SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator
Action number: CA17107
STSM title: Analysisng the thermal protection of firefighter/high functional clothing
STSM start and end date: 14/07/2021 to 18/07/2021
Grantee name: Adnan Ahmed Mazari

PURPOSE OF THE STSM:

Firefighters are always working under constant threat because of hazardous working conditions due to which they need suitable amount of protection against dangerous situations. The primary task of firefighter clothing is to guarantee that the rate of rise of temperature in human skin must be reduced or slowed down in order to provide sufficient amount of time to the firefighter to respond efficiently along with minimization of hazardous injuries to skin. Firefighter protective clothing normally consists of three layers: outer shell, moisture barrier and thermal liner. When thermal protective performance of firefighter protective clothing is enhanced, the time of exposure against radiant heat flux is increased, which will provide extra amount of time to firefighter to carry on their work without suffering from severe skin burn injuries. There are several ways to improve thermal protective performance. In this study, four different multilayer combinations of firefighter protective clothing will be investigated. Two samples have combinations consisting of outer shell, moisture barrier and thermal liner. In other two sample arrangements, aerogel sheet will be also employed as a substitute to thermal barrier.

Objectives of the research are

1- To test the heat and mass transfer through fire fighter clothing.
2- To analyze the effect of each layer of firefighter clothing on the overall decrease in the comfort properties.
3- To propose better combination of layers for improved performance related to comfort, heat insulation and moisture permeability

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

The STSM at Lodz University of Technology was very helpful to learn from the expertise of Prof. Małgorzata Matusiaki, who is specialized in the field of the comfort where as Dr. Mazari is more focused on the physiological properties. The STSM helped to discuss and analyse the samples of Fire fighter technical clothings for the possible measurement of heat insulation, comfort and performance.
In this experimental work, Improvement in thermal insulation properties of firefighter protective clothing with the help of Aerogel blankets. Aerogel layer was used as substitute layer to thermal barrier. Two different outer shells, one moisture barrier and one thermal liner were employed as stated in table 1. Four different combinations of clothing assemblies were prepared as mentioned in table 2 and figure 1 respectively.

Table 1: Specifications of multilayer clothing arrangement

Layer	Fabric Code	Component	Fabric weight [g/m²]	Thickness [mm]
Outer layer 1	O(1)	% 75 Metaaramid-23% Para aramid-%2 Antistatic	220	0.82
Outer layer 2	O(2)	Proban (100 % cotton)	245	0.96
Moisture barrier	M	PTFE membrane laminated to meta aramid	125	0.9
Thermal liner	T	Liner:50/50meta -Aramid /FR Viscose Thermal part: Para-aramid	380	3.12
Aerogel blanket	P	Trimethylsilylated silica gel, oxidized polyacrylonitrile polymer	320	2.75

Table 2: Combinations of clothing assemblies

Sr #	Fabric arrangement in multilayer clothing assembly	Fabric Code
1	Outer shell (1) + Moisture barrier+ Thermal liner	A
2	Outer shell (2) + Moisture barrier + Thermal liner	B
3	Outer shell (1) + Moisture Barrier + Aerogel sheet	C
4	Outer shell (2) + Moisture Barrier + Aerogel sheet	D

