POLYTECHNIQUE MONTRÉAL
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Convective Heat Transfer Between a Bead Packing and Its Bounding Wall

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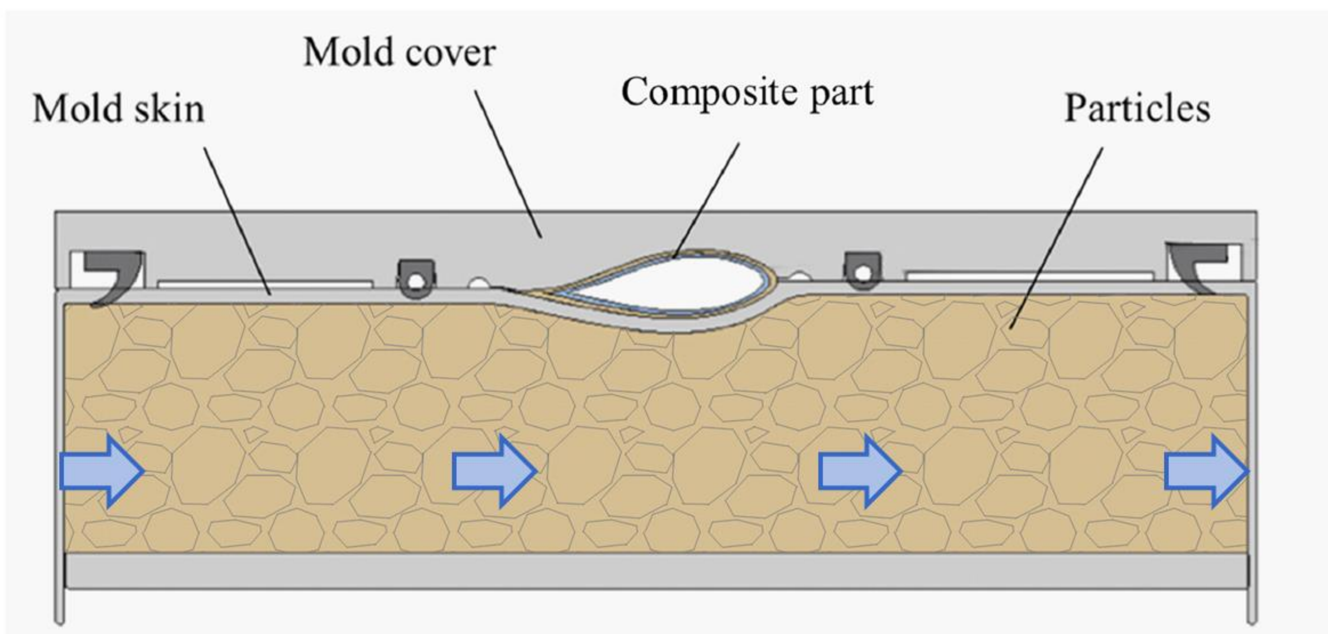
GRANULAR MOLD



- The mold has chambers filled with **particles**.
- The chamber is covered by a **replaceable skin** reproducing the shape of the part.
- The mold can be heated or cooled by circulating a **fluid** in the granular bed.

VOLUME AVERAGING

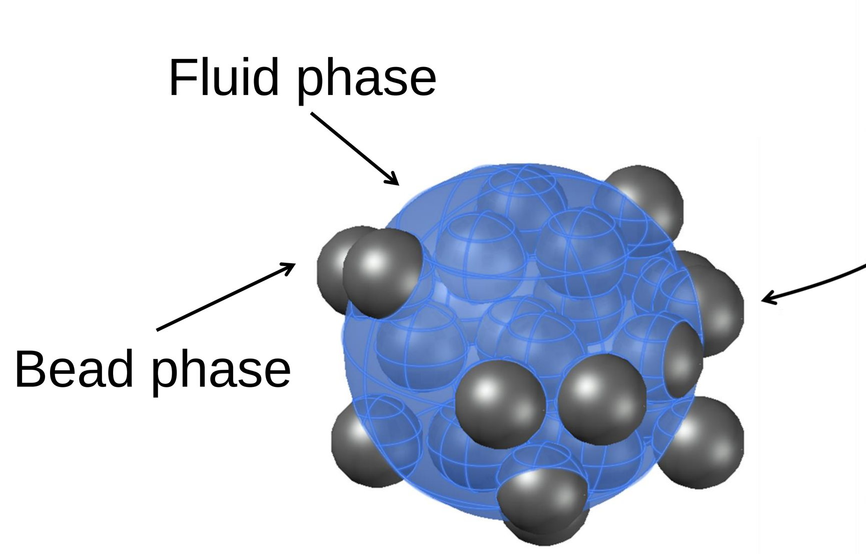
- Bead phase + Fluid phase
- Representative Elementary Volume (REV)
- Constant REV size
- Homogeneous regions of the bead packings

