability show that cotton is most unsafe where as nylon is the safest for use in saree fabric.

9.3 AVERAGE INCIDENT HEAT FLUX STUDIES

Cotton blouse is safest option for all saree to be used along with the other supporting garments, except polyester, polyester:cotton (50:50) and polyester:cotton (67:33) saree, where polyester blouse shows least average heat incident flux and proved to be safest, to be used along with the supporting garments.

Light cotton petticoat shows least average incident heat flux for all saree material and is safest to be used along with all the saree as compared to heavy cotton petticoat.

Average incident heat flux studies show dissimilar results and ranking of saree along with the supporting garments. As the burn-injuries are due to incident heat fluxes on the skin, increase in the average incident heat flux, increases the severity and higher will be the degree of burn. Accordingly, cotton saree show least average incident heat flux and ranks first in safety followed by nylon, polyester:cotton (33:67), polyester:viscose (33:67), polyester:cotton (67:33), polyester:viscose (50:50), polyester:cotton (67:33), polyester:viscose (67:33), polyester:cotton (50:50) and polyester.

Compared to the approach of ignition studies (as it is used in most flammability test parameters across the world and even used in this study) and heat flux, for ranking of safety of saree, heat flux study is more logical and practical, because safety just cannot be ranked on the basis of possibility of catching fire of garment. But it should be based on actual heat absorbed by the human skin during the burning of garment and thus this study supports and recommends the ranking of saree as per the heat flux approach.

9.4 THERMAL PARAMETERS CORRELATIONS

It is seen that for all the fabric samples like cotton, nylon, polyester and viscose as the gsm of the fabric increases, the AIHF values also increases, showing polynomial correlation. Nylon shows less average incident heat flux values for around 500-gsm fabrics but for heavy gsm, the average heat incident flux values are higher compared with cotton, polyester and Viscose. When flame propagation rate is plotted against gsm for various fabrics and their combinations, it is seen in most of the cases the flame propagation rate remains almost constant up to 250 gsm and there after it increases as the gsm increases. Even the flame propagation rate depends upon the composition of material and the angle of burning, from the predicted plots it can be seen that rate of burning does not show any strong correlation between burning rate and gsm.

9.5 FABRIC CHARACTERISTICS STUDIES

Increasing pick density increases the flame propagation time and burning time for all (plain, twill, satin and matt) weaves. Increase in pick density lead to increase in weight per unit area, there by more amount of mass to burn, which requires more time to burn. In addition, average incident heat flux values found to be increased with the pick density.

The Flame Propagation time and the Burning time for matt weave for all samples 30, 40, 50, 60 and 70 is highest, followed by satin, twill and plain weaves. Similarly, the average incident heat flux for matt weave is significantly higher as compared to the other weaves. Satin weaves shows less average incident heat flux values compared to matt weave, but more than twill and plain weave. Plain weave shows least average incident heat flux values.

Dyed fabrics show higher resistance to flame propagation and burning rate. In most of the cases in plain, matt, twill and satin weaves the reactive dye shows more flame resistance as compared to direct and vat dyes. Reactive dye molecules forms covalent bonds with fibre where in case of Vat and direct dye, dye molecules attach to fiber due to polar attraction, which need less

energy to break, and burning will be similar to that of bleached sample. But the direct dye and Vat dye shows more flame resistance then bleached fabric. However, results of average heat incident flux when compared with bleached samples do not show significant change in the values indicating no influence of direct, reactive and vat dye on average heat incident flux values.

9.6 AFTER CARE PRACTICES

Cotton show significant increase in average incident heat fluxes after 5 washes. Polyester:cotton blend does not show any change in average incident heat fluxes values for initial washings up to 15 washes, but shows significant change only after 20 washes and polyester fabric show no significant changes in average incident heat fluxes due to number of washing process, as there is no physical and chemical change in the polyester fabric due to washing.

In actual practice ironing of clothing is carried out after washing and drying process, therefore each fabric is washed before ironing of samples; the results of these tests give the combined effect of washing and ironing. While comparing the results of washing and ironing, it is found that there is no significant change in gsm and average incident heat flux values for all the samples of cotton, polyester and its blend after several washing and ironing cycles. The effect of only washing cycles on flammability is found moderate.

Exposure to light does not influence mass per unit area of all fabric samples. The burning test results of polyester and its blend with cotton show significant increase in average incident heat flux values only after 15 hours of light exposure. This change in average incident heat flux may be due to thermoplastic behaviour of polyester fibres, which brings a change in molecular state due to constant light and heat application. Study on cotton fabric revels that there exists no significant change on average incident heat fluxes even after 15 hours of light exposure.

It is observed that due to blueing process, the hydrophilic cotton yarns swells and in turn shrinks the fabric, there by increasing the weight per unit area of

the sample. This increase in gsm of fabric samples does not influence the average incident heat flux for low concentration but influences at high concentration blued samples. This increase in average heat incident flux can be due to deposition of blueing agent particles on the fabric, supporting the combustion and burning process.

9.7 SUGGESTION FOR FURTHER WORK

The work detailed in this thesis has shown that saree can be ranked based on their flammability hazard in terms of ignitability and average incident heat flux. In order to validate more thoroughly each of the newly developed techniques to measure the flammability of fabrics, further studies are required in areas indicated below:

1. The average heat incident flux values needs to be validated over a wider range of fabrics comprising different fibre, yarn and fabric structures and especially FR-treated fabrics. Ignition modulus of polyester:cotton blends fabrics needs to be closely investigated so as to examine the effect of blend ratios.

2. In depth studies of variations of flame dimensions at different fabric orientations needs to be examined which in turn would enable estimation of the amount of heat transferred to the virgin fabric and hence the rate of flame propagation. The reasons for the occurrence of turbulent flame behaviour at certain angles of inclination and stages of burning require being investigation.

3. An accurate method of measuring temperatures at the basal layers of skin need to be investigated to solve the proposed three dimensional model for prediction of burn injury.

4. The early ignition conditions and associated rise of heat release (which also increases the value of PHRR) due to fast flash ignition in the cone calorimeter as discussed in Section 7.6.5, might not replicate more realistic ignition conditions where the ignition is via burning match-stick or a gas flame and there are clearly different pyrolysis circumstances. A more realistic effect of incident heat flux on TTP and peak heat

release rate could therefore be studied using a direct contact flame as a source of ignition.

5. Smoke toxicity hazard of apparel fabrics has not been addressed in this thesis. Thus, this aspect of flammability hazard can be studied as one of the major parameters in ranking the fabrics for their potential burning hazard.

6. Fabric samples from the real fire victims need to be tested by using the above-developed methodologies and the data correlated with that for experimental fabrics in this thesis and burn severity derived from Hospital Burns Unit experiences.