

Design and development of an instrument for analyzing performance of fire protective clothing and determining second degree burn time for skin

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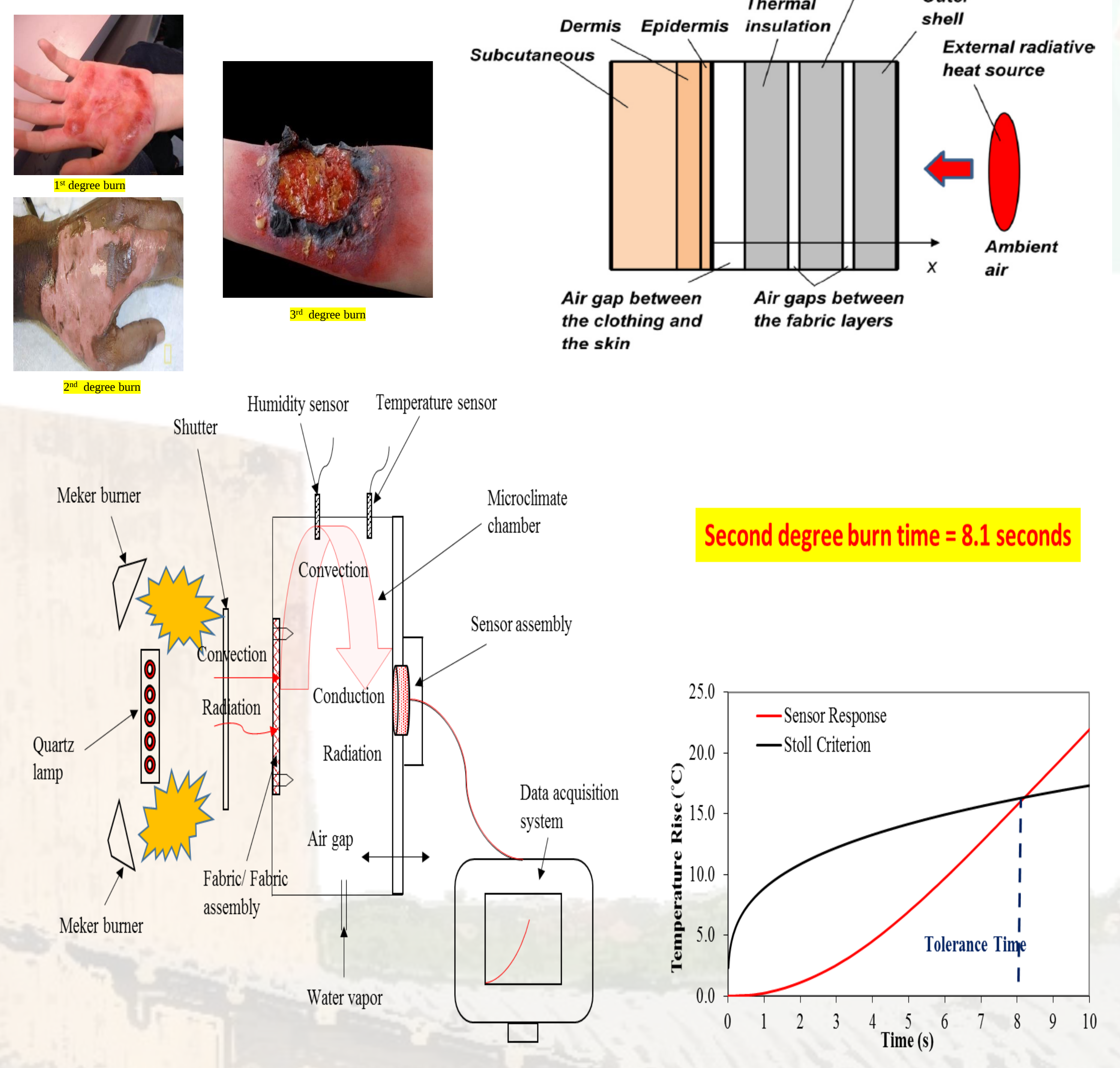
Abstract

Safety of industrial workers and firefighters operating under hazardous conditions is a major concern now-a-days. These people encounter various level of heat and flame exposures while performing duty. This instrument measures heat transfer through fabric and air gap system, second degree burn time and able to deal with heat transfer through the skin layers and operates in three modes conductive, radiative and conductive cum radiative.

Introduction

It is observed that although enough research have been done to analyze fire resistance of fabrics still the mechanism of heat and moisture transmission through fire protective fabrics has not been understood completely, especially the effect of moisture on thermal protective performance of the fabrics. Effect of moisture present in the protective fabrics is very complex on protective performance of the fabrics and skin burn injuries. It is different for different type of exposures, level of exposures and amount of moisture present in the fabric. It is evident from the literature that no such instrument is available till now which can analyze heat and moisture transmission simultaneously at such extreme environmental conditions.

Materials and Methods



Conclusions

- ✓ Equipment can operate on three modes: 100% Radiative heat exposure, 100% Flame exposure and 50-50 Convective-Radiative heat exposure.
- ✓ Microclimatic conditions in the air gap may change depending upon the activity level of the wearer.
- ✓ The proposed instrument could assist the manufacturers or the researchers to develop better fabrics for fire protective clothing.

