Parametric study for the optimal release of thermal energy from composite materials.

UK Energy Storage 2019

Dr Robert Sutton

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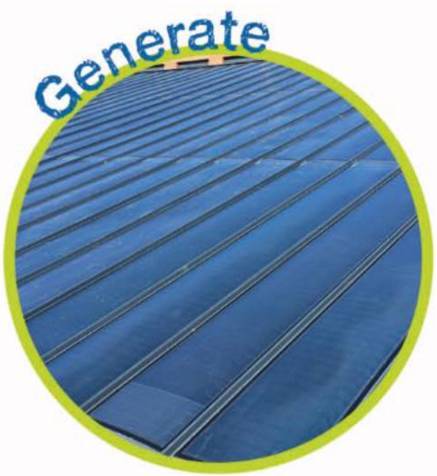

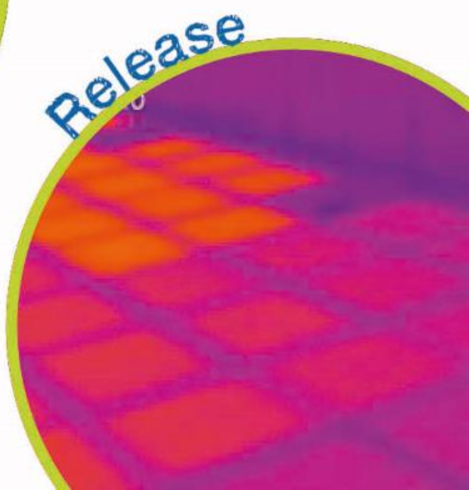

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Agenda

- Thermal Storage
  - Project Drivers
  - Material Selection
- Discharge Performance of Selected Materials
- Parametric Study
  - Volume and Flow
- Summary

Thermal Storage

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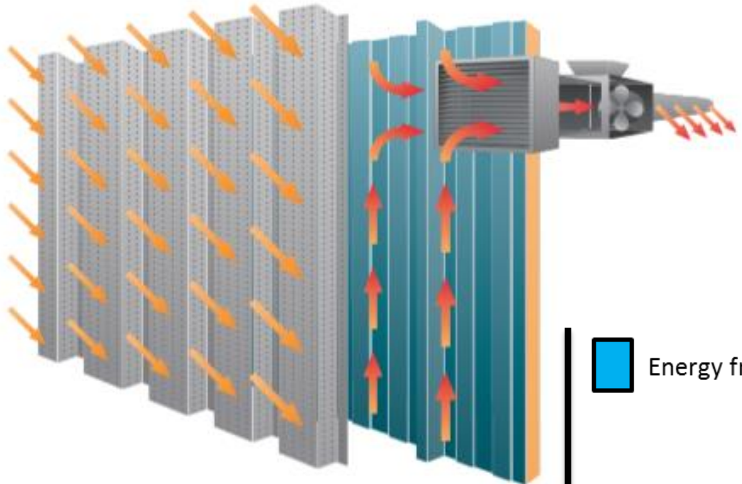
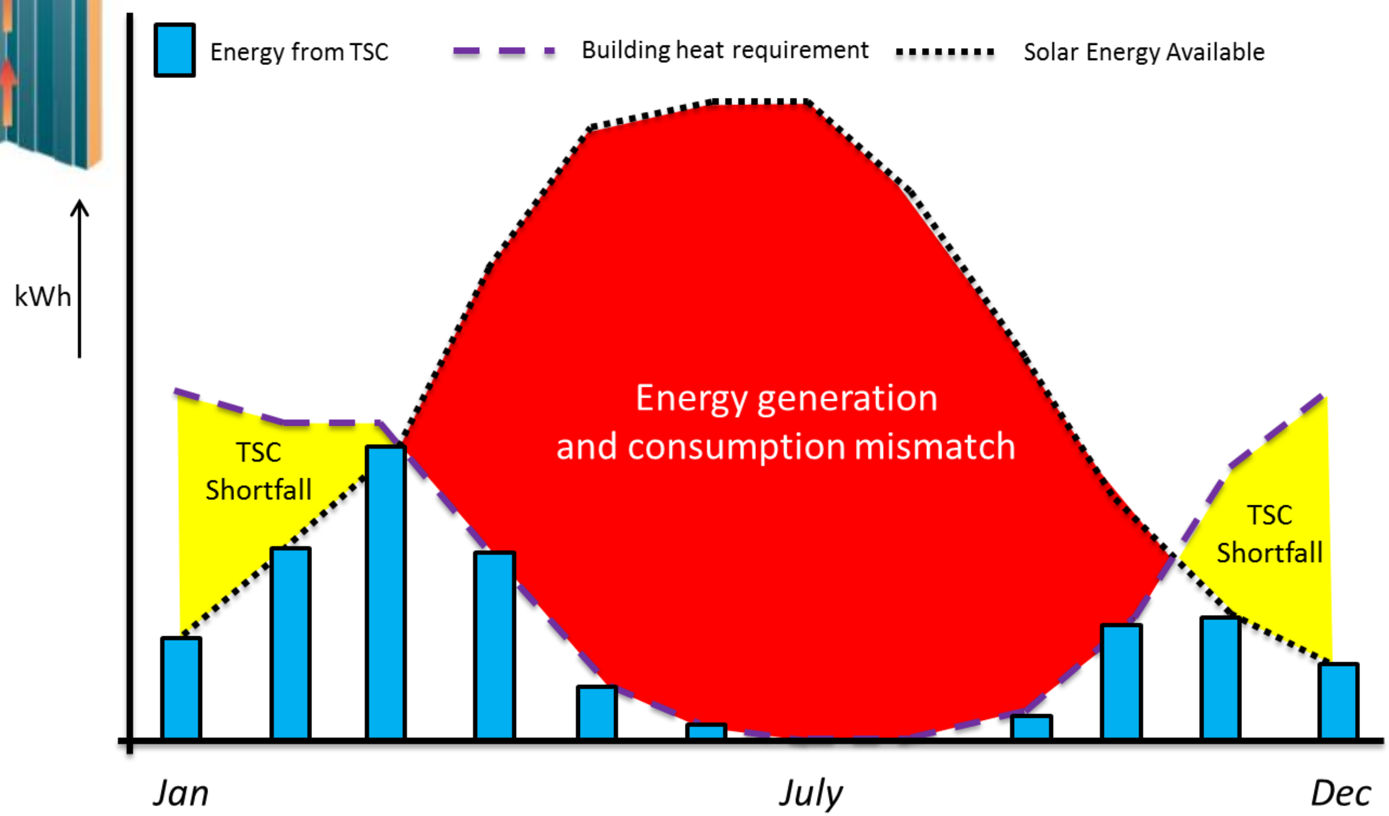
Project Drivers

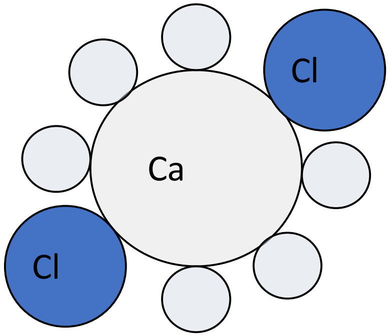




Thermochemical Storage

$$AB + Heat \leftrightarrow A + B$$

$$Salt \cdot x(H_2O) + Heat \leftrightarrow Salt + H_2O$$



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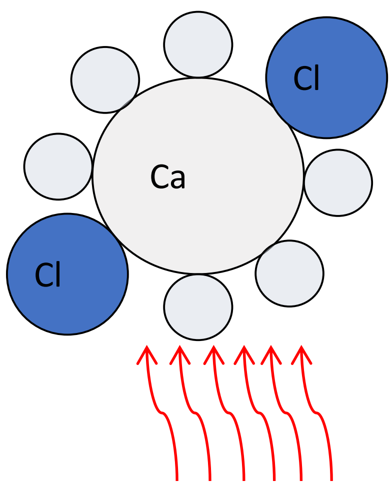

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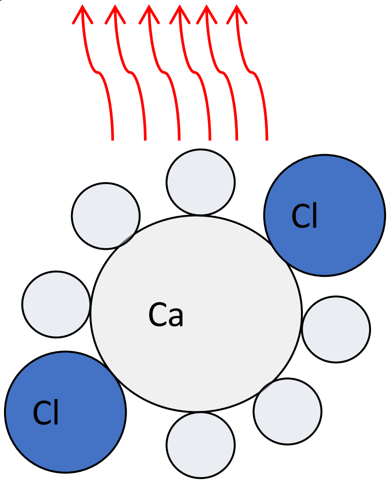
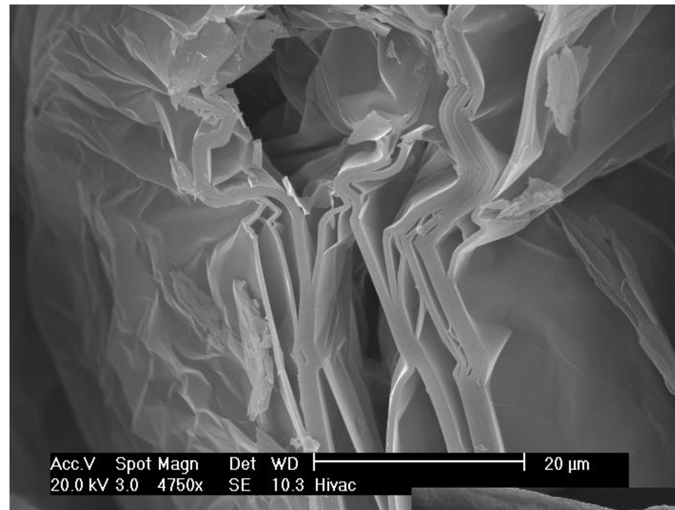
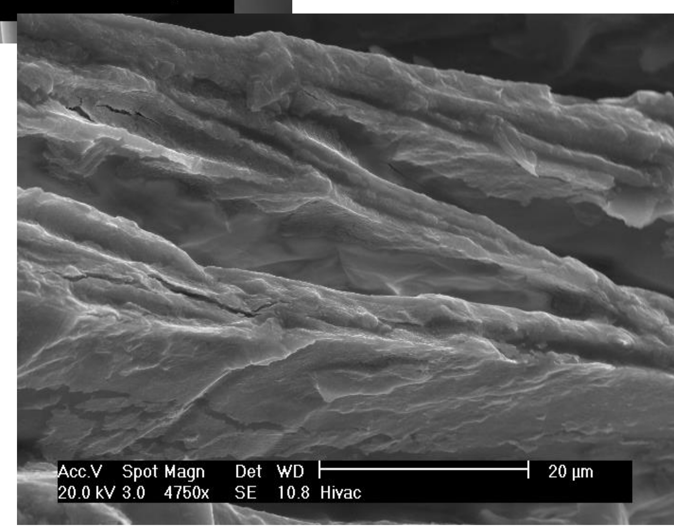


