Name: _____

Thermal Energy and Insulated Clothing

Material engineers develop and test materials for different products. Some materials engineers specialize in working with textiles, like fabrics or cloth. Textiles are used to create aerodynamic suits for speed skaters, protective suits for people who work with dangerous chemicals, and uniforms for athletes.

Today, you will learn about textiles that are used to stop the flow of heat to keep people from getting too hot or cold. Follow the steps below to learn about different insulating materials and design your own insulated clothing!

Step 1: Read information about thermal energy

Read the attached article. Then, answer the questions below.

1. What is heat transfer?

2. Do you think a piece of clothing with 2 layers or 4 layers would be better at reducing heat transfer? Why?

3. Firefighters need insulation to stop heat from flowing through to them to they don't get too hot. Describe a time when people need insulation to stop heat from flowing away from them, so they don't get to cold.

4. Why is it important to test a prototype before sending it into production?

Name: _____

Thermal Energy and Insulated Clothing

Step 2: Choose a type of clothing to design

Imagine you have been hired as a materials engineer to create a new type of insulated clothing that will be worn during winter. Insulated clothing is clothing that is made out of materials that minimize heat transfer. When it is cold outside, an insulated jacket slows down the body heat flowing away from the person to the air around them. As a result, more body heat stays close to the body and keeps the person warm.

Read about three groups who are looking for new, insulated clothing. Choose one group from the list below.

Athletes who practice sports in the winter

Material engineers recently designed sportswear that is coated in a special yarn. When it is warm, the yarn reacts to sweat and lets more heat out of the material to cool athletes down. When it is cold, the yarn also insulates, or traps, more heat close to the athletes' bodies. These athletes want a new design of jacket to wear when its super cold out, but they don't want to get too hot from their workout.

People with medical conditions, like arthritis

People with arthritis report that cold weather makes their symptoms flare up. This means it is more painful to bend their joints. They are encouraged to wear thermal gloves and clothing. These materials stop the heat from transferring from their bodies to the surrounding air. They also stop cold winds from getting through. As a result, their joints do not get as stiff because they are warmer, they don't feel as cold.

Police dogs

Thermal gear isn't just for humans! Police dogs need thermal jackets for when they go on patrol in rough winter conditions, like cold temperatures, snow, and sleet. These jackets keep the dogs' body heat from transferring away from the dog to the surroundings. They also stop the wind from getting through. The jackets also need to be waterproof so the dogs don't get soaked when they are chasing bad guys through puddles.

Name: _____

Thermal Energy and Insulated Clothing

Step 3: Read about material options

To design your clothing, you will need insulating materials as well as an inner and outer layer of fabric. The insulating materials slow down the flow of heat. The inner and outer layers hold the insulating material in place. Below, you will see examples of materials that are used for the insulation as well as outer and inner layers of fabric.

Insulating Materials

Some insulating materials are made from feathers. Different feathers have different qualities.

Duck Feathers

- Slow down heat the least
- Will protect against cold as low as 40 degrees F
- Low cost (anyone could afford this material)
- Heaviest weight

Canadian Goose Feathers

- Slow down heat a medium amount
- Will protect against cold as low as 25 degrees F
- Medium cost (some people can afford this material)
- Medium weight

Hungarian Goose Feathers

- Slow down heat the most
- Will protect against cold as low as 0 degrees F
- High cost (very few people can afford this material)
- Light weight

Outer Layer

Outer layers is visible to other people and the environment. If also protects against wind, snow, or rain. Examples include:

Nylon

- Thin, lightweight, and inexpensive
- Stops the wind but isn't waterproof
- Can tear easily

Rubber

- Thicker and heavier than nylon
- Stops the wind and rain
- Doesn't tear easily

Inner layer

This layer touches the body of the person or animal wearing the clothing. It should be comfortable. Examples include:

Cotton

- Inexpensive and comfortable
- Can get wet if you sweat too much
- Doesn't dry easily

Rubber

- Expensive and comfortable
- Flexible and stretchy
- Doesn't soak up sweat

Name: _____

Thermal Energy and Insulated Clothing

Step 4: Design a new piece of clothing

Design a piece of clothing for the group you chose in step 1. Requirements for your clothing include:

- Three layers: outer layer, insulating materials, and inner layer
- At least one other cool feature (built-in headphones, pocket for a dog bone)
- Material choices that match the group you are designing for (e.g., think about weight, cost, features of the material)

Name: _____

Thermal Energy and Insulated Clothing

Step 5: Design a tag

Design a tag that will go inside the clothing. Your tag must have the following information:

- A diagram showing how your clothing prevents heat transfer (hint: use the diagram on page 3 of your article for help)
- List of materials that are in the three layers
- Optional: name of company and logo (you can make up a company or use one that you know)

Name: _____

Thermal Energy and Insulated Clothing

Step 6: Explain choices

Write 3-5 sentences explaining why you chose each of your materials below. Be sure to explain how your choices will make the best piece of clothing for the group you are designing for.