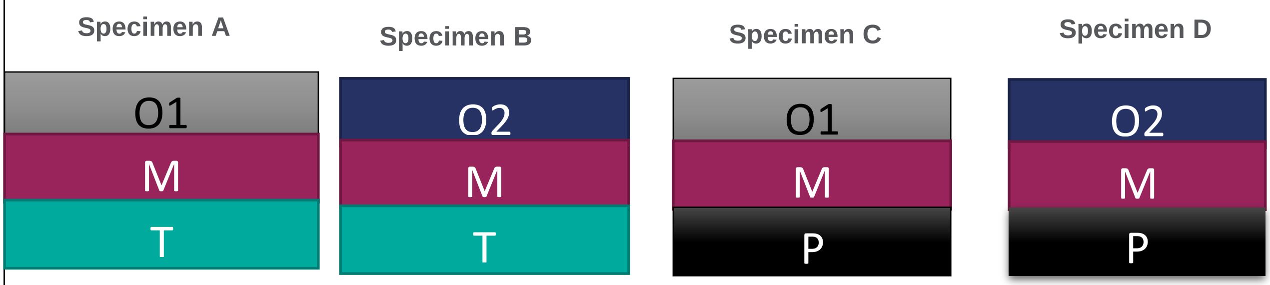


Figure 1: Samples combination

<u>DESCRIPTION OF THE MAIN RESULTS OBTAINED</u>

Four different combination of sample are prepared for the testing as shown in figure 1, it includes, NOMEX and PROBAN as outer layer, **Moisture** barrier in the middle, and **Thermal** barrier/ Aerogel blancket which is next to the skin. The samples will be tested for air permeability, water vapor permeability, thermal conductivity and radiation heat insulation.
Initially the water vapour resistance and thermal resistance are measured on the device Permatest and Alambeta and following results are obtained,

Table 3: Water vapour and thermal resitance of samples

Fabric arrangement in multilayer clothing assembly	Thermal resistance [m²K/W]	Water vapour resitance[m²Pa/W]
Outer shell (1) + Moisture barrier+ Thermal liner	0.14	38
Outer shell (2) + Moisture barrier + Thermal liner	0.12	37
Outer shell (1) + Moisture Barrier + Aerogel sheet	0.19	49
Outer shell (2) + Moisture Barrier + Aerogel sheet	0.16	43

A careful analysis of Table 3 revealed that more water vapor resistance was witnessed in specimen C and D utilizing aerogel blanket. This might be due to hydrophobic nature of aerogel and presence of closed pores inside the structure of aerogel blanket

Secondly the air permability of the outer shell is measured as all other layers are impermeable.

Table 4: Air permeability of samples (outer layers)

Air permability of samples	l/m²/sec
O1	389
O2	375

Thw X637 B radiant heat transmission machine uses ISO 6942 standard to measure transmission of heat through material or material assembly.