Material Selection

- Focussed on composite materials involving hydrated salts

- Salt In Matrix (SIM)
- Vermiculite:
  - $CaCl_2$
  - $LiNO_3$
  - $MgSO_4$





Discharge Performance

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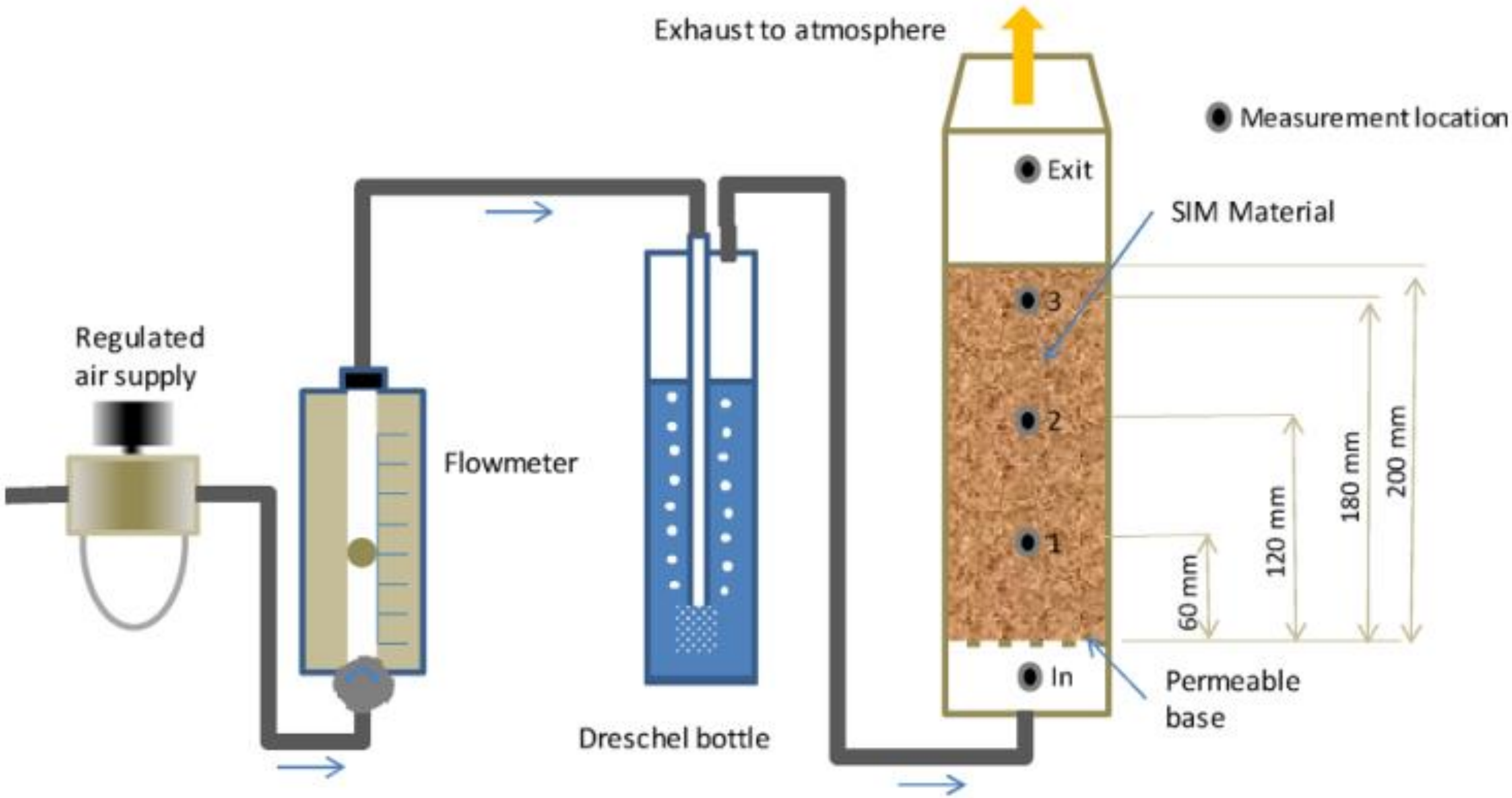
Discharge Reactor



Material Comparison

SIM	Peak ΔT_1 (°C)	Ed_1 (kWh/m^3)	Peak ΔT_e (°C)	Ed_e (kWh/m_3)
V-$CaCl_2$	25	217.0	10	66.3
V-$LiNO_3$	11	321.5	4	66.9
V-$MgSO_4$	16	76.9	4	2.2

- Ed of optimised system is typically 250-500 kWh/m^3
- Transference of generated energy to exit biggest challenge
- V-$LiNO_3$ provides lower but more sustained ΔT
  - Considerably more expensive than $CaCl_2$

Deliquescence

- Salt Deliquescence
  - Hygroscopic
  - Over saturation of salt
  - ‘Dampening’ of generated energy

- Material Agglomeration
  - Barrier to material activation
  - Boundary layer between ‘activated’ and ‘un-activated’ material

Summary of Discharge Performance

- Material performance cannot simply scaled for building scale applications.

- Salt deliquescence is a barrier to material performance.

- Transit of moist air is limited to **$<$100 mm** from reactor inlet.

- Reactor design and operation are vital to the implementation of building scale systems.

Parametric Study

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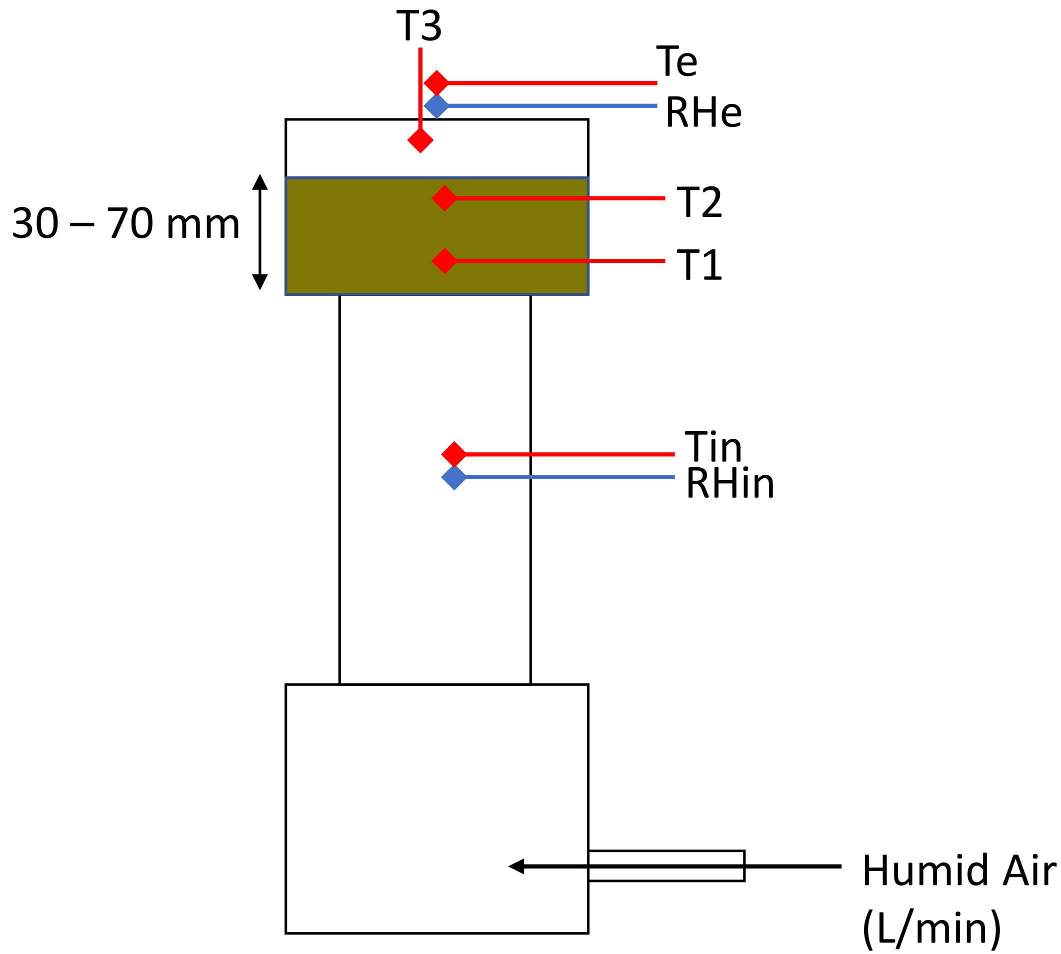
Reduced Path Length



