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experiment 17: Response Times of Temperature Sensors (Short Report)

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**Results**

0.3mm Thermocouple

1.1mm Thermocouple

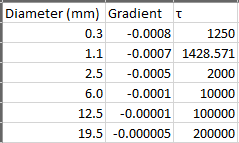
2.5mm Thermocouple

6mm Thermocouple

2.5mm Thermocouple in 12.5mm Thermowell

2.5mm Thermocouple in 19.5mm Thermowell

Response Times of the Sensors as a Function of their Diameters



**Discussion of Results**

For each dataset collected from the thermocouples/thermowells, the objective was to plot a graph of the measured temperature as a function of time, and to also plot as a function of time in order to gain an appreciation of system dynamics.

Where:

T – The temperature at any given time, t (˚C)

t – Time since the step change in the temperature was applied (ms)

T0 – Temperature at the start of the experiment (˚C)

ΔT – Step change in temperature (˚C)

For the latter graph, this leads to a straight line with slope .

Where:

τ – Response Time (ms)

(Heriot-Watt University School of Engineering & Physical Sciences, 2018)

For the thermocouples with the smaller diameters, a rapid response time was observed. The 0.3mm thermocouple took merely 4 seconds to read the temperature of the water bath. The smaller thermocouples (0.3mm, 1.1mm and 2.5mm) reacted so quickly that the data appeared jagged when plotted. This could be due to limitations in the accuracy of the thermocouple when many readings are taking place, however, it is more likely to be due to the fact that the heat will transfer very quickly through the thin diameter of the smaller thermocouples, causing the probe to rapidly read the correct temperature.

However, the largest thermocouple and the thermowells showed the expected trends on the temperature-time graphs of the rate of change of temperature decreasing as time increased. As the thermocouple/thermowell gets closer to reading the true results, it becomes more difficult to read the exact temperature. This is because the thicker diameters cause heat to be transferred more slowly through the device to the sensor.

As the thermocouple diameter was increased, it was clearly observed that the response time also increased closely in correlation to a power. The correlation observed has an R2 value of 0.9898, implying a very strong positive correlation between thermocouple diameter and response time.

Thermocouples with larger diameters are required in situations where corrosion or a high fluid velocity would damage a smaller diameter thermocouple, however, this comes with the trade-off that the probe will take a much longer time to report the correct temperature, which could make this unsuitable where the temperature needs to be reported very accurately within a very short time frame.

For the experiment, potential sources of error include the difficulty and inaccuracy of controlling the temperature of the water bath, which could potentially have affected the results despite efforts to keep it at a consistent temperature. Another source of inaccuracy occurred when lowering the thermocouple or thermowell into the water bath, as it was physically impossible to do it the exact same way each time, however, by removing the data from before when the probe hit the water and correcting the time scale, this source of error was mostly negated.

In conclusion, it was found that the thicker the diameter was of the thermocouple or the thermowell, the slower the response time would be.

(Heriot-Watt University School of Engineering & Physical Sciences, 2018) (pico Technology, n.d.)

**Appendix I**

Example Calculations

# **References**

Heriot-Watt University School of Engineering & Physical Sciences, 2018. *Response times of temperature sensors.* Edinburgh: Heriot-Watt University.

pico Technology, n.d. *8 channel thermocouple data logger.* [Online]   
Available at: https://www.picotech.com/data-logger/tc-08/thermocouple-data-logger  
[Accessed 6 October 2018].