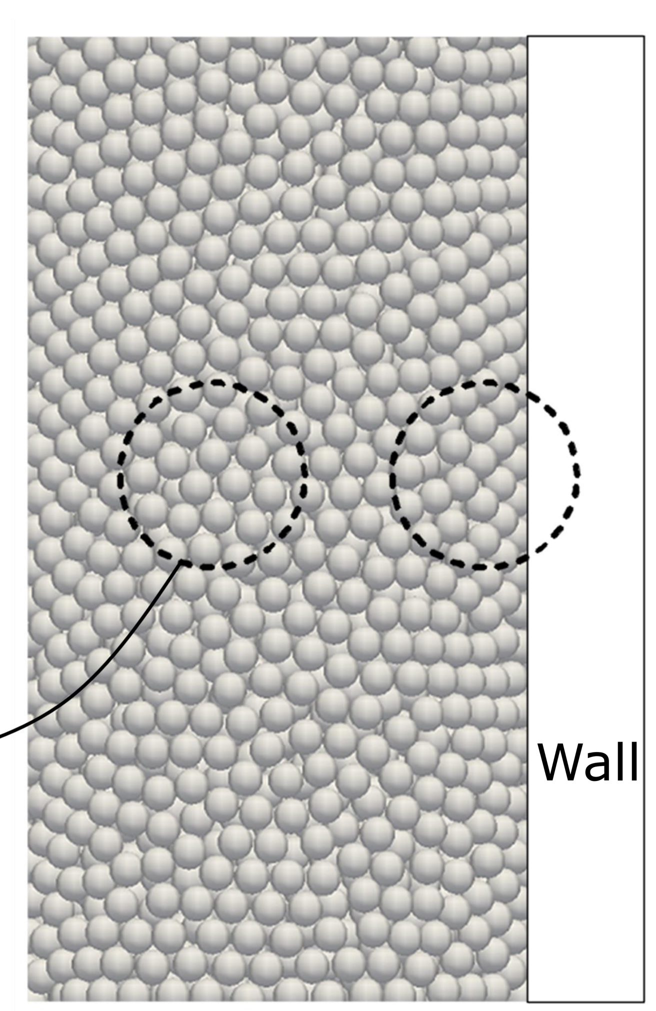
$$\langle\psi\rangle^f = \frac{1}{V_f}\int_{V_f}\psi\, dV = \frac{1}{\phi_V\, V}\int_{V_f}\psi\, dV$$

$$\langle\psi\rangle^s = \frac{1}{V_s}\int_{V_s}\psi\, dV = \frac{1}{(1-\phi_V)\, V}\int_{V_s}\psi\, dV$$