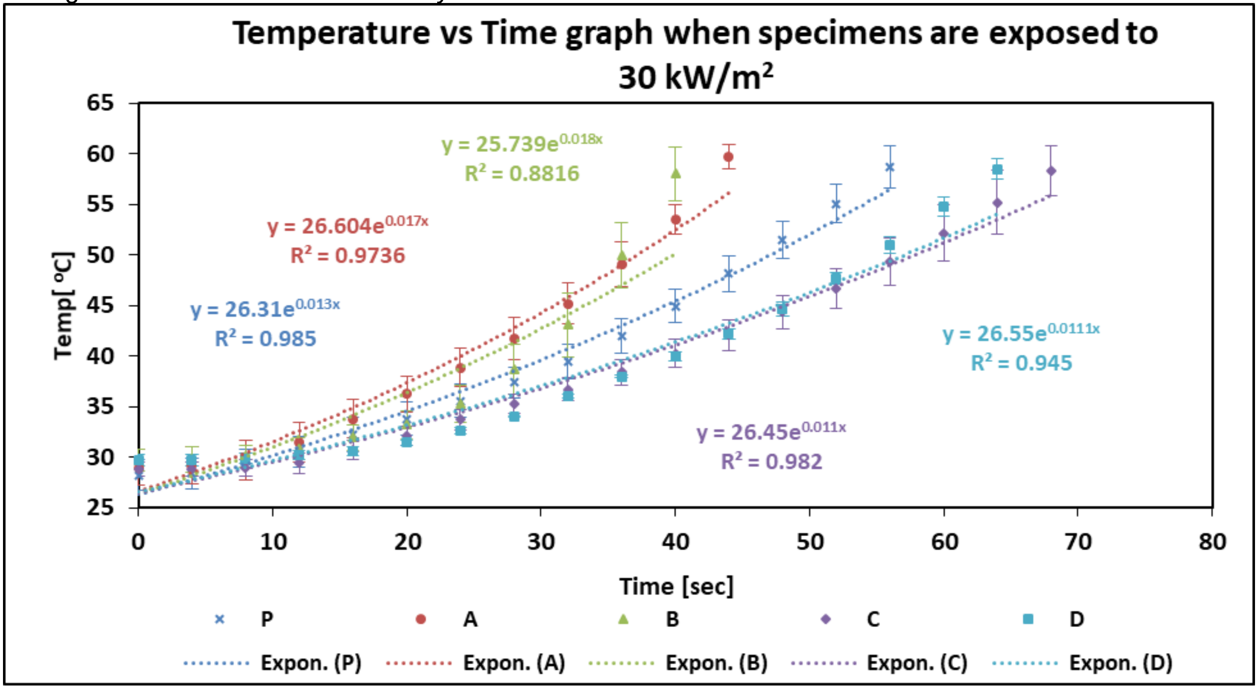


Figure 2: Samples combination

In case of 30 kW/m^2 from figure 2, there was dissimilarity in the pattern of the curves for aerogel blanket and specimen A showing loss of thermal stability of fibers at higher flux density as compared to aerogel blanket. But the curve of specimen B depicts irregular behavior after 30 seconds showing sudden sharp increment in the temperature, which is clear indication of decrease in thermal protective behavior of specimen because structural changes or deterioration of outer shell of specimen B due to swift rate of decomposition of cellulosic fibers as the incident temperature at surface of specimen

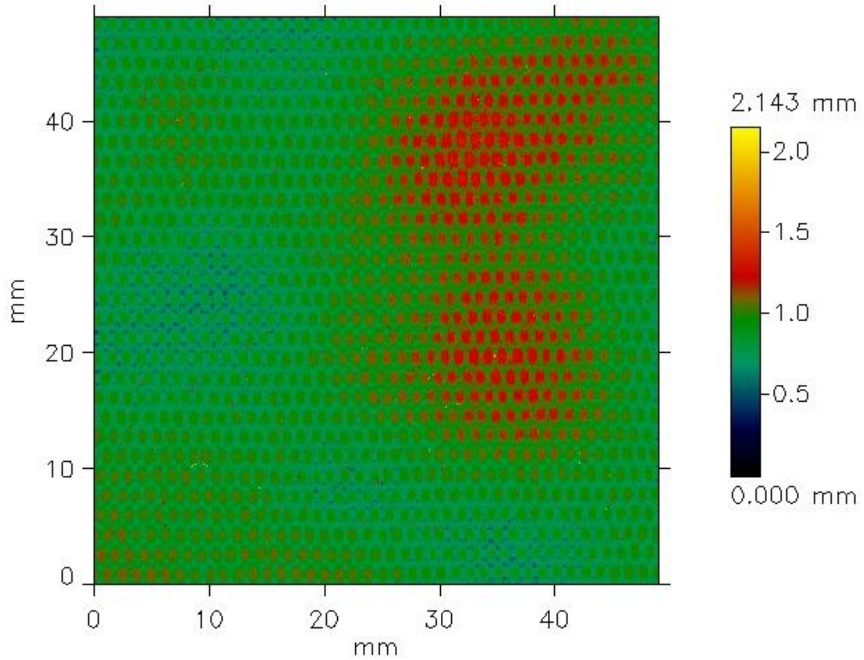
FUTURE COLLABORATIONS (if applicable)

The STSM was very useful to know the research capabilities of both institutes and find opurtunities to apply for mutual projects.

The STSM was also used to undetstand the the working principle of unique device at Lodz University, which is MICRSPY profile analyser, it is a fast optical point sensor which works on the principle of chromatic distance measurement. The CWL's non-destructive method works equally reliably on highly reflective and low-reflective surfaces.

Prof. Matusiak gave training for using the specific device. The device is very useful in determining the roughness and waviness of any textile samples.