Li Na the Materials Engineer: Learning About Textiles

Who is Li na?

Hi, I'm Li Na! I am a materials engineer.

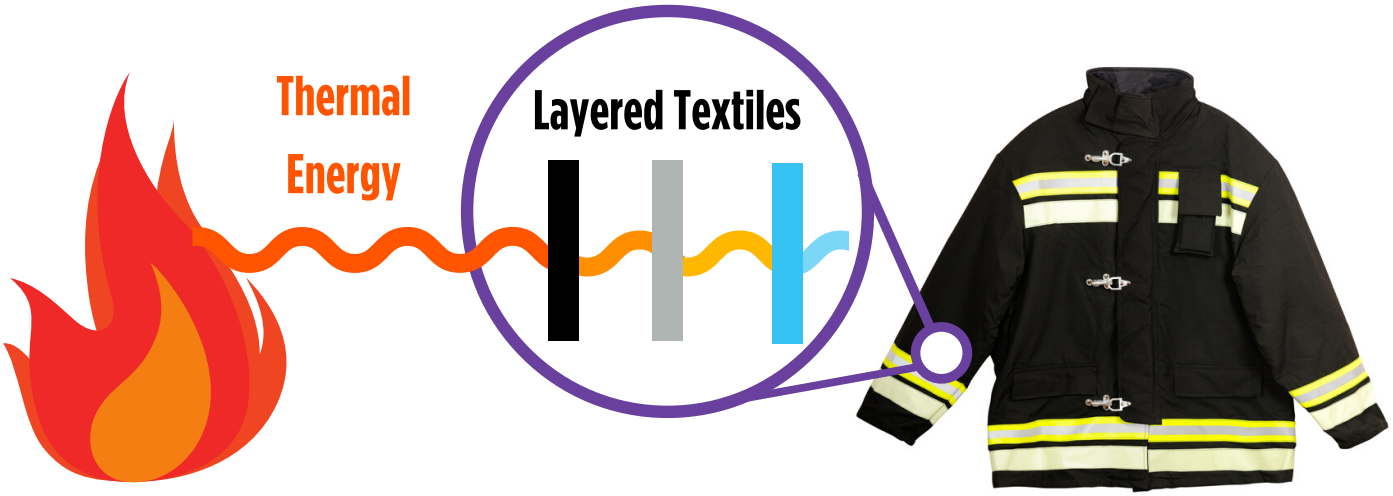
A materials engineer designs, creates, and tests materials that are used to make new products. As a materials engineer, I specialize in textiles. Textiles are fabrics used to make products, such as clothing and bath towels.

What I am Working On

I am designing a new protective suit for firefighters. So far, most suits are made from aramid fibers. Aramid fibers are materials that are very heat-resistant and strong. However, these suits can be bulky and cause firefighters to get too hot.

My goal is to create a new fire suit that will protect firefighters from burns and from getting too hot while working.

The suit will include a jacket and pants for firefighters to wear. The suit needs to protect the firefighters from burns and the heat of the fire by reducing the amount of thermal energy transferred from the fire to the firefighter's body. Thermal energy is energy that makes something hotter or colder. When thermal energy transfers from one object to another, we call it heat transfer. My new suit will minimize heat transfer by layering new textiles that won't let heat through to the firefighter's body.



Favorite Tools/Gadgets to Use at Work

Testing chamber:

An enclosed area used to start fires and test the firefighter gear.

Manikins:

A human-shaped dummy used for testing firefighter gear.

iPad:

A device for Internet research and collecting test data.

Testing the Design

After completing my prototype of the fire suit, I need to make sure it works to reduce thermal energy transfer. A prototype is a working model of a design that is often used for testing an idea.

