

Job offer – PhD in Mechanical and Aeronautical Engineering
(For non-French scientists only)

Research Project Short Title as Submitted to CEFIPRA: “Commercial production of Hydrogen-lubricated beam foil bearings towards the development of high-speed H₂-compressors for clean energy recovery systems”

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Reference Number of the Job Offer: IFI_CEF_26_15

Project description

- **Keywords :** Hydrogen compressors; Beam-type foil bearings; Gas foil bearings; Rotordynamics; Tribo-thermal modelling; High-speed turbomachinery
- **Context :** Hydrogen is emerging as an important clean energy carrier, but its large-scale use requires efficient compression, storage and transportation technologies. Hydrogen compressors increasingly rely on high-speed, oil-free turbomachinery, creating demanding requirements for bearings operating at very high rotational speeds. Gas foil bearings offer low friction and oil-free operation, but conventional designs face limitations in load-carrying capacity, dynamic stability and manufacturing complexity. The project addresses these challenges through the development of a beam-type foil bearing specifically intended for high-speed hydrogen-compressor applications. The proposed design combines compliant beam supports with controlled stiffness and friction-induced damping, while integrating tribological, thermal and rotordynamic considerations. The India–France academic and industrial partnership brings complementary expertise in bearing modelling, rotor dynamics, experimentation, prototyping and industrial validation. The project targets development and demonstration of the proposed technology up to Technology Readiness Level 5 (TRL 5).
- **Abstract of the Research Project :** The project aims to develop, characterize and validate a novel beam-type gas foil bearing for high-speed, oil-free hydrogen compressors. The proposed bearing is intended to address limitations of conventional foil bearings, particularly low load-carrying capacity, dynamic instability and manufacturing complexity. The research combines analytical, numerical and experimental approaches covering the bearing structure, gas-film lubrication, thermal behavior, tribology and rotor dynamics. An analytical nonlinear model will describe the stiffness and friction-induced damping of individual compliant beams, while finite-element shell models will represent the compliant and top foils. These models will be coupled with a small-perturbation lubrication formulation to determine bearing stiffness and damping.
A thermal model incorporating hydrogen thermodynamics will be used to predict pressure, temperature, load capacity, friction torque and lift-off characteristics. The resulting bearing characteristics will then be integrated into nonlinear rotordynamic models of a rigid high-speed compressor rotor, including constant-speed, acceleration and retardation conditions. Start-up and shutdown behavior will be described using contact-mechanics and mixed-lubrication models. Radial and axial prototypes will be designed and manufactured and experimentally characterized through dedicated test rigs in India and existing facilities at Institut Pprime in France. Experimental measurements will be compared with theoretical predictions. Finally, the developed bearing and rotor will be adapted to an industrial hydrogen-compressor architecture and tested in an industrial environment, with the objective of demonstrating proof of concept and reaching TRL 5.

- **Scientific Objectives of the Project :**
 1. Develop an analytical nonlinear model for the stiffness and friction-induced damping of a beam-type compliant foil, including large displacements and beam/support contact, and couple it with finite-element models of the compliant and top foils.
 2. Develop numerical lubrication and thermal models to determine the dynamic stiffness and damping of the gas film and predict pressure, temperature, load capacity, friction torque and lift-off characteristics, including hydrogen thermodynamics.
 3. Establish nonlinear rotordynamic models for a high-speed rigid rotor supported by two beam-type foil bearings, covering steady operation, unbalance response, stability, sub-synchronous behavior, acceleration and retardation.
 4. Develop contact-mechanics and mixed-lubrication models for start-up and shutdown.
 5. Design, manufacture and experimentally characterize radial and axial beam-type foil bearings, comparing measured stiffness, damping, load capacity, torque and lift-off speed with predictions.
 6. Integrate the developed bearings into an industrial compressor configuration and demonstrate their feasibility through in-situ testing, targeting TRL 5.
- **Methodology and Timeline of the Project :** The 36-month program is organized in six sequential and partially overlapping phases.
 1. Months 1–6: The French team will develop the nonlinear analytical model of the damping beam, including large displacement and friction effects, while the Indian team develops finite-element shell models for the compliant and top foils. The industrial partner will provide the compressor-rotor design data.
 2. Months 7–12: The models will be coupled with a small-perturbation compressible Reynolds formulation to obtain bearing stiffness and damping. In parallel, a thermal model will solve the Reynolds and energy equations while accounting for hydrogen thermodynamics and rotor thermal expansion.
 3. Months 13–18: The bearing models will be integrated into four/five-degree-of-freedom rigid-rotor models. Constant-speed and transient acceleration/retardation responses will be analyzed using unbalance response, Campbell and stability diagrams, rotor orbits, Poincaré maps, bifurcation diagrams and FFTs. Contact-mechanics and mixed-lubrication models will address start-up and shutdown. Radial and axial bearings will be designed and manufactured.
 4. Months 19–24: Large-size bearings will be experimentally characterized at Institut Pprime, while dedicated journal-and thrust-bearing test rigs are fabricated in India.
 5. Months 25–30: Dynamic rotor tests in France and tribological tests in India will provide experimental data for model validation.
 6. Months 31–36: The bearing and rotor will be adapted to the industrial compressor, manufactured, and subjected to in-situ testing by the French industrial partner. The final phase will demonstrate the proof of concept and prototype at TRL 5 and establish a pathway toward systematic production and industrial implementation.

Candidate profile

- Candidates can be all nationalities except French. In case of double nationality (French and another one), the candidate is not eligible. In the context of CEFIPRA, Indian candidates are preferred
- Applicants for PhD must have a master's degree (or be in the process of obtaining one) or have a University degree equivalent to a European Master's (5-year duration) to be eligible at the time of the deadline of the call [keep for PhD job offer only]
- No competences in French language are required
- Candidate competences
 - Master's degree (or equivalent 5-year degree) in Mechanical Engineering, Aerospace Engineering, Applied Mechanics or Computational Physics.

- Solid foundation in hydrodynamic and compressible thin-film flows, mixed-lubrication, and thermal-fluid interactions.
- Expertise in beam and shell elasticity theory, non-linear structural mechanics (large displacements, structural contacts), and solid-to-solid contact dynamics.
- Understanding of high-speed turbomachinery rotordynamics, including dynamic stability.
- Familiarity with high-pressure/high-speed real-gas thermodynamics and heat transfer in turbomachinery.
- Candidate know-how
 - Proficiency in coding custom numerical solvers (Python, MATLAB, Fortran, or C/C++).
 - Finite Element Analysis (FEA) experience for structural modeling and non-linear contact analysis.
 - Rotordynamic modeling
 - Hands-on experience with dynamic test rigs, high-speed rotational instrumentation and data acquisition systems.
 - Scientific writing and communication skills in English (no French required).
 - Ability to work effectively in a bi-national, collaborative academic-industrial project (India–France partnership).
- Expected starting date: 01-04-2027
- Expected duration: 36 months

How to candidate?

Documents to be provided :

- i. A cover letter (reasons for the candidature, professional project ...) max 2 pages
- ii. A copy of the master's degree or a proof of the program followed (and expected date of end) OR A copy of the PhD degree or a proof of the PhD program followed (and expected date of defense) max 1 page
- iii. A copy of results for previous scholarship (max 3 pages)
- iv. International curriculum vitae (max 2 pages)
- v. One letter of recommendation from any Indian institution –mandatory