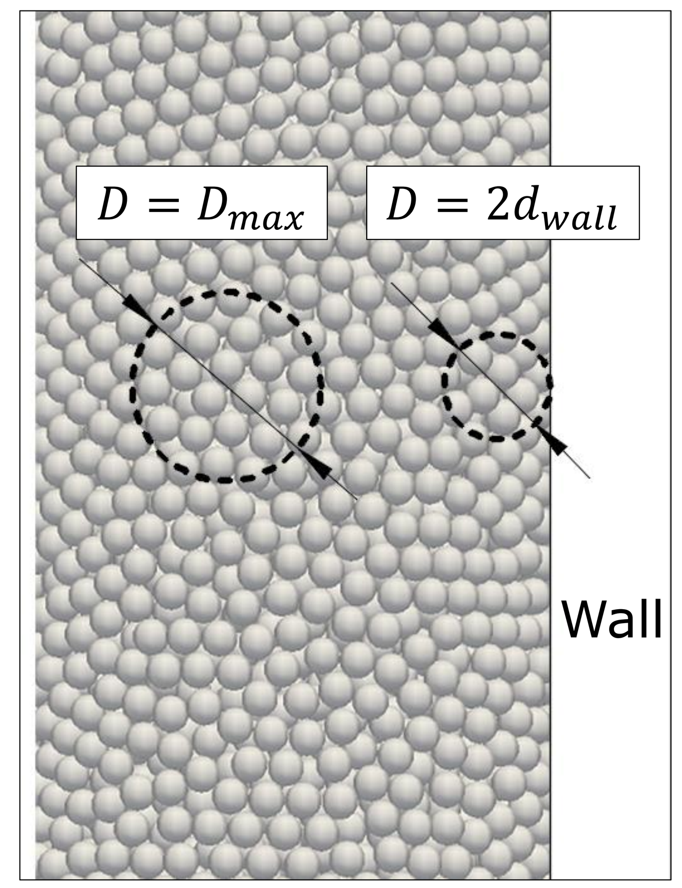
where the porosity ϕ_V writes:

$$\phi_V = \frac{1}{V}\int_{V_f} dV$$

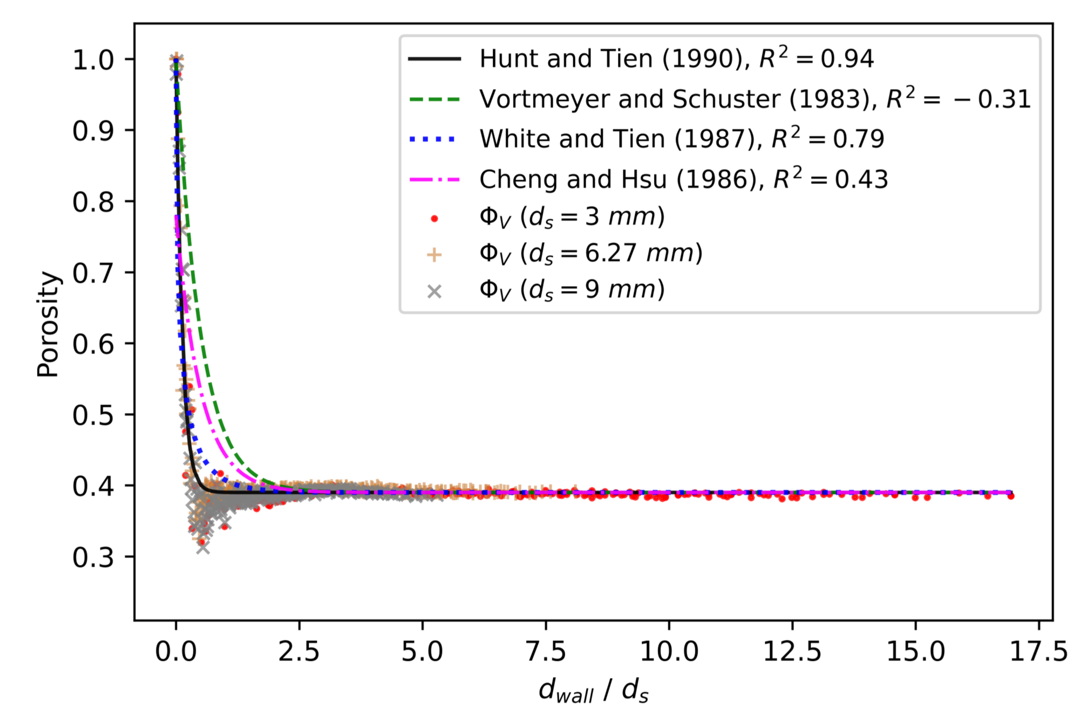




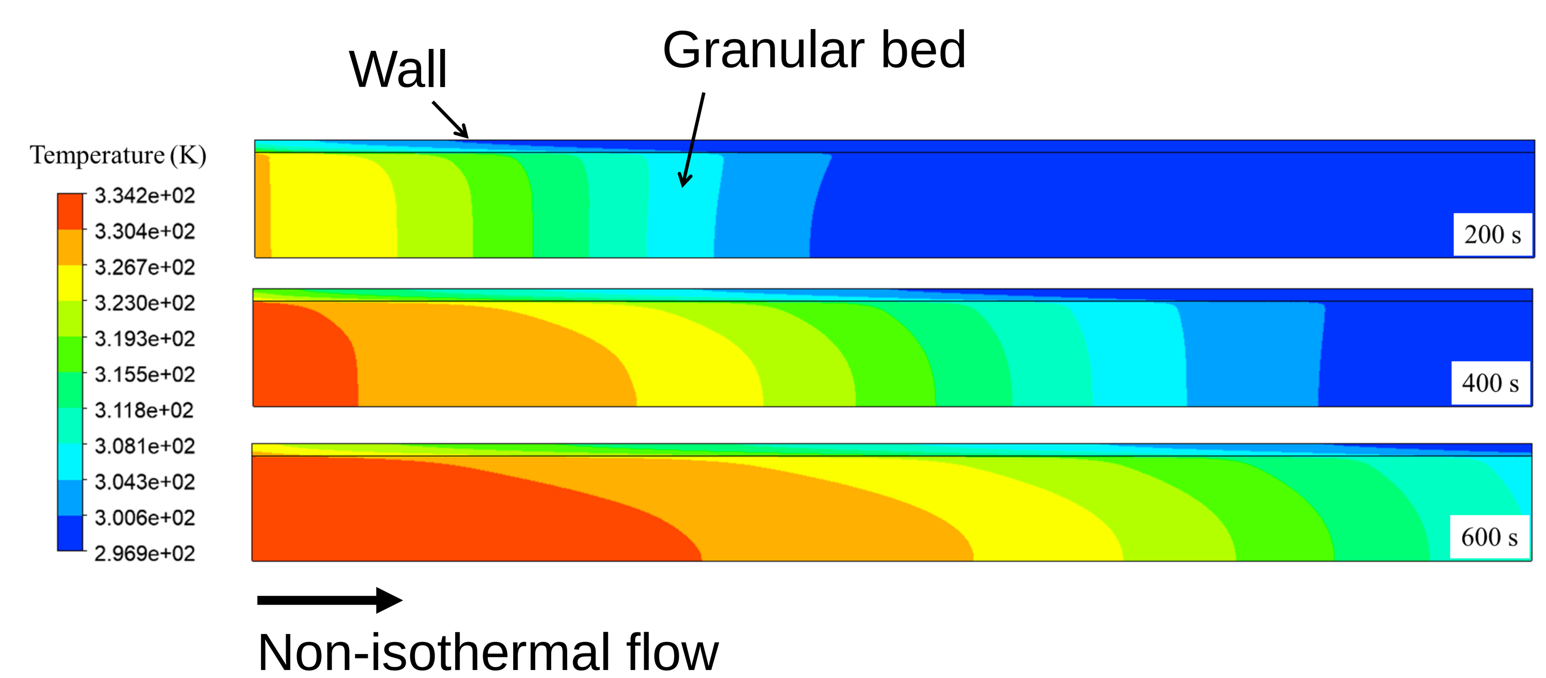
VOLUME AVERAGING WITH A NON-CONSTANT REV



- Simplify the derivation of the macroscopic equations without considering the wall as a third phase.
- Eliminate the incompatibility of quantities at the wall.
- Generate REV size variation induced **source terms** in macroscopic equations.
- Allow determining the exponential porosity profile directly from the packing structure.



NUMERICAL ANALYSIS



- The profile of ϕ_V and REV size induced source terms were implemented with User Defined Functions (Ansys Fluent)

ACKNOWLEDGMENTS

CRSNG NSERC
crepec
FONCER
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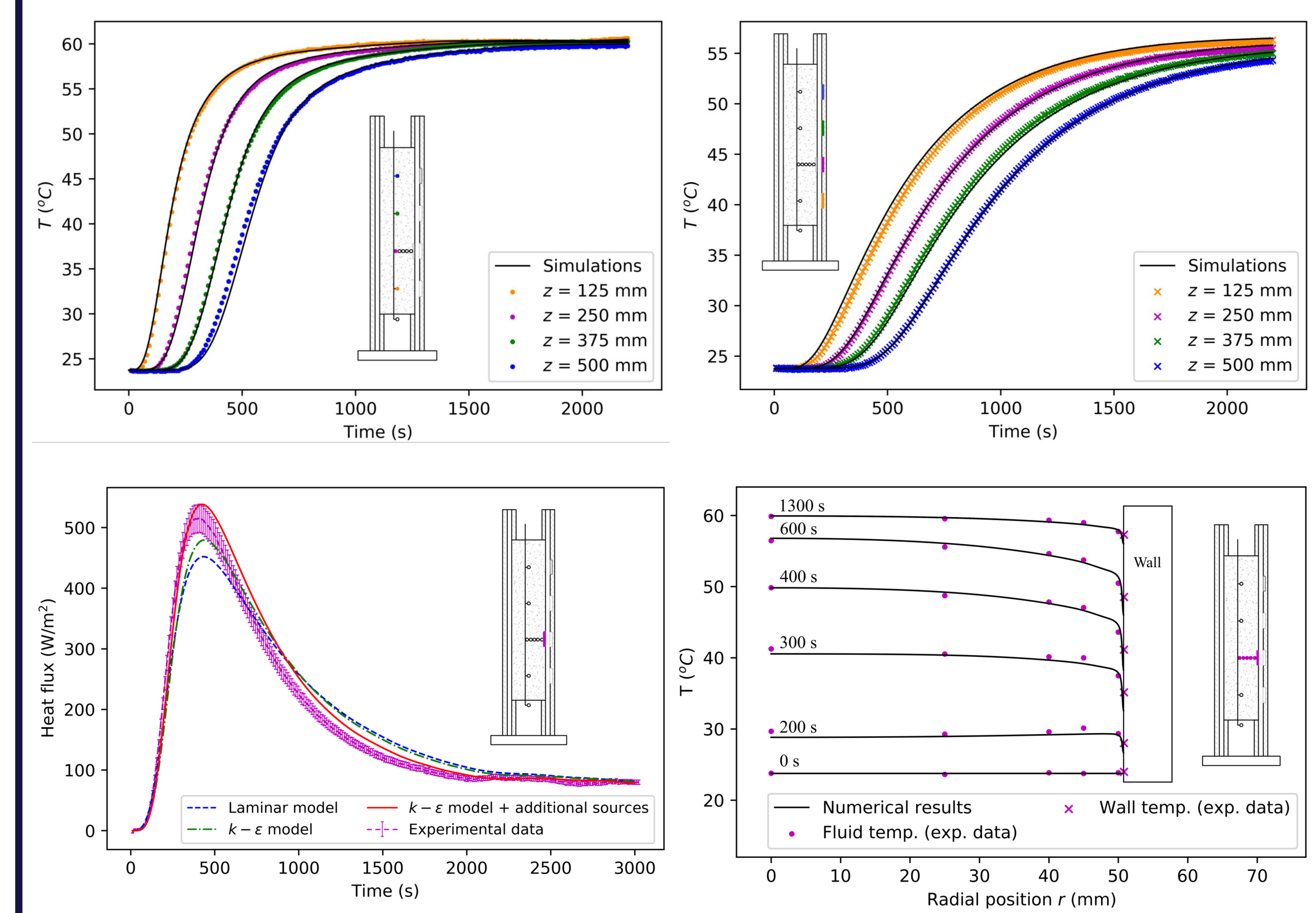
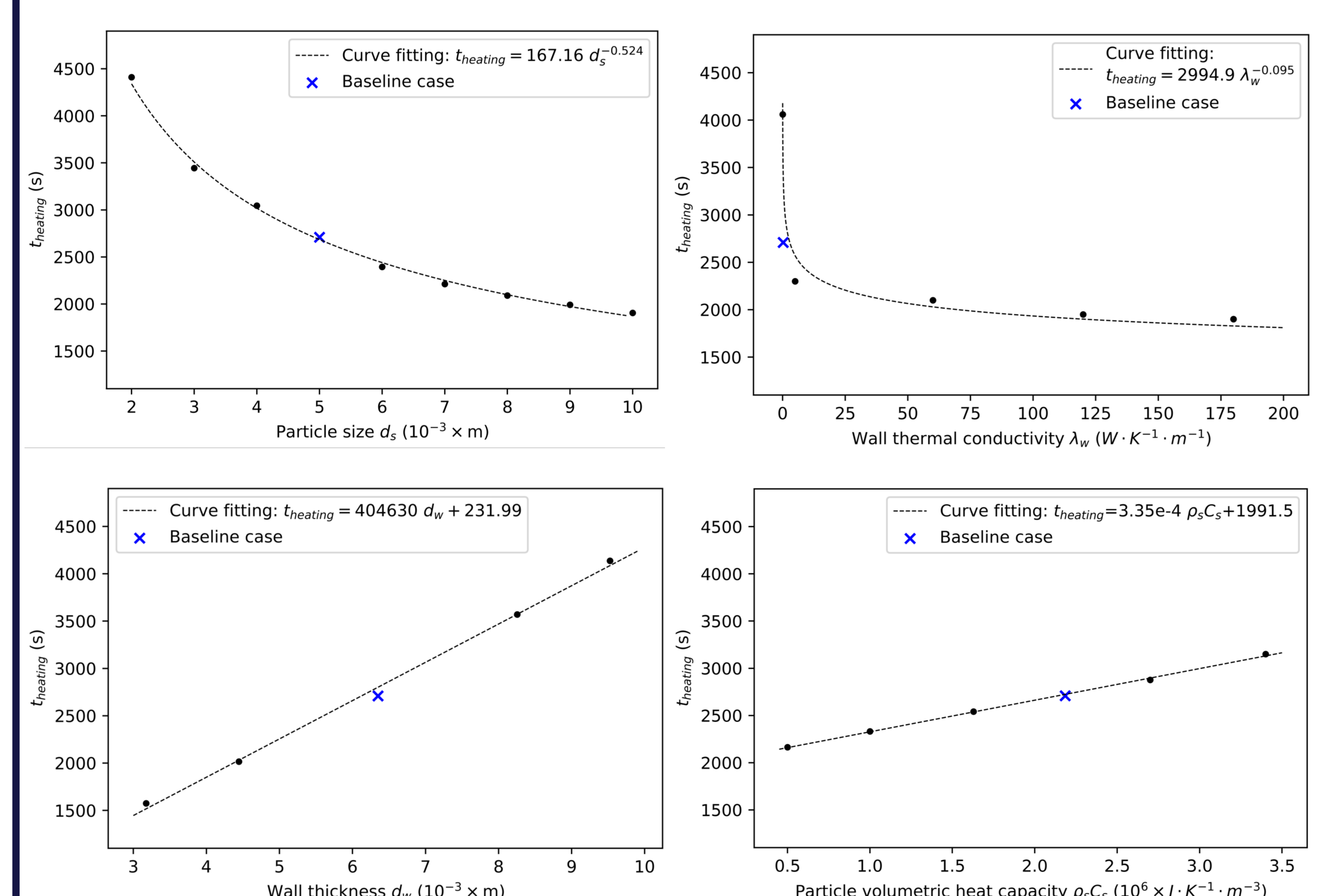
GPS SBES
Calcul Québec

EXPERIMENTAL VALIDATION



HEATING EFFICIENCY OF THE BOUNDING WALL



CONCLUSIONS

- A framework was proposed to model the convective heat transfer from a granular bed to its bounding wall.
- A satisfactory agreement was observed between the numerical results and the experimental observations.
- Reducing the wall thickness and increasing the particle size play a key role to reduce the time to reach wall temperature uniformity.