- Path length <100 mm
- Reduction in deliquescence
- Fully developed flow

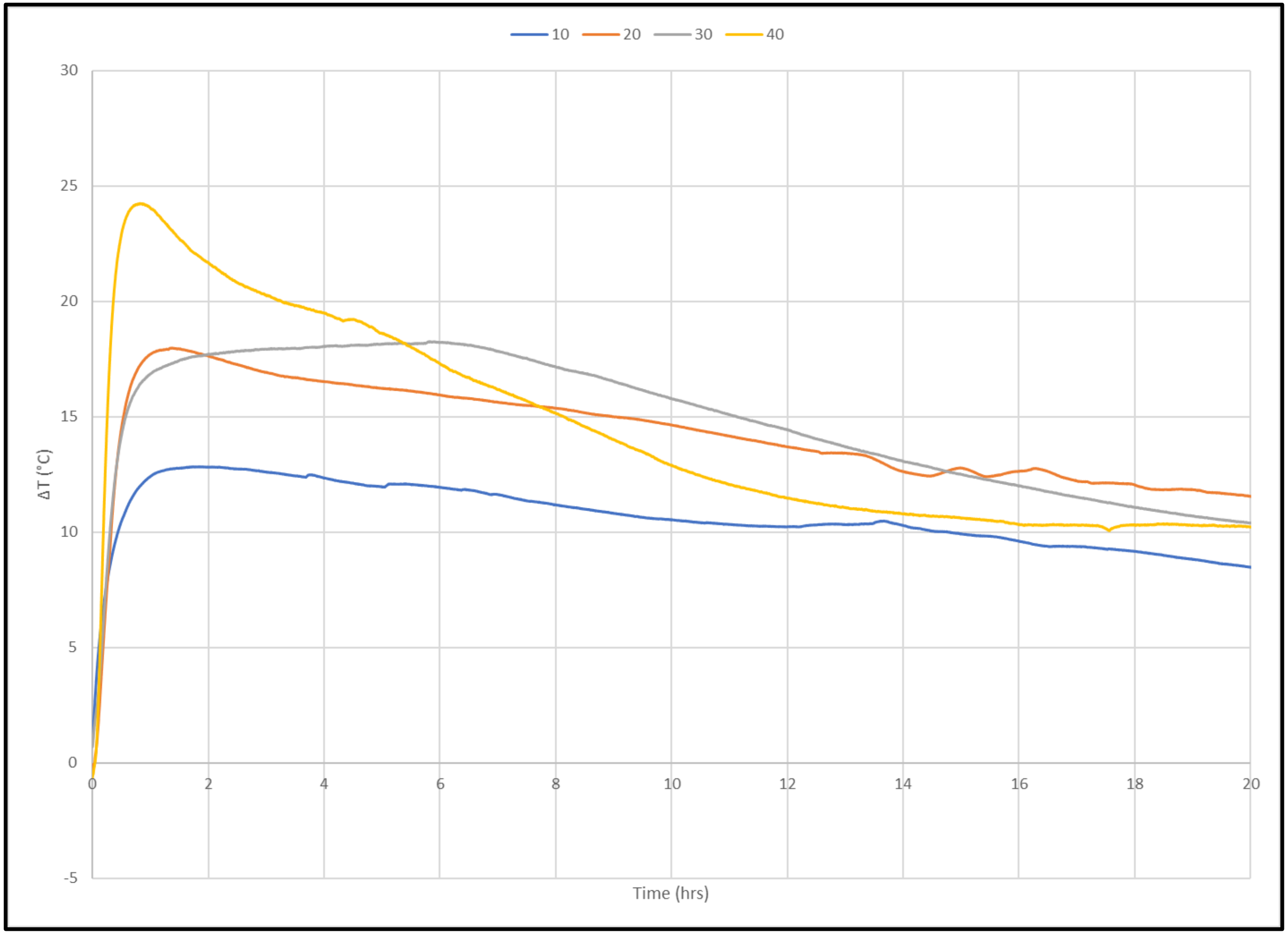
- 250-500 g
- Parametric study
  - Flow rate
  - Volume

Volume and Flow Parameters

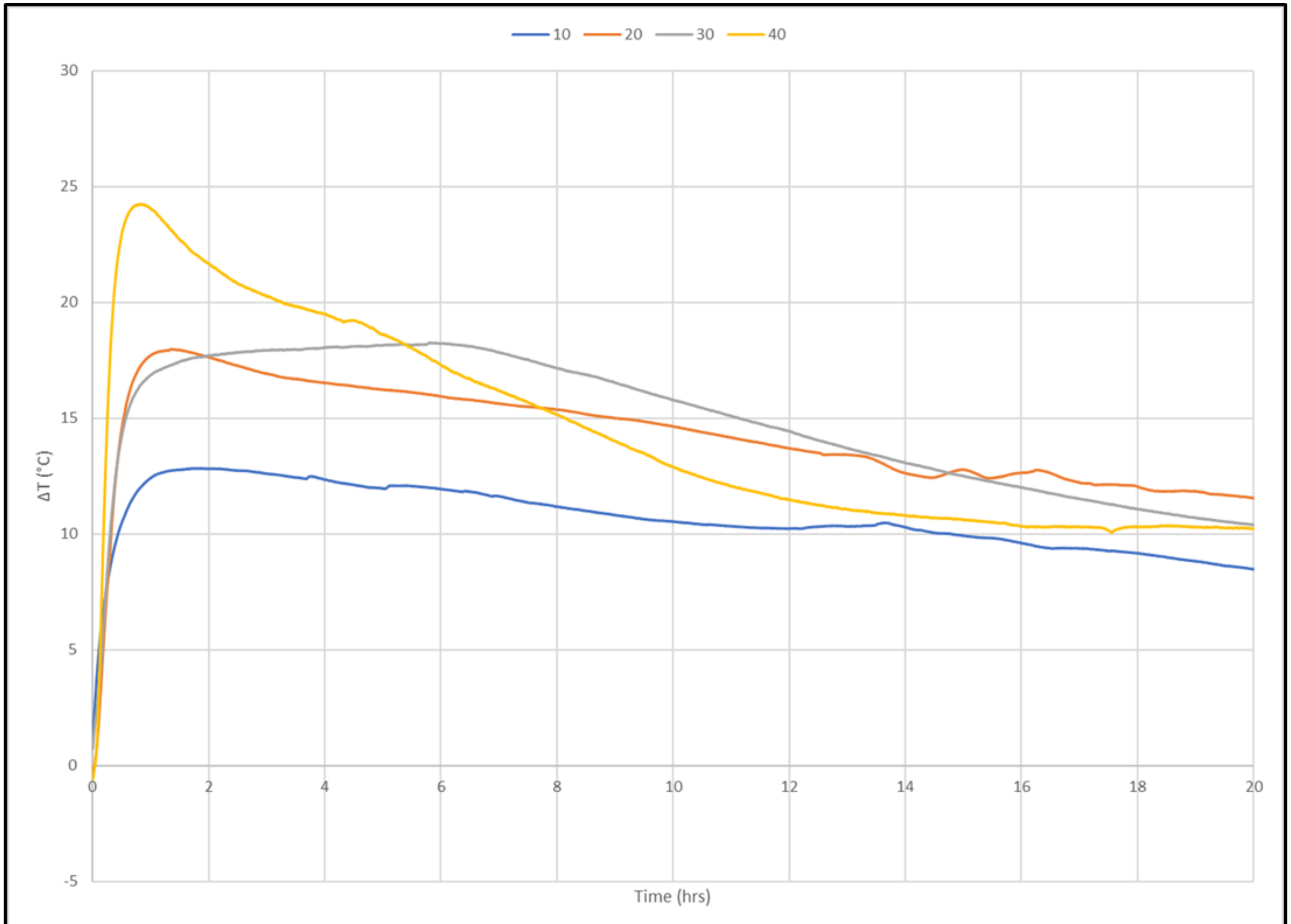
	30 mm	40 mm	50 mm	60 mm	70 mm
10 lpm					
20 lpm					
30 lpm					
40 lpm					