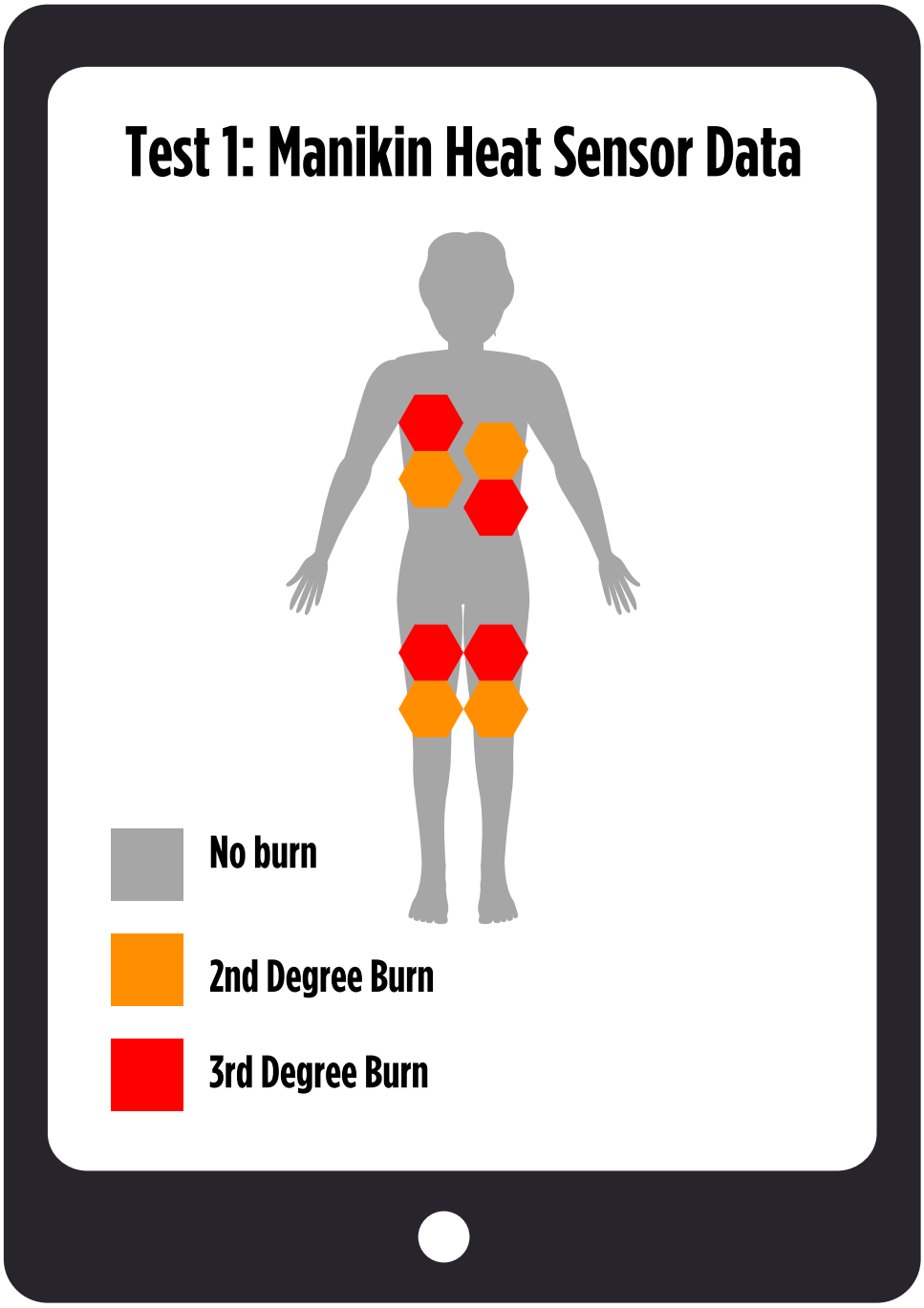
To test the prototype, I dress my manikin in the new suit. The manikin has heat sensors all around it that will provide data on predicting the amount of burns a real person would get if they were wearing the suit in a fire.

Heat Sensors

Then, I put the manikin in the testing chamber where I can start a fire but keep it in a safe and contained area. When the testing is complete, the heat sensors send the data about the burns to my iPad.

