Estimating the Response Time of a Temperature Probe

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Abstract

This report estimates the first-order response time of a temperature probe from a step change between two well-stirred baths. The starter separates the measurement model, observations, uncertainty budget, and conclusions so that the same structure can be reused for other scientific reports.

1 Objective and model

After a sudden change in bath temperature, the indicated temperature is modelled as

$$T(t) = T_\infty - (T_\infty - T_0)\exp(-t/\tau), \tag{1.1}$$

where τ is the response time. We estimate τ by fitting the measured values and report the residual pattern rather than only the fitted parameter [1].

2 Method

Immerse the probe in a stirred bath at 20 °C, move it quickly to a second bath at approximately 60 °C, and sample once per second. Keep the probe depth, stirring rate, and transfer time constant across three repeats. Record the bath temperatures independently.

3 Observations and result

Fitting equation (1.1) gives $\tau = 1{,}8(2)$ s for this illustrative data set. State the fit method, parameter covariance, and whether the residuals are consistent with the assumed first-order model.

4 Uncertainty and conclusion

Include calibration, timing, bath stability, and repeatability components in the uncertainty budget. A useful conclusion says both what the data support and what would change the decision: here, the probe reaches 95% of the step after about 3τ, but transfer delay could bias the earliest points.

Table 3.1: Example observations; replace them with the exported instrument data.

t (s)	T (°C)	$u(T)$ (°C)
0	20,1	0,2
2	45,8	0,2
4	55,6	0,2
6	58,7	0,2
8	59,6	0,2

References

[1] John R. Taylor. *An Introduction to Error Analysis*. 2nd ed. University Science Books, 1997 (cit. on p. 1).