- V-$CaCl_2$
  - 2:1 ratio

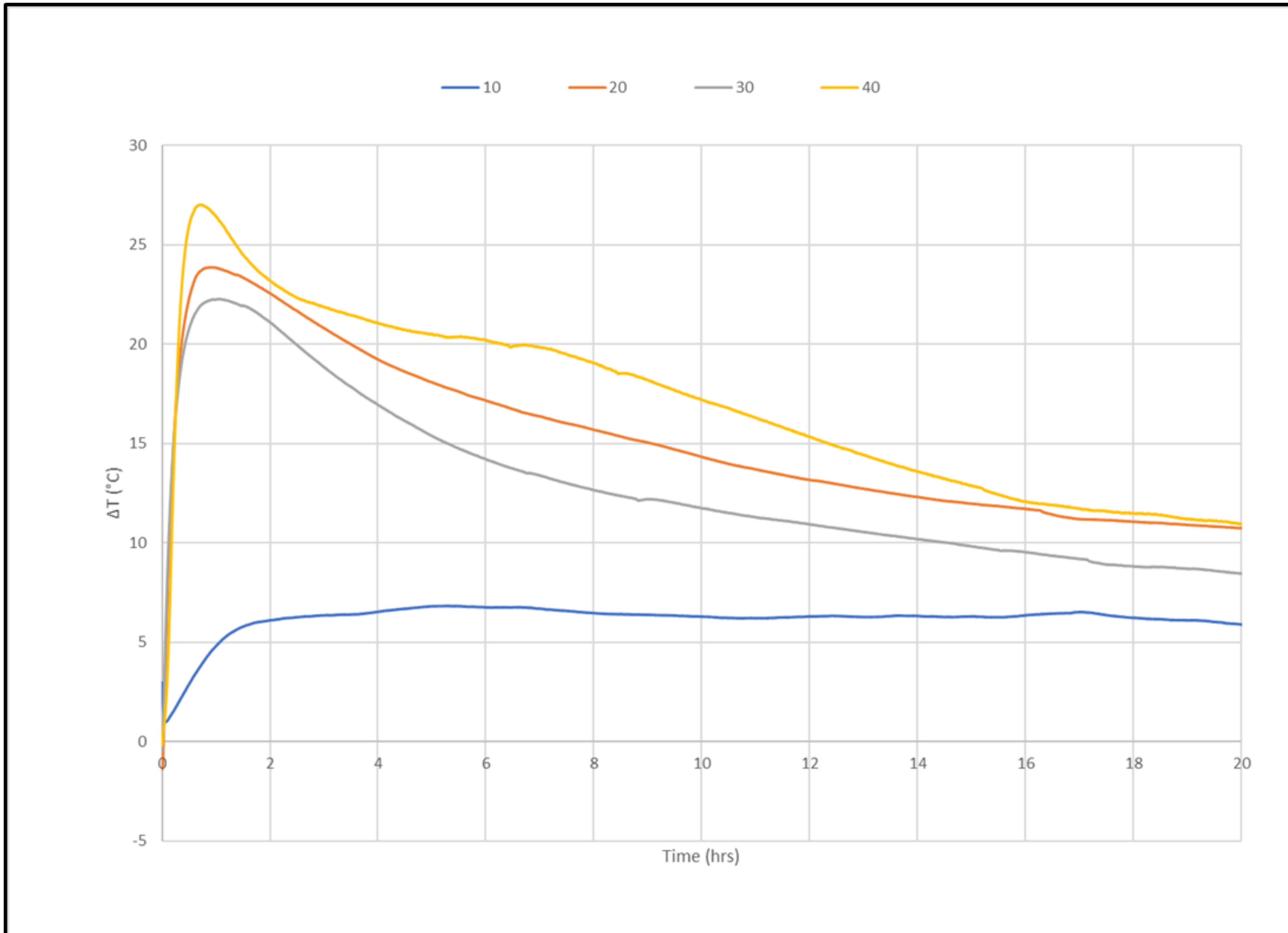
Performance @ P1- 30mm



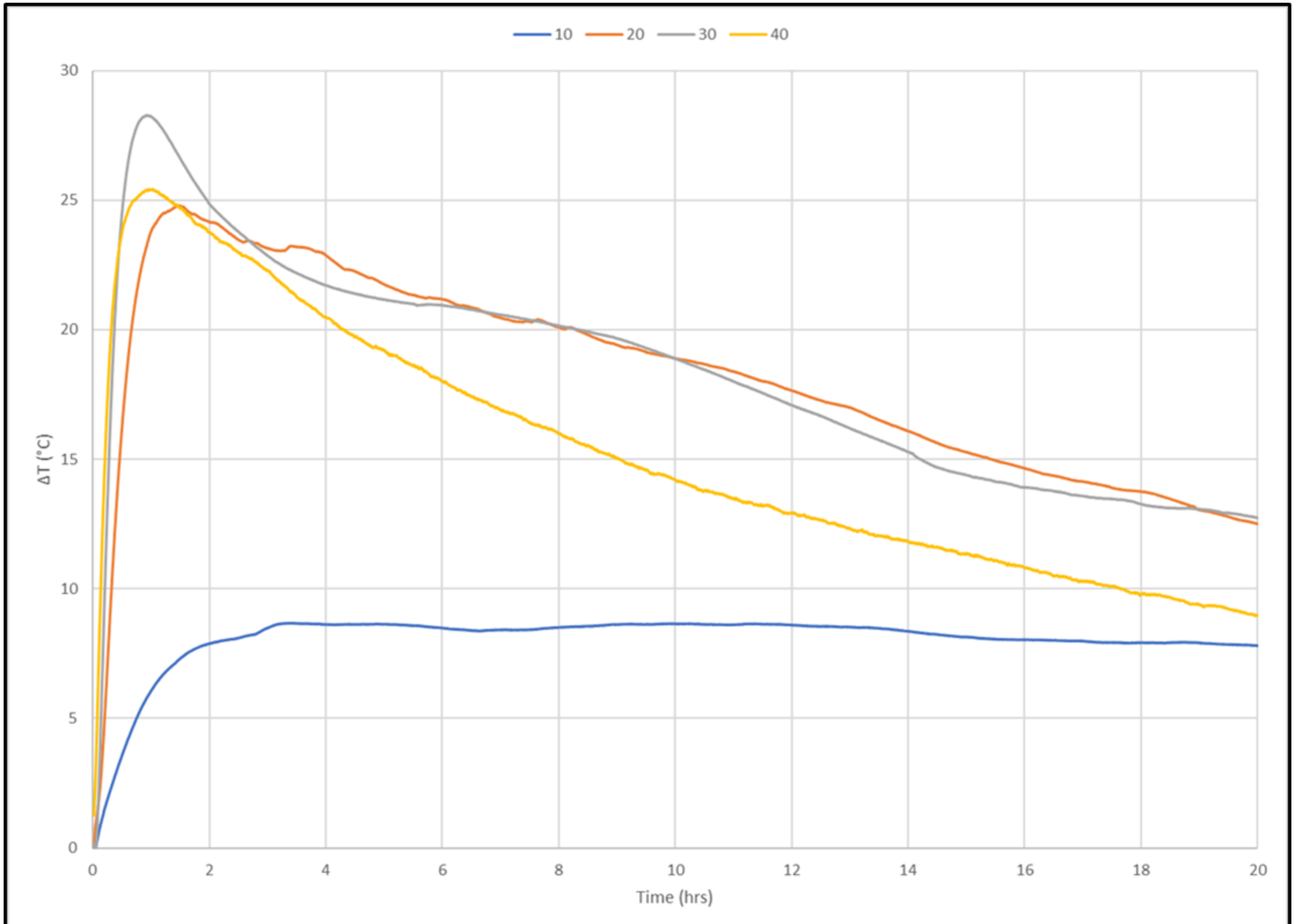
Performance @ P1- 40mm



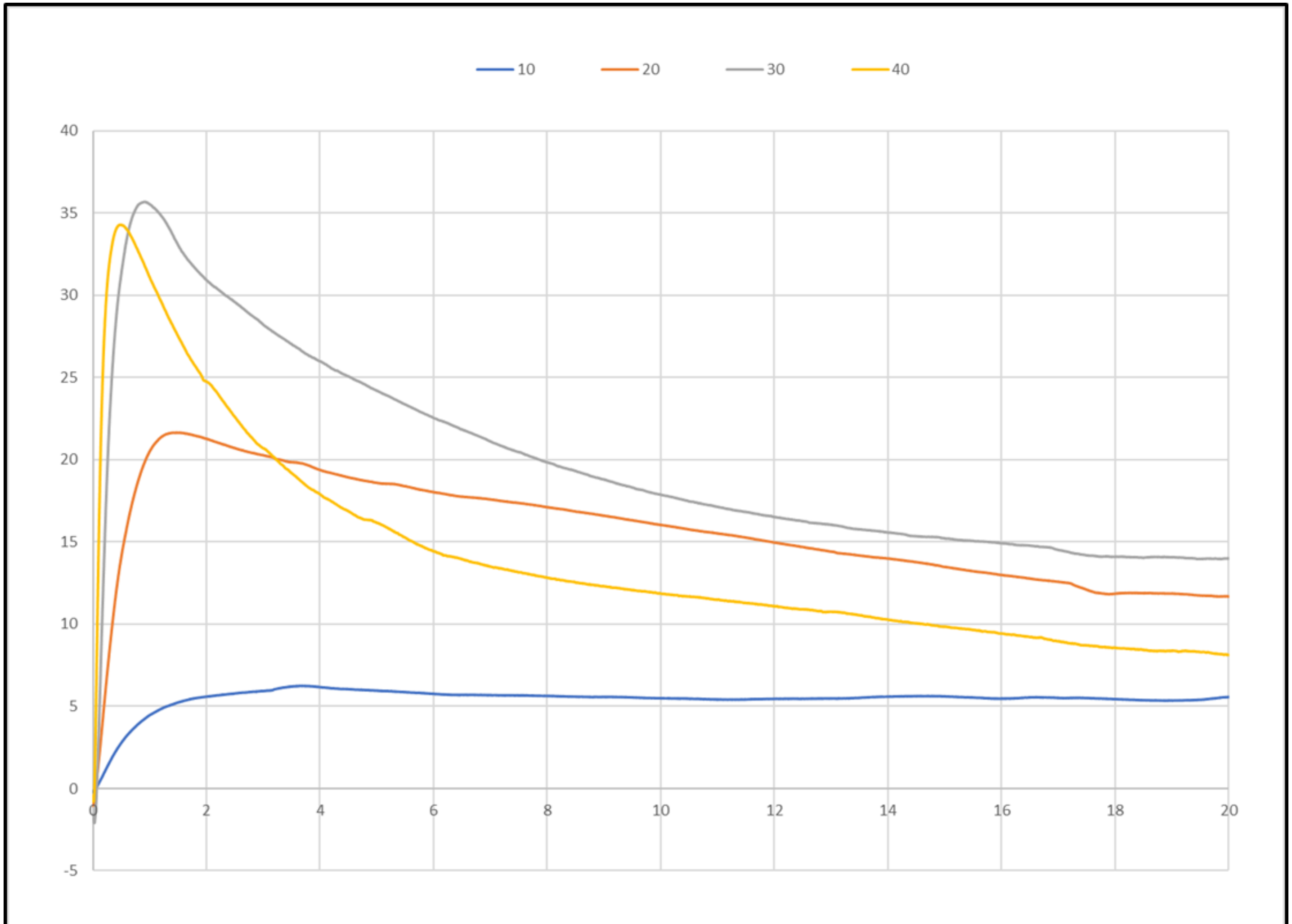
Performance @ P1- 50mm



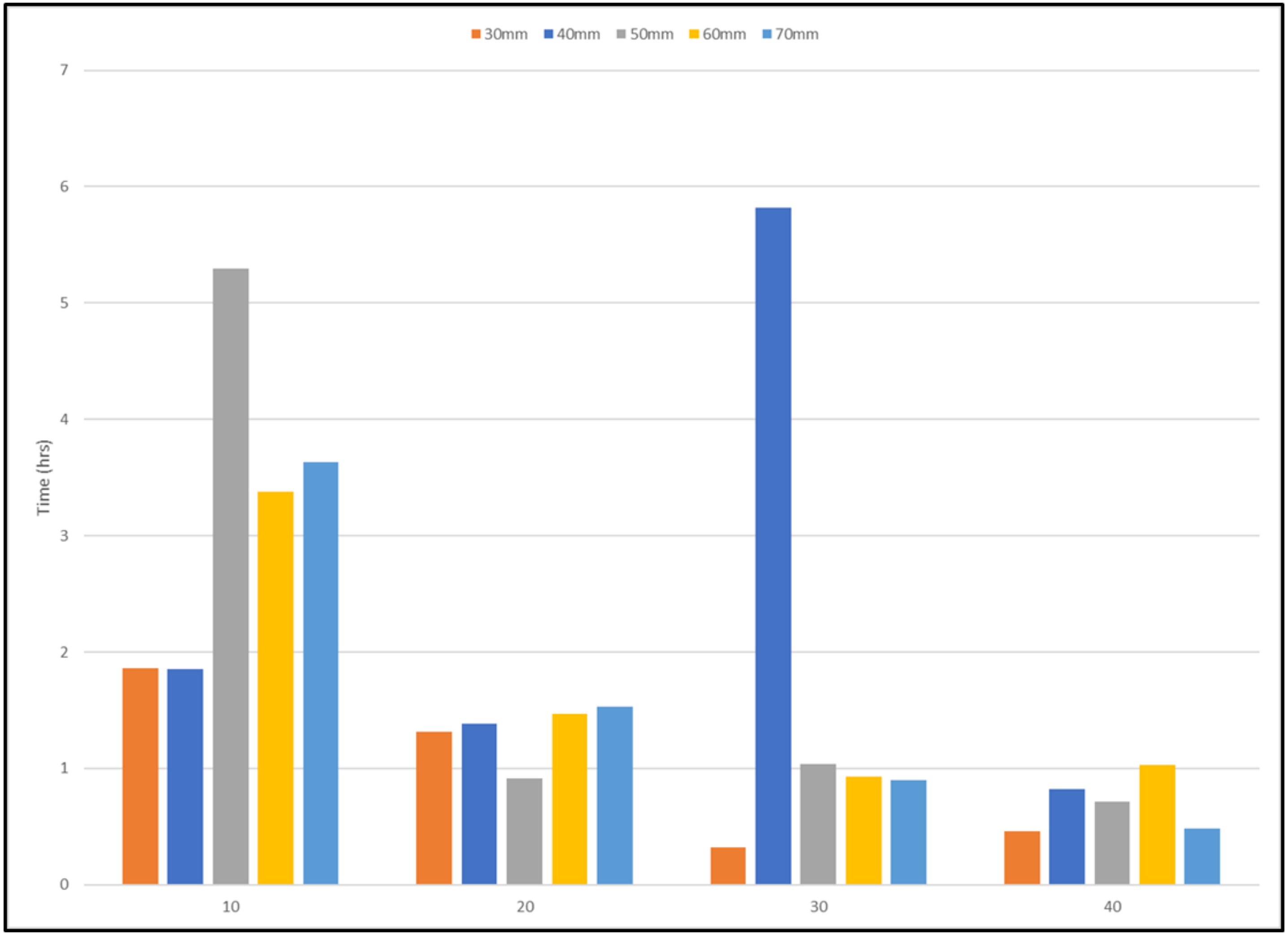
