CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
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Project Number
S1823

Project Title
Using Specific Heat Capacity to Engineer a Thermal Evacuation Suit to Address Heat Transfer Processes

Abstract

Objectives/Goals
To engineer a high heat conduction thermal evacuation suit that also addresses superheated penetrating gas. Suit will allow a person to escape a fire of temperatures reaching 980 degrees Celsius and convection heat of 32kph for five minutes without causing any permanent damage to the user.

Methods/Materials
Tested various silica for heat reflection and insulation. Modified sodium polyacrylate to achieve the highest amount of insulation while retaining full mobility. Once ideal combinations were found, I created prototypes and tested them on temperatures of up to 980 degrees Celsius and superheated penetrating gas up to 32kph. Recorded their times and temperatures to find their specific heat capacity and compared it against the current bunker gear used by firefighters. Test was designed to last five minutes in a scenario that would have the user exposed to 980 degrees Celsius in fully immersed flames and superheated gas. Independent variables: different types of silica fabrics, sodium polyacrylate compound, and Magna Nomex. Dependent variables: time of fire/heat resistance and superheated gas. Controlled variables (constants): propane torch, heat gun, charcoal briquettes, measurement tools (laser digital thermometer, Oneida digital thermometer probe, and anemometer), construction materials, and time exposed to open flame.

Results
The best light-weight full mobility thermal evacuation suit has the right balance of silica thickness and sodium polyacrylate compound with a safety layer of Magna Nomex. This combination addressed a full immersion fire of 980 degrees Celsius with superheated gas while allowing full mobility without harming the user for five minutes.

Conclusions/Discussion
Refrasil UC100-48 has the ability to be a high heat insulator and a shield from direct flame. The sodium polyacrylate compound proved to be a superior insulator and barrier to superheated gas. All silica are semi-conductors. Silica stops open flame from penetrating, but it conducts heats up to 400 degrees Celsius. The sodium polyacrylate compound is a high heat insulator, which effectively delays heat transfer. The compound also blocks any superheated gas due to its strong ionic bonds. The combination of silica and sodium polyacrylate compound produced latent heat graphs that had uniquely long plateaus that reached up to two minutes.

Summary Statement
To engineer an evacuation suit that addresses high intensity heat and superheated gas so that it allows the user to self-rescue with no bodily injury.

Help Received
Henry Modregon helped me understand the different properties and assisted me in testing the various materials. Captain Jaime Phillips provided me with first-hand accounts on the field.