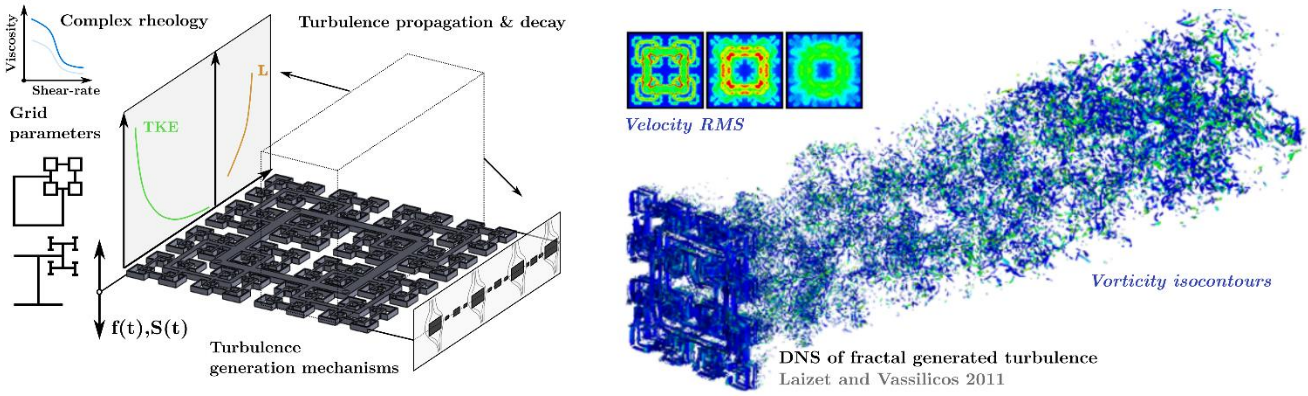
# **M2 Internship** – Numerical study of fractal oscillating grid turbulence as a tool to improve mixing in complex-rheology biological fluids

**Context:** A number of bio-processes involve the **use of fluids that are inherently complex due to their biological nature**. Mastering process intensification through enhanced and combined heat-mass transfer and mixing is thus extremely challenging. Strategies to ensure **efficient mixing with limited imposed shear-stress**, adaptable to complex fluid's rheology, have to be found. **Oscillating grids** are a common play-field for the study of turbulence at low mean shear [1]–[3] with turbulent production at relatively low imposed shear-rates. Yet, the application of oscillating grid turbulence (OGT) in non-Newtonian fluids raises several questions regarding the **mechanism of turbulence generation and its properties** [2], [4]. Fractal grids have proven their efficiency regarding turbulence generation in air tunnels, but have so far never been applied to oscillating grid systems, in Newtonian let alone non-Newtonian fluids, despite their **potentially ground-breaking improvement of mixing**. The goal of this internship is thus to assess the possibilities and different strategies for **numerically simulating the flow around oscillating fractal grids** in more or less complex fluids, using direct numerical simulation (DNS) [5], [6]. In this internship, we will make use of the meshing strategy developed in previous projects (MultiMatchGrid) to perform numerical simulations using **OpenFoam.** The main tasks will be to adapt the meshing strategy, make use of already implemented non-Newtonian rheological models, and define a suitable simulation strategy for oscillatory grids. Various test simulations will be then performed and validated by comparison with experimental data




**Person specification:** We are looking for an enthusiastic and motivated Engineering/MSc/M2 student, with solid basis in fluid mechanics, numerical methods, and a background in computational fluid dynamics (CFD). Strong analytical, organisation and communication skills, and proficiency in English language are required. A good understanding of the basics of turbulence and its modelling is essential. Prior experience with DNS, OpenFoam, strong programming skills (Python, C++, Matlab …), and parallel computing skills will be valued. Notions in rheology and complex fluids' dynamics would be a plus.

**Work environment:** The successful applicant will be part of two research teams in Lille and Douai. The position is based at the research centre of **IMT Nord Europe** in Douai (https://imt-nord-europe.fr/), **centre for energy and environment**, in the team on **Fluids and components**, that conducts research on complex fluids, complex flows, and their role in transfer and process intensification. A significant part of the work will be conducted in collaboration with the **Laboratoire de Mécanique des Fluides de Lille (LMFL – CNRS) at ENSAM Lille.** The M2 internship is part of an **ANR-funded research project** involving collaborations with **international partners** (Univ. Mons, Univ. College London), experimentalists, and bio-process specialists. The opportunity to contribute to publications in peer-reviewed scientific journals will be offered.

**How to apply:** Send detailed CV, cover letter and transcripts to **Tom LACASSAGNE** tom.lacassagne@imt-nord-europe.fr and **Francesco ROMANO (**francesco.romano@ensam.eu**). Applications will be considered until the position is filled.**

[1] E. J. Hopfinger et J.-A. Toly , J. Fluid Mech., vol. 78, no 01, p. 155-175, nov. 1976
[2] T. Lacassagne, S. Simoëns, M. EL Hajem, A. Lyon, et J.-Y. Champagne, Phys. Fluids, vol. 31, no 8, p. 083102, 2019,
[3] T. Lacassagne, M. EL Hajem, J.-Y. Champagne, et S. Simoëns, Int. J. Heat Mass Transf., vol. 194, p. 122975, 2022
[4] T. Lacassagne, A. Lyon, S. Simoëns, M. E. Hajem, et J.-Y. Champagne, Exp. Fluids, vol. 61, no 1, p. 15, 2019
[5] S. Laizet, E. Lamballais, et J. C. Vassilicos, Comput. Fluids, vol. 39, no 3, p. 471-484, 2010
[6] S. Laizet et J. C. Vassilicos, Flow Turbul. Combust., vol. 87, no 4, p. 673-705, 2011