Performance @ P1- 60mm



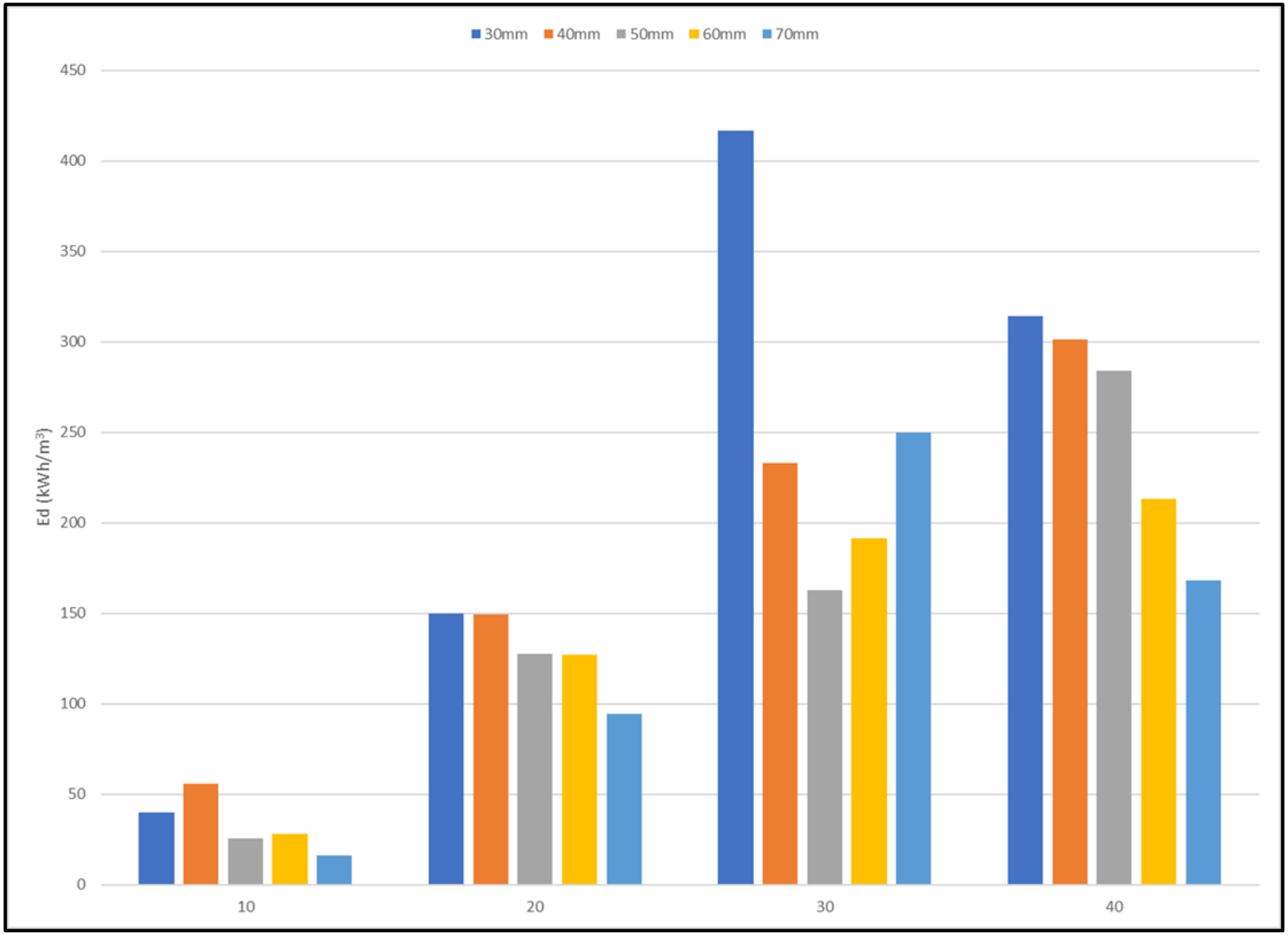
Performance @ P1- 70mm



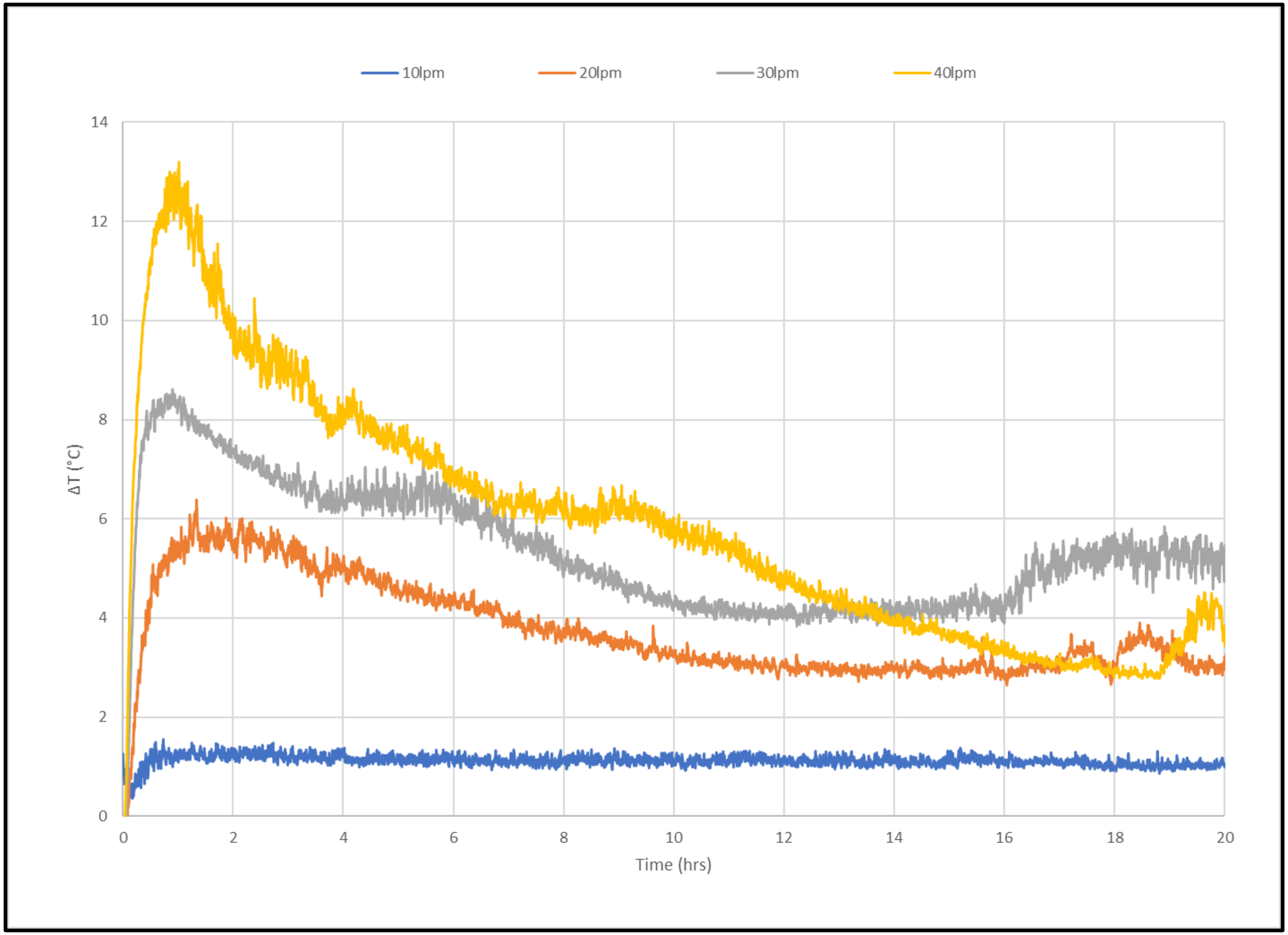
Performance @ P1- Time to PΔT



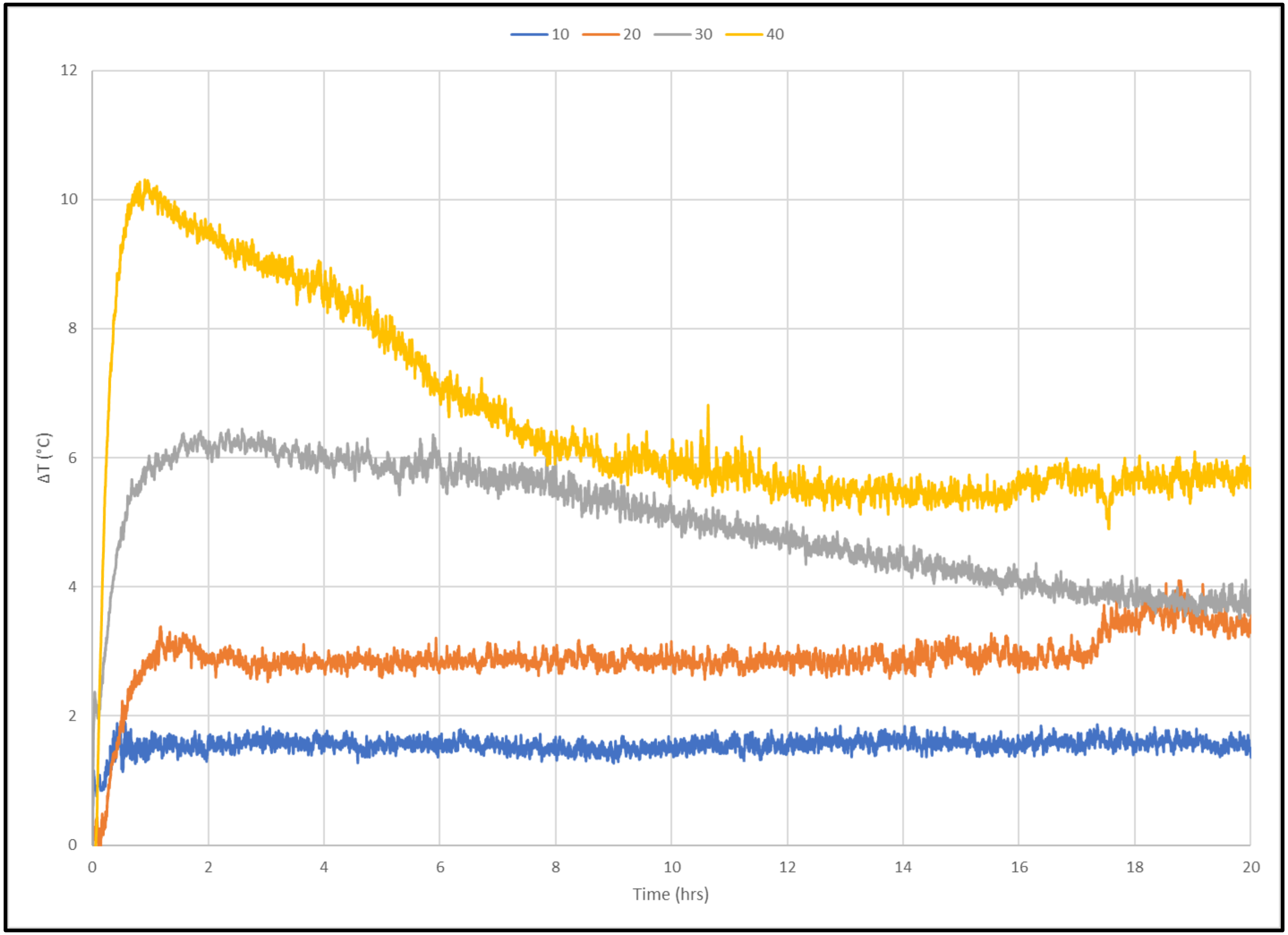
Performance @ P1- Ed



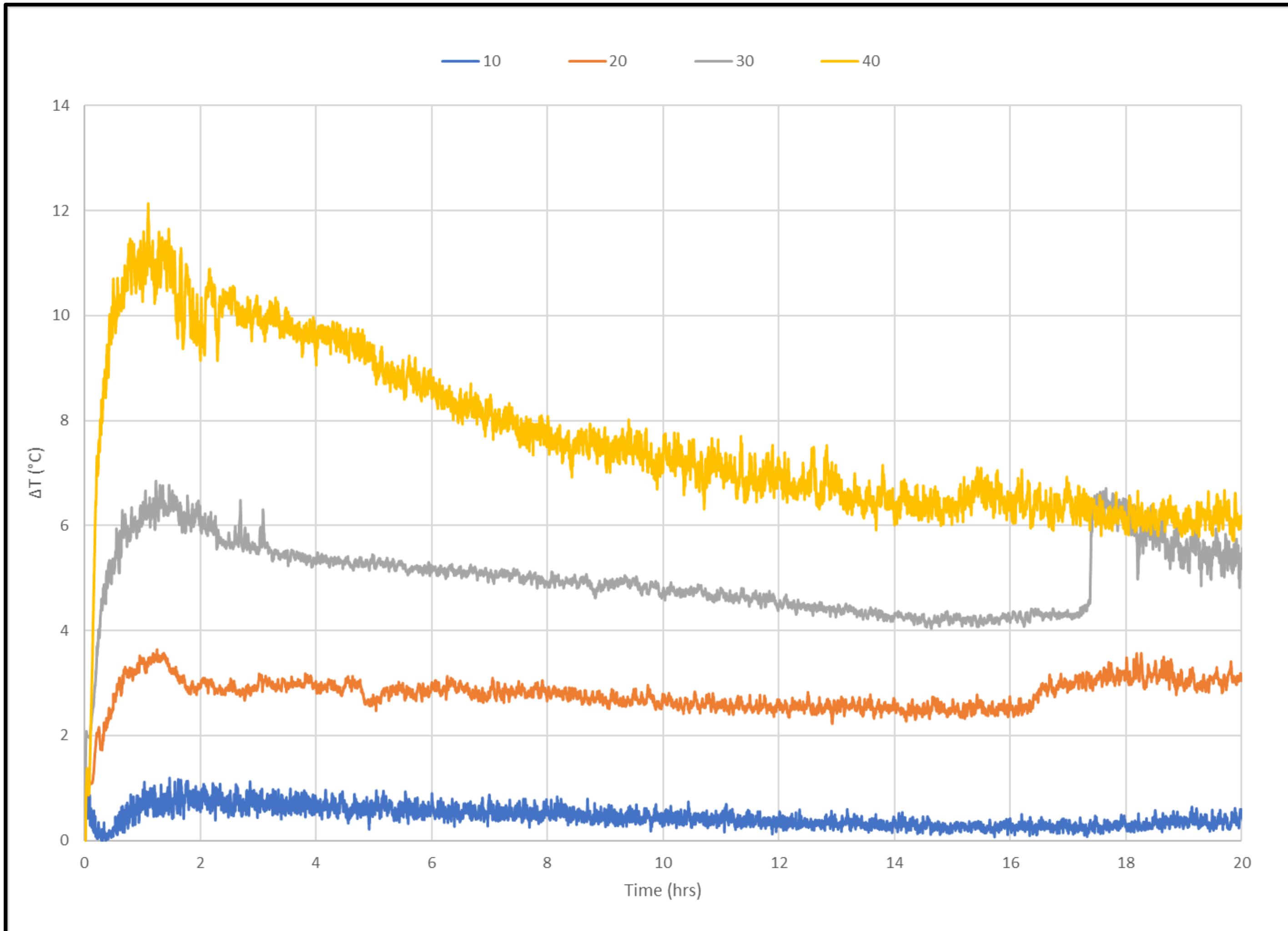
