Semester project* at LAMD-EPFL

**Can also be adapted for master's thesis*

Moving wall and thin fluid film effects on backward- and forward-facing step flows

General information

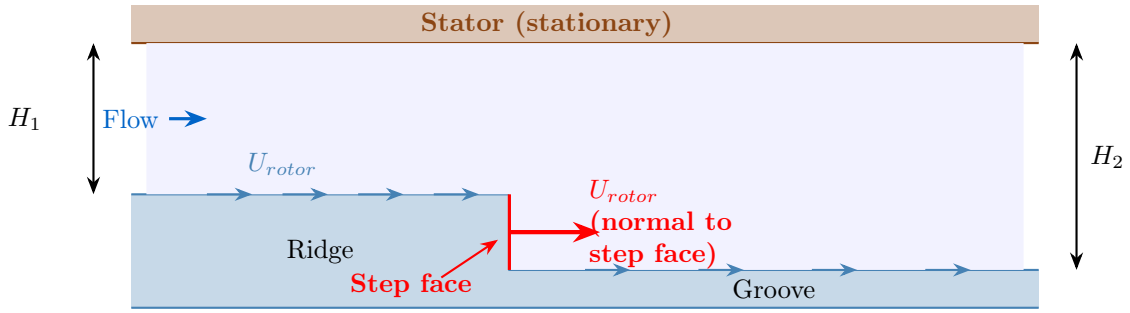
- Laboratory: Laboratory for Applied Mechanical Design (LAMD), EPFL
- Supervisors: Aman Jain, Prof. Jürg Schiffmann
- Contact:
  - aman.jain@epfl.ch
- Location: Neuchâtel (train tickets will be provided by EPFL)
  - Meetings from EPFL main campus can be discussed

Background and objectives

Backward-Facing Step (BFS) and Forward-Facing Step (FFS) flows are classical benchmark problems in fluid mechanics, extensively studied for understanding flow separation, reattachment, and recirculation phenomena. However, existing literature predominantly focuses on stationary wall configurations.

In Herringbone Grooved Journal Bearings (HGJBs), the groove-ridge interfaces create geometries analogous to BFS and FFS. The transition from ridge to groove forms a BFS-like expansion, while the groove to ridge transition creates an FFS-like contraction. Critically, in HGJBs, the step wall (rotor surface) moves at high tangential velocities, and the step face experiences motion **normal to its surface**, a configuration largely unexplored in the literature. Additionally, the thin film environment (5–50 μm clearance) and skewed herringbone geometry create unique flow conditions.

Recent experimental observations have revealed particle trapping in HGJBs operating. We hypothesize that this is linked to flow separation and recirculation zones near the groove-ridge interfaces. The objective of this project is to use CFD (ANSYS Fluent) to investigate BFS/FFS flows with moving walls representative of HGJB conditions, employing either dynamic mesh or relative reference frame approaches. The study will characterize how wall motion and thin-fluid film affect separation, reattachment, and recirculation, providing insights into particle trapping mechanisms in HGJBs.



Key insight: Horizontal surfaces → wall motion **tangential** to surface (standard moving wall BC)
Vertical step face → wall motion **normal** to surface (requires special treatment)

Figure 1: Backward-facing step geometry in laboratory frame showing the moving rotor surface. The step face moves normal to its own surface, which cannot be captured by standard moving wall boundary conditions.

Working plan guideline

1. Literature review on BFS/FFS flows, moving wall effects, and grooved bearing dynamics
2. Development of 2D BFS/FFS models in ANSYS Fluent; validation against benchmark data
3. Implementation and validation of relative reference frame approach (moving top wall with stationary step) against dynamic mesh simulations
4. Extension to 3D skewed geometries representative of herringbone groove angles
5. Parametric study: effect of wall velocity, step height ratio, and Reynolds number on separation/reattachment characteristics
6. Analysis of results and correlation with particle trapping mechanisms
7. Report and presentation

NB: adjustments can be done based on the student preferences and progress.

Recommended prerequisites

- Fluid mechanics
- CFD fundamentals (prior experience with ANSYS Fluent is a plus but not required)
- MATLAB or Python, CFD Post, Paraview (Any post-processing and visualization tool)