Following output of the textile samples were obtained from the experimental results.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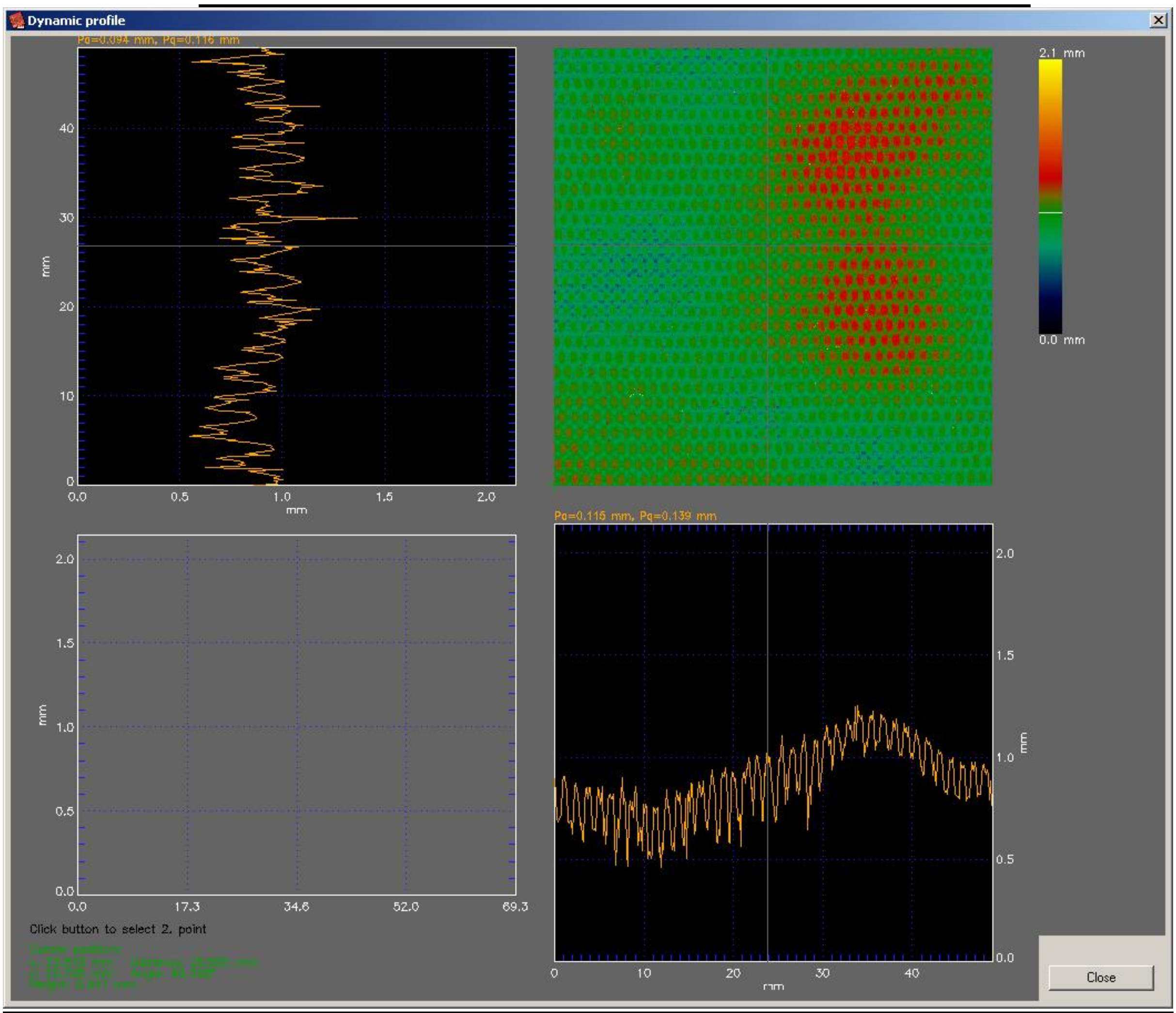
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