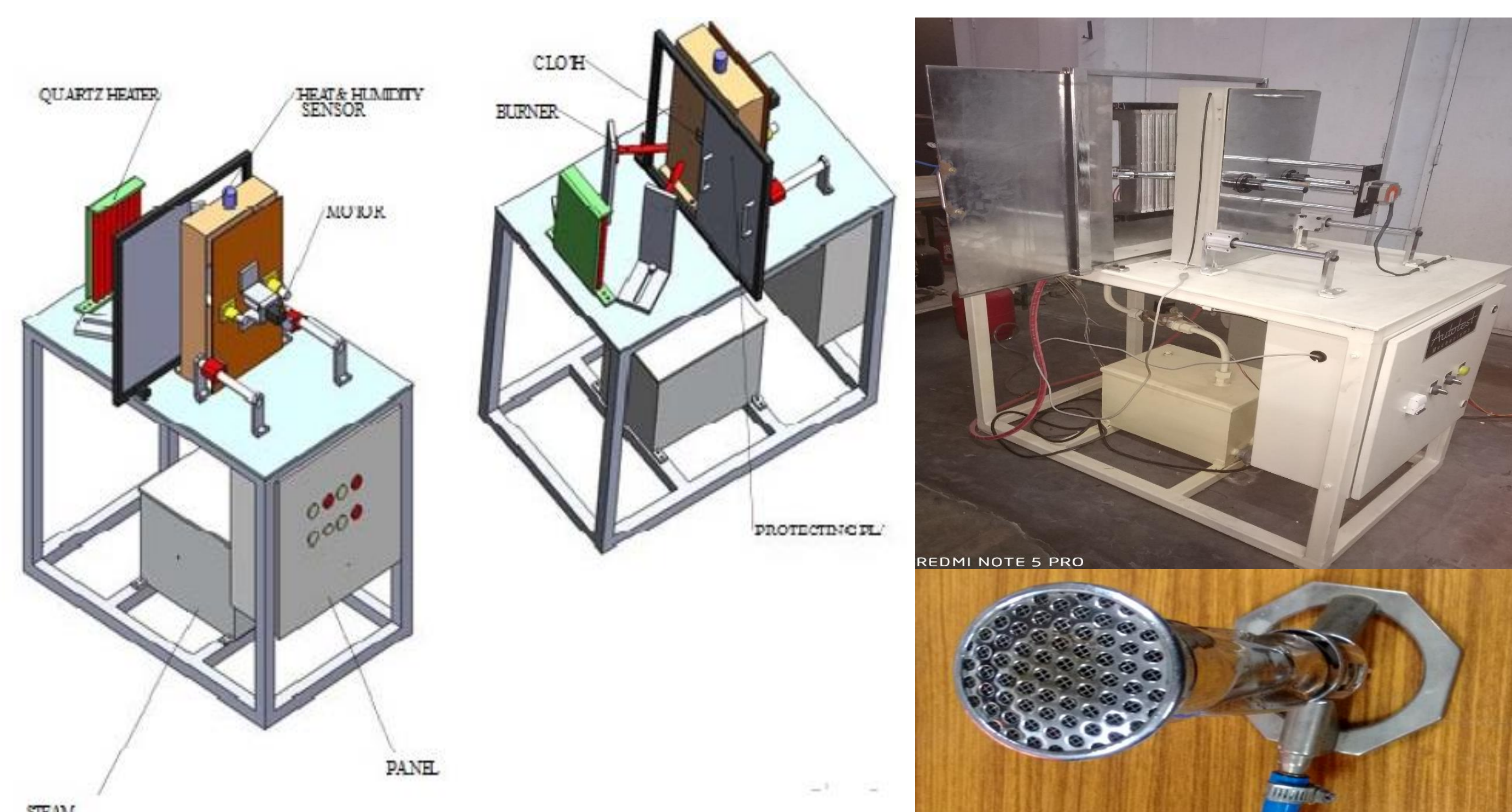
Industrial Significance

- Indian Application Number- 201711009514
- Non-Disclosure Agreement has been signed between IIT Delhi and Texlab Industries Pvt. Ltd. Ahmedabad, on 07.12.2018 for up scaling the prototype.

Technology Readiness Level

- ➔ Instrument has been developed and set up in lab.
- ➔ Setting of heat flux, other parameter and testing is under process.

Result



- To measure heat transfer through fabric and air gap system. Air gap can be static or dynamic as per requirement. Sweating and microclimatic conditions in the air gap can be changed as per requirement
- The instrument not only measures heat transmission through fabrics exposed to fire but will also be able to quantify the second degree burn time and extent of the skin burn accurately.
- The proposed instrument will be able to deal with heat transfer through the skin layers and predict second degree burn time more accurately, taking non-Fourier phenomenon in skin into account.

Application Potential:

➤ Immediate

This equipment can be used for testing fire protective clothing/fabrics and R&D purpose.

➤ Long Term

This equipment can replace horizontal TPP Tester, which is available in commercially, as it simulates conditions during structural fire outbreak. It can also be used for testing Composites. Applications in aerospace and building structure industry is possible.

The developed instrument will be use to predict skin burn degree and the thermal protective performance of the fabric by Henrique's Burn Integral Method.

$$\Omega = \int_0^t P \exp\left(-\frac{\Delta E}{RT}\right) dt$$

Where,

- P = Pre-exponential factor (1/s),
- T = Temperature (K),
- ΔE = Activation energy, and
- R = Universal gas constant (8.314kJ/kg-K).

References

- Udayraj, Prabal Talukdar, Apurba Das, Ramasamy Alagirusamy, Heat and mass transfer through thermal protective clothing – A review, International Journal of Thermal Sciences, Volume 106, August 2016, Pages 32–56.
- Udayraj, Prabal Talukdar, Apurba Das, Ramasamy Alagirusamy, Estimation of radiative properties of thermal protective clothing, Applied Thermal Engineering, Volume 100, 5 May 2016, Pages 788–797.
- Udayraj, Talukdar, P., Alagirusamy, R., Das, A., Heat transfer analysis and second degree burn prediction in human skin exposed to flame and radiant heat using dual phase lag phenomenon, International Journal of Heat and Mass Transfer, Volume 78, November 2014, Pages 1068–1079.

Acknowledgement

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