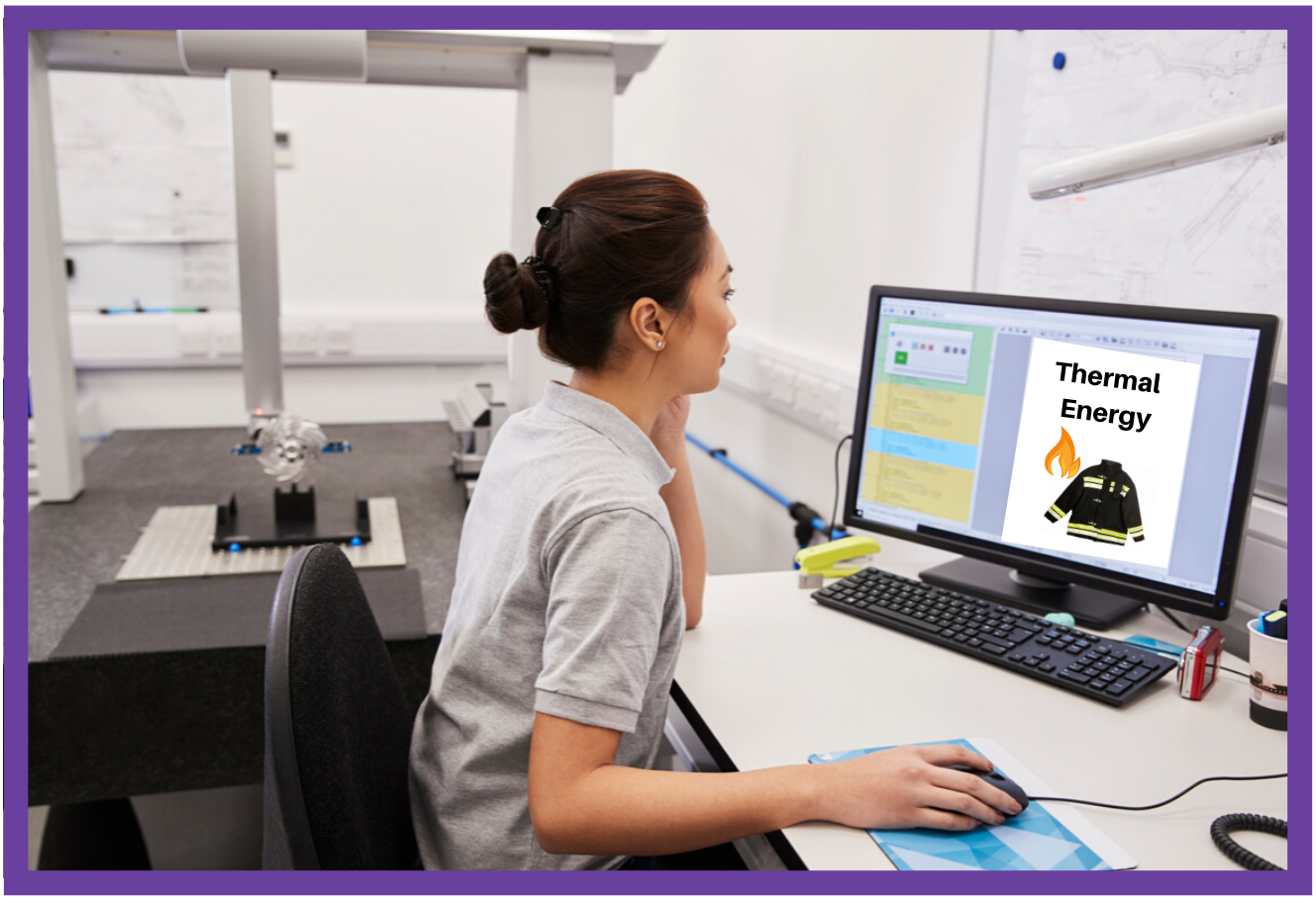
Reviewing Test Results

My next step is to review the data from my test to see if the manikin was protected by the suit. My results show that there were burns on the manikin, which means the material will not protect firefighters from fires. I was really disappointed in the results because I had spent a lot of time researching the materials I used to make the new fire suit. I thought there was no way that the firefighter could be hurt in the suit, but I was wrong.



Experiment/Project

Even though I was upset, I know that it is normal for the first prototype to not be perfect. Engineers usually design something, test it, make necessary changes, then test it again! This process repeats itself over and over until the design is perfect. I know that I just need to do some more research to see why too much thermal energy was transferred from the fire to the manikin. Then, I can make a new prototype and try again!



Text Message Conversation

Since I was feeling bummed about my day at work, I decided to text my friend, Jake, who is also a materials engineer.