IOCN 2025 Conference
The 5th International Online Conference on Nanomaterials
22–24 September 2025 | Online
MDPI

Effect of Novel Fin Distribution on the Melting Process of Thermal Storage Units

Abdeldjalil Belazreg 1, Aissa Abderrahmane 2
[1],[2] Laboratoire de Physique Quantique de La Matière et Modélisation Mathématique (LPQ3M), University of Mascara, Algeria

INTRODUCTION & AIM

- Latent Heat Thermal Energy Storage (LHTES) with PCMs → **high energy density** but **low thermal conductivity**.
- Enhancement strategies: fins, nanoparticles, optimized geometries.
- **Aim:** Evaluate novel fin shapes + Cu nanoparticles in paraffin PCM (Tm ≈ 50 °C) inside octagonal shell-and-tube unit
- Fins studied:
  - C1: Dual-radial
  - C2: Tree-likeC3:
  - Roots-like

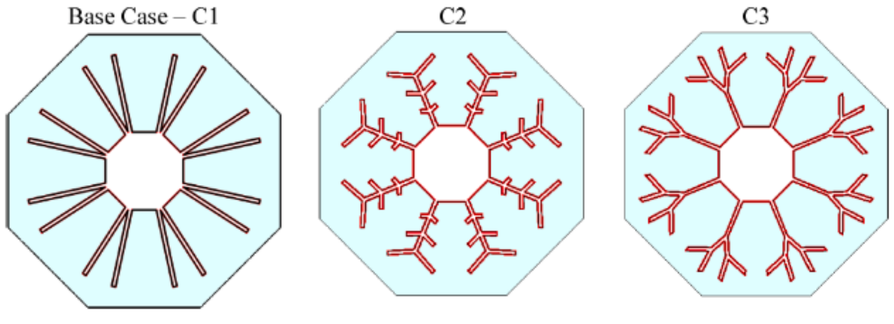

Fig. 1 – 2D schematic of the octagonal shell-and-tube unit

Methodology

- PCM = Paraffin wax (Tm ≈ 50 °C), Cu nanoparticles (0–8 vol%).
- Fins: C1 (dual-radial), C2 (tree-like), C3 (roots-like).
- COMSOL FEM, 2D, laminar, Boussinesq approx.
- Inner tube heated (60 °C), outer shell insulated.