Performance @ Pe- 30mm



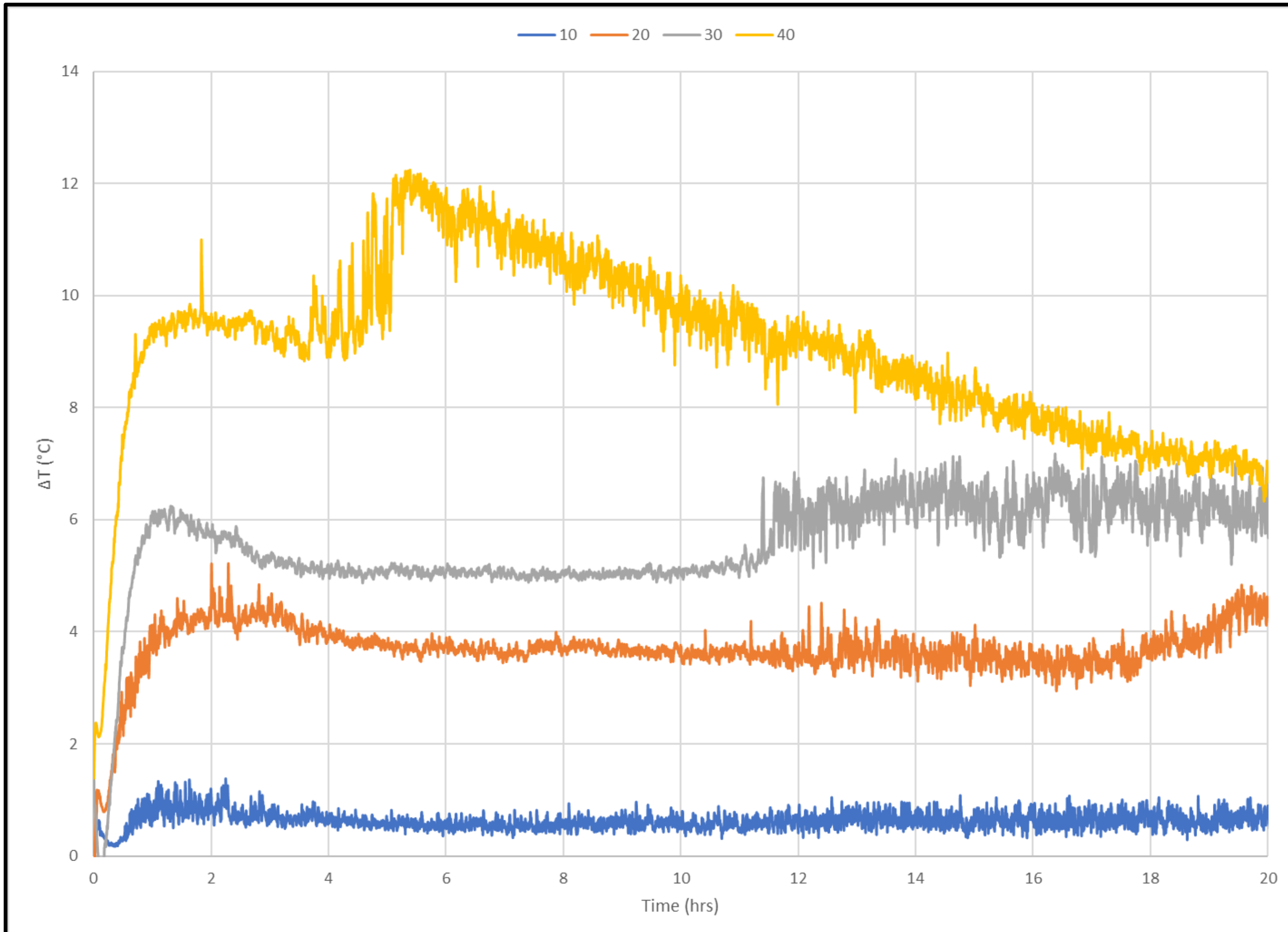
Performance @ Pe- 40mm



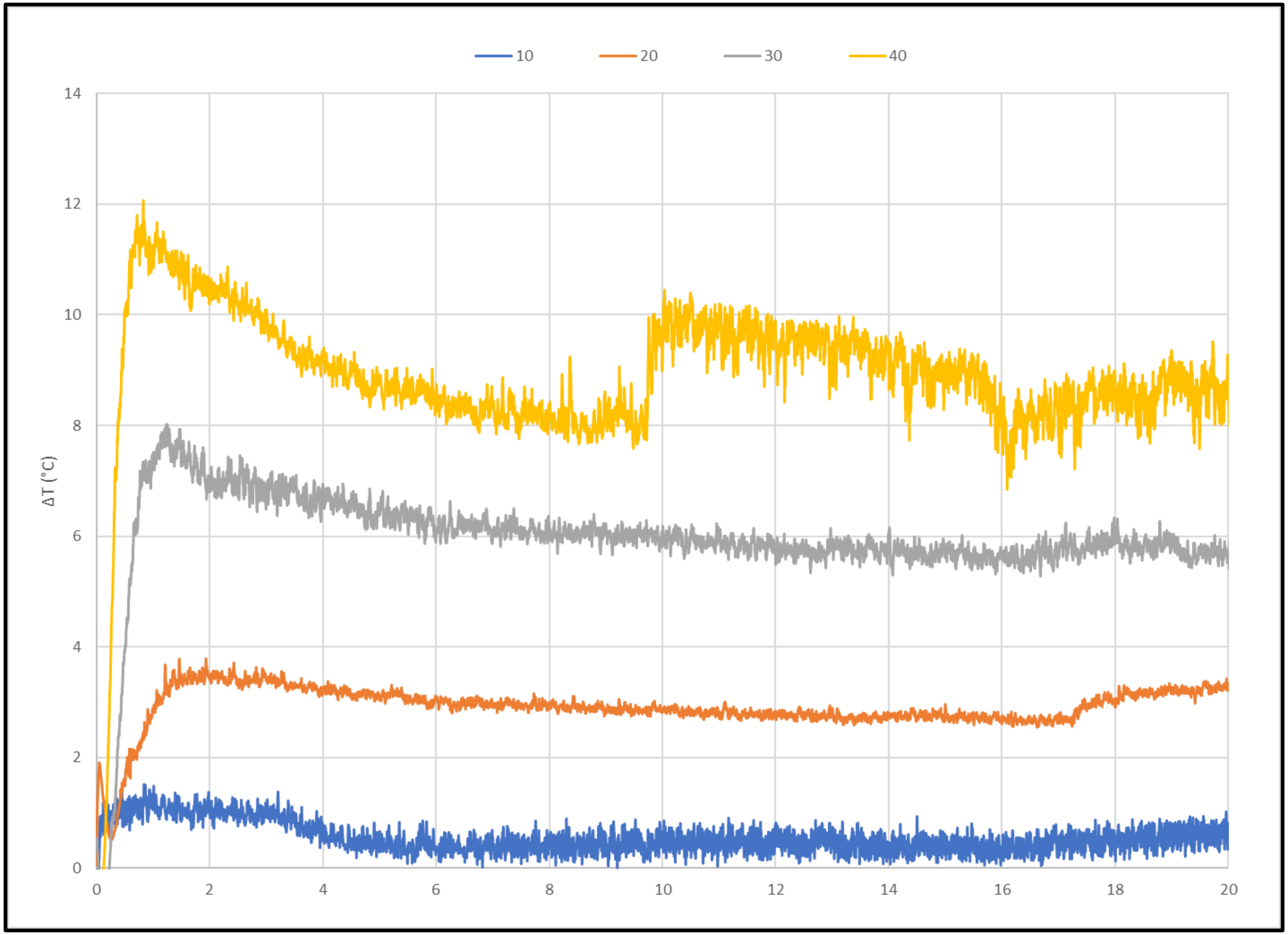
Performance @ Pe- 50mm



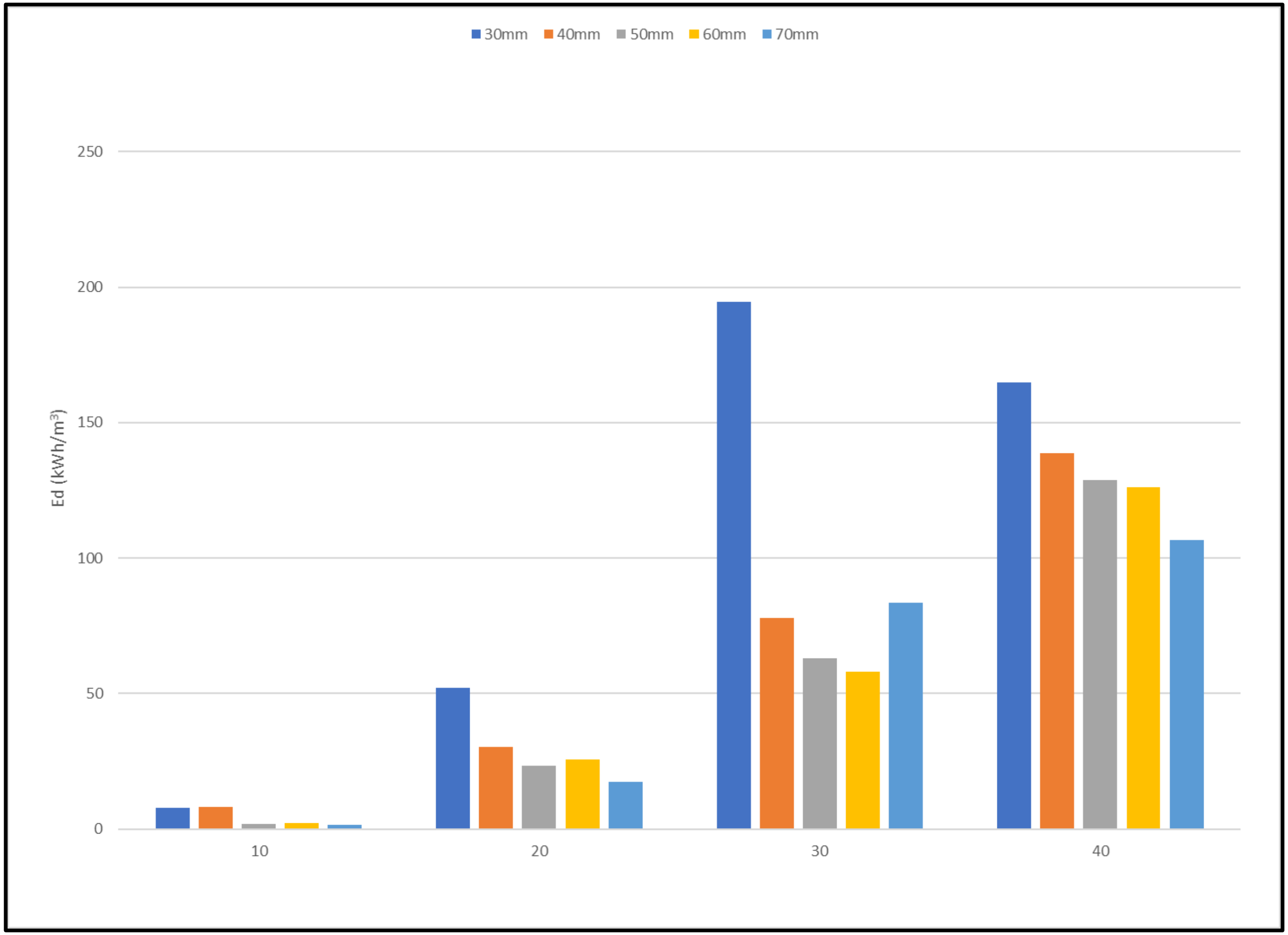
Performance @ Pe- 60mm



