

Unit 3: The Visit

The Location

The location for this visit was a S.A.T.R.A (Shoes and Allied Trades Research Association) product testing facility in Kettering, Northamptonshire. S.A.T.R.A originally began as shoe testing company when Northamptonshire was still prominent in the shoe production industry. They now test a variety of products for various companies. These products include: stab-proof vests, trainers, fire retardant clothes, chainsaw resistant clothes, various types of helmets, reflective cloth and climbing ropes. More information about the company and their operations can be found at www.satra.co.uk.

We observed some of these products being tested and collected quantitative data on some of them. Below I will outline two of these demonstrations and the physics principles involved.

Fire Retardant Clothes Testing Rig

This rig consisted of a human shaped manikin with flame-producing burners mounted around pointing towards the manikin. When switched on the burners covered the manikin in flame, giving the effect of an extreme fire. The temperature of the burners could be varied via an electronic control system, as could the length of burn. Different types of clothes can be placed over the manikin to see how well they withstand the fire.

Embedded into the manikin were a number of thermocouple temperature sensors. These are used to see how well the particular item insulates the manikin. It is no good for a type of cloth to not burn, but to let most of the heat through, as it would not be safe to use in situations of great heat (for use as firefighters' garments etc). I will explain how the thermocouple sensors function.

Thermocouples

Thermocouples rely on the Seebeck effect to function, discovered in 1822 by Estonian Thomas Seebeck. He found that if two wires, made of different materials, were joined and two different temperatures were applied at the two ends, then there will be a voltage between them. The reverse of this is the Peltier effect, which occurs when a current is put across the two ends, one end gives up heat energy and the other gains it.

The voltage produced can be used to calculate the temperature difference. If you know the temperature of one end (usually kept in an ice bath to simplify the procedure) and the particular coefficient for the combination of materials you are using, you can find the temperature of the other end. The higher the temperature difference, the higher the voltage produced, this works in direct proportion. This is how thermocouple temperature sensors work.

You can use most metals to form a thermocouple to produce thermoelectricity. Below is a list of all suitable elements. As you move the pair of elements you are using further down the list, the voltage produced at a certain temperature difference decreases.

Silicon
Bismuth
Nickel
Cobalt
Palladium
Platinum
Uranium
Copper
Manganese
Titanium
Mercury
Lead
Tin
Chromium
Molybdenum
Rhodium
Iridium
Gold
Silver
Aluminium
Zinc
Tungsten
Cadmium
Iron
Arsenic
Tellurium
Germanium

However, alloys of elements are usually used. Below is a diagram of a K-type thermocouple, one of the most popular varieties.

Tables have been produced for thermocouples such as these, showing the temperature difference at certain voltages. This makes it easier to determine the temperature difference when you get a voltage output. However, you cannot just connect the thermocouple to a voltmeter to get a reading, as the connection will create a second thermocouple junction. Therefore a technique called cold junction compensation (CJC) has to be used. This can be done either by keeping the second junction in an ice bath, or by measuring its temperature and taking that into account. This temperature is measured using a precise thermistor in contact with the junction.

The main reason that thermocouples are used over other forms of temperature sensors is that they give very accurate readings for a very reasonable cost. They are much better value when compared to other forms of temperature sensors, for example ones involving bi-metallic strips. A k-type thermocouple costs from 80p to £1.60 (does not include bulk-buy discounts), whereas other types can be more expensive. However, thermocouples are accurate to 0.5% whereas more expensive types can be accurate to 0.01%. This difference in accuracy is usually negligible for most purposes, and so thermocouples are usually used due to the price factor.

Most thermocouples are suitable for a temperature range of –200 to 1260 degrees Celsius. It is possible to manufacture different types for very high temperatures, and these can work between 1093 to 2205 degrees Celsius. If you want to exceed these temperature ranges, then you would most likely have to use another type of temperature sensor.

Other Uses

Another way in which they could be used is in food production. They could be used to control the thermostat for large ovens and effectively monitor the temperature inside. They could also be used in some kind of a sprinkler system, rather than the wax based ones used at the moment. This would have some safety implications as they would need their own circuit, but it would make it easier to monitor and control fires.