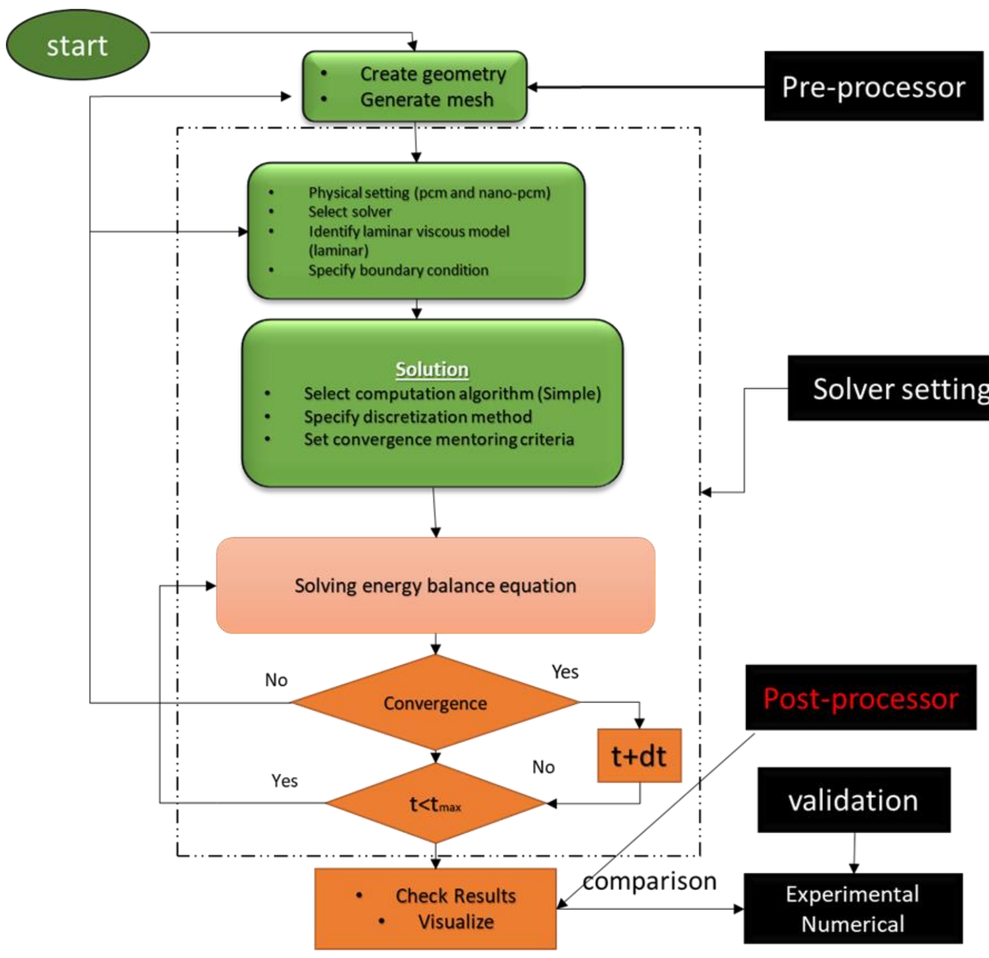

Fig. 2 – Numerical method flowchart (Galerkin FEM in COMSOL)

RESULTS & DISCUSSION

Effect of Fin Design

- C3 (roots-like fins) distributes heat best, especially at bottom (weak convection zone).
- Melting time reduction:
- 56% vs C1 (dual-radial)
- 91% vs C2 (tree-like)
- C3 reaches 99% liquid fraction in 39 min (≈ half the time of arc-fins reported in literature).