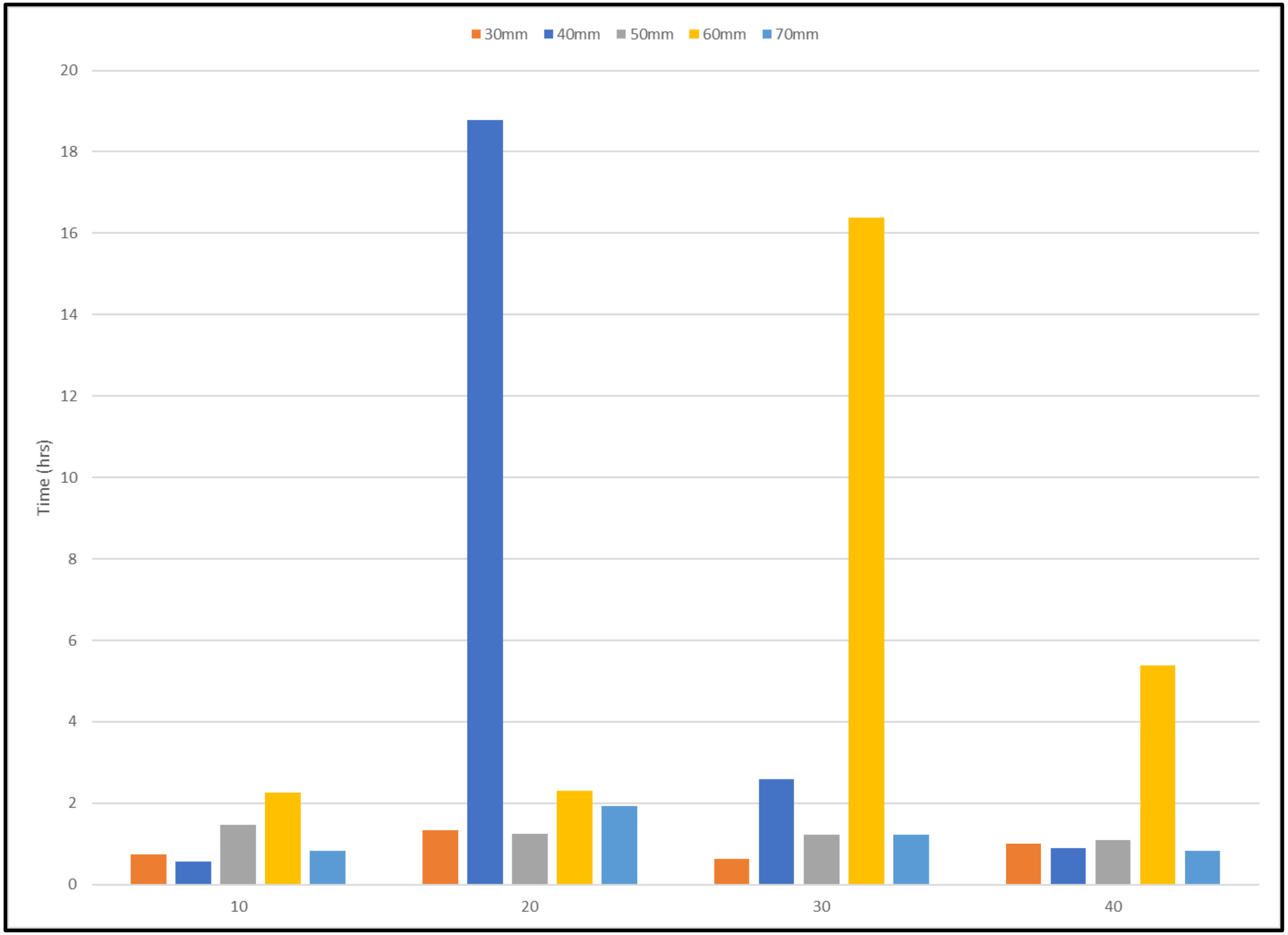
Performance @ Pe- 70mm



Performance @ Pe- Ed



Performance @ Pe- Time to PΔT



Summary

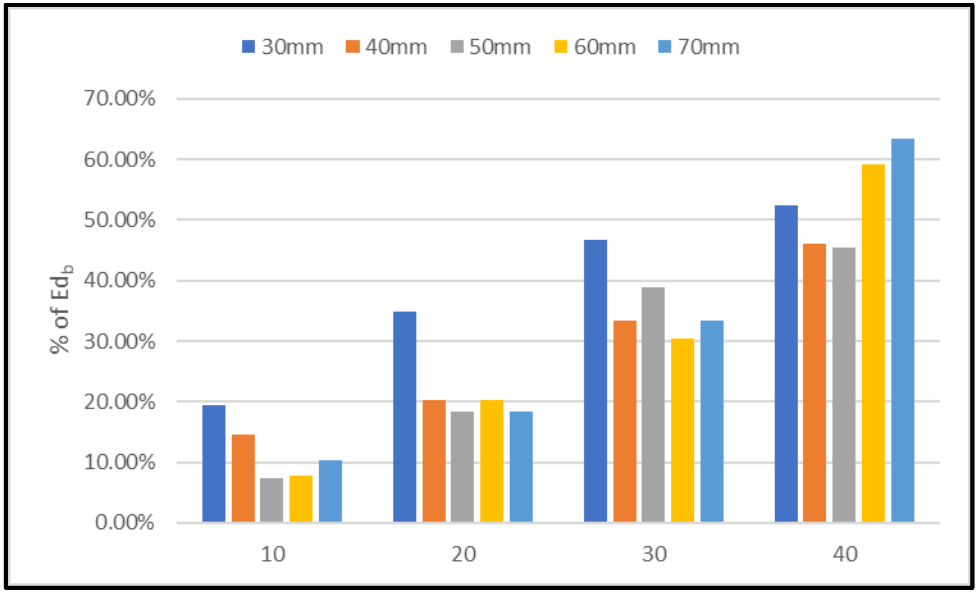
- ΔT @ P2 ~ ΔT @ P1
- ΔT @ P3 ~ ΔT @ Pe

- Bulk
  - Higher flow rate
    - >>> ΔT
    - >>> Ed
    - <<< time to PΔT

- Exit
  - Increase material depth
    - More sustained ΔT
  - Higher Flow rate
    - >>> Ed

Common Trends

- Increase material depth
  - <<< ΔT
  - <<< Ed
- Energy Recovery improves with > f.r.



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