CSC Propostion thesis - UTBM

1 MISCELLANEOUS INFORMATION

1.1 Title

- Numerical Analysis and Optimization of advanced Heat Transfer in Porous Lattice Structures

1.2 Key words

- New advanded process, heat exchanger, porous media, numerical modeling, optimization

1.3 ADMINISTRATIVE INFORMATION

➔ Host laboratory/University	ICB UMR 6303, CNRS Université Marie et Louis Pasteur Université de Technologie de Belfort Montbéliard 90010 Belfort cedex
➔ Supervisors	• Pr Gomes Samuel • Pr Nadhir Lebaal • Pr Said Abboudi

2 THESIS PROPOSAL

2.1 PROJECT

Heat exchangers (HEs) are critical industrial equipment designed for thermal management, enabling heat transfer between hot and cold fluids. They play a pivotal role in developing contemporary industrial technologies. Compact heat exchangers have emerged as one of the most sophisticated cooling techniques available today.

Advanced manufacturing processes has opened new frontiers, particularly in utilizing lattice structures as porous media a remarkably effective approach to thermal dissipation. The primary objective of these innovative structures is to transmit heat between hot and cold zones by simultaneously leveraging two fundamental thermal phenomena: heat conduction and convection.

Numerical simulation of this conjugate heat transfer can be modelled through two approaches: the porous media model and the real physical model. The research aims to optimize lattice configurations within heat exchangers to significantly enhance their thermal efficiency.

Due to computational constraints limiting full-scale numerical simulations of 3D lattice structures, the porous media model methodology emerges as a particularly robust approach for heat exchanger numerical modelling. Through sequenced numerical simulations of the lattice structure configuration model, it becomes possible to derive viscous and inertial resistance coefficients for the equivalent porous media zone in each directional axis by precise computational fitting.

A surrogate model will be constructed encompassing various lattice structures and configurations, employing multiple identification methods. This approach will rely on meticulous comparative analysis of simulated values between the porous media model and the 3D real physical lattice structure model.

Ultimately, an optimization algorithm will be implemented to refine lattice geometry and density, with the overarching goal of maximizing the system's overall thermal efficiency.

2.2 PROPOSED WORK PLAN

- Literature Review and Theoretical Background
- Numerical simulations of 3D lattice structures
- Porous media model methodology

- Experimental Validation and Application to heat exchanger
- Optimization of porous lattice system.

2.3 References

[1] N. Lebaal, A. Settar, S. Roth, S. Gomes, Conjugate heat transfer analysis within in lattice-filled heat exchanger for additive manufacturing, Mech. Adv. Mater. Struct. (2020) 1–9. https://doi.org/10.1080/15376494.2020.1819489.

[2] R. Saim, H. Benzenine, S. Abboudi, H. Oztop, N. Abu-Hamdeh. Three-dimensional analysis of heat transfer in a channel provided with solid baffle, single and double perforation: A heat exchanger application. *Int. Journal of Numerical Methods for Heat & Fluid Flow*, 2019, Vol. 30 No. 9, pp. 4267-4280.

[3] A. Kopanidis, A. Theodorakakos, E. Gavaises, D. Bouris, 3D numerical simulation of flow and conjugate heat transfer through a pore scale model of high porosity open cell metal foam, Int. J. Heat Mass Transf. 53 (2010) 2539–2550. https://doi.org/10.1016/j.ijheatmasstransfer.2009.12.067.

[4] Z. Li, Y. Ding, Q. Liao, M. Cheng, X. Zhu, An approach based on the porous media model for numerical simulation of 3D finned-tubes heat exchanger, Int. J. Heat Mass Transf. 173 (2021) 121226. https://doi.org/10.1016/j.ijheatmasstransfer.2021.121226.

[5] N. Lebaal, Robust low cost meta-modeling optimization algorithm based on meta-heuristic and knowledge databases approach: Application to polymer extrusion die design, Finite Elem. Anal. Des. 162 (2019) 51–66. https://doi.org/10.1016/j.finel.2019.05.004.

3 Skills required to apply

- Holder of a master's degree in computational mechanics or materials science.
- Strong skills in Heat transfer.
- Strong skills in numerical modelling and simulation.
- Good communication skills (oral, written) and organizational skills.
- Good level of English.
- Good autonomy, ability to synthesize.
- Dynamic, rigorous candidate with good teamwork skills.