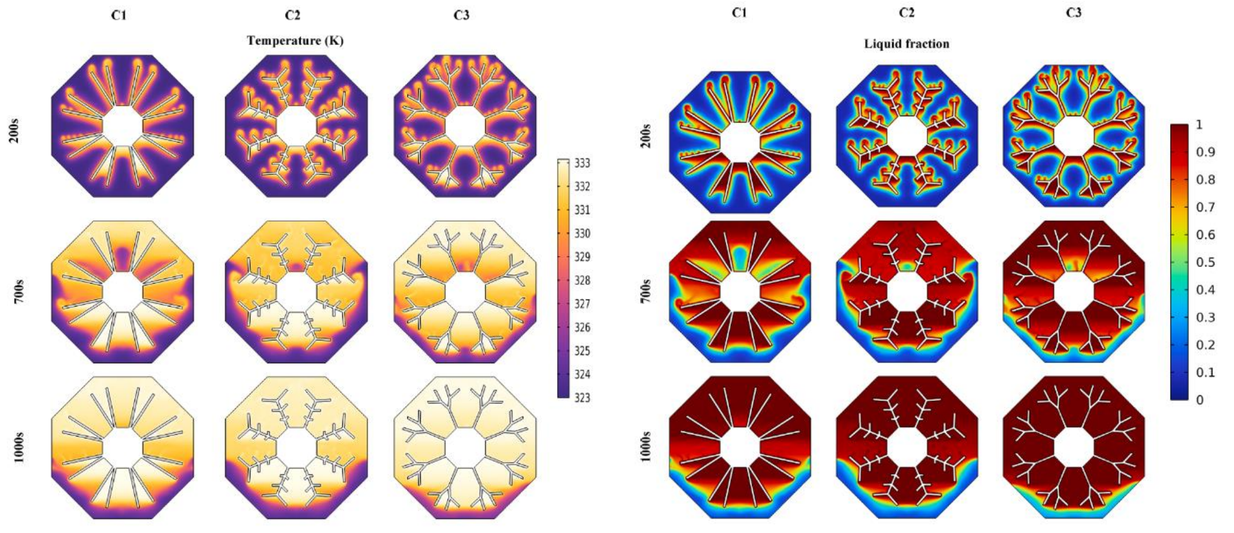

Fig. 3 Liquid fraction and temperature distribution for C1, C2, and C3

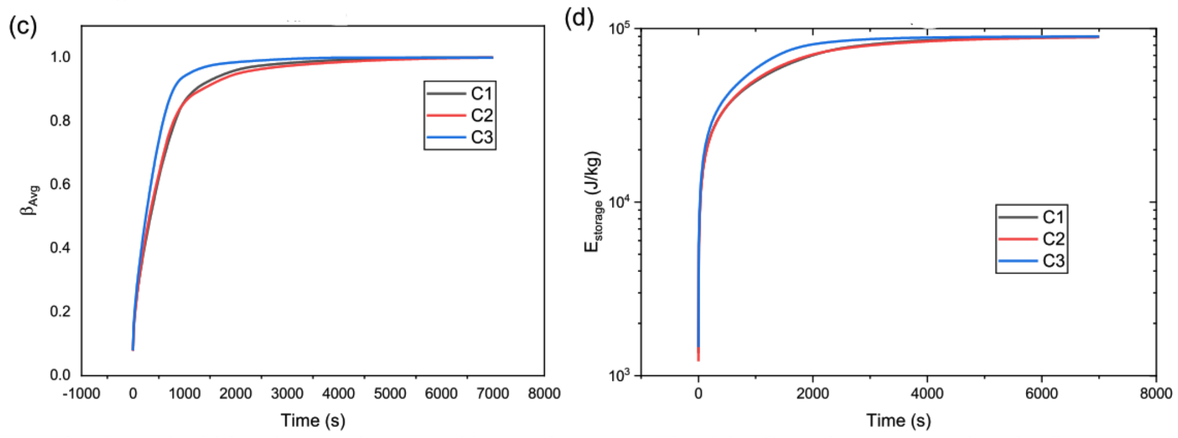

Fig. 4c – Liquid fraction vs. time – melting performance **Fig. 4d** – Stored energy vs. time for fin geometries

2. **Nanoparticles Enhance Performance**

- Adding Cu nanoparticles increases PCM thermal conductivity.
- 8 vol% Cu → 28.6% faster melting vs pure PCM with C3 fins
- Higher concentration → more uniform temperature & quicker energy storage.
- Stored energy reaches target faster with C3 + Cu nanoparticle

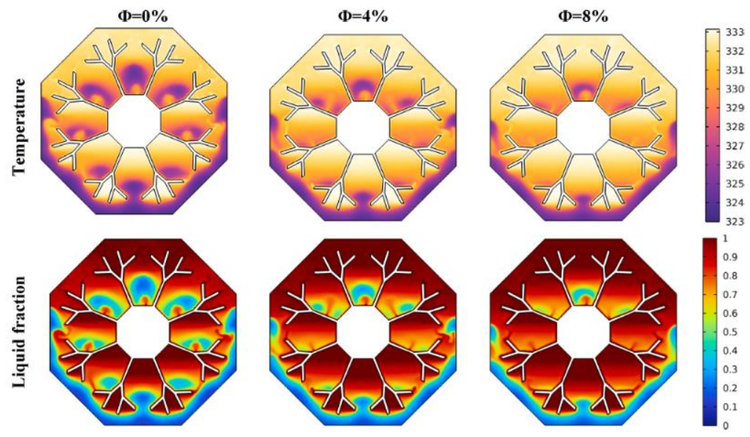

Fig. 5 – Temperature & liquid fraction with 0%, 4%, 8% Cu nanoparticles

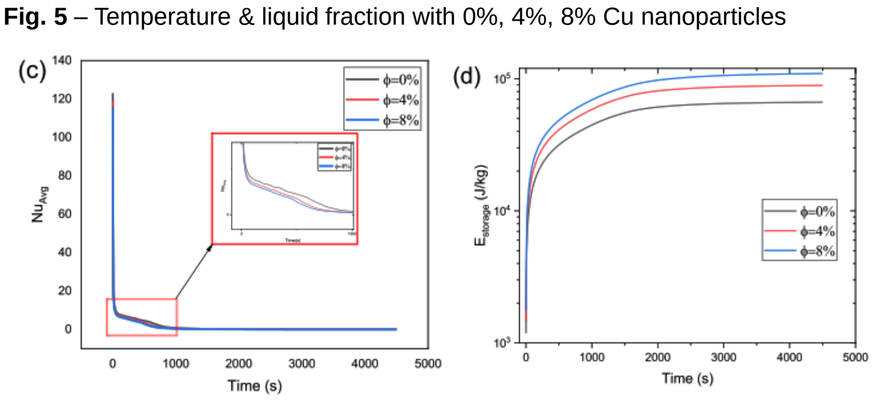

Fig. 6c – Liquid fraction vs. time – effect of nanoparticle concentration **Fig. 6d** – Stored energy vs. time with nanoparticle enhancement

CONCLUSION

- Roots-like fins (C3) minimize thermal resistance and accelerate PCM melting.
- Cu nanoparticles (8 vol%) provide further performance boost.
- Best design: Roots-like fins + 8% Cu-NEPCM → compact, high-performance thermal storage..

FUTURE WORK / REFERENCES

Key References:

Qasem et al., Appl. Therm. Eng., 243 (2024) 122547.

Saeed et al., J. Energy Storage, 53 (2022) 105172.

Belazreg et al., Case Stud. Therm. Eng., 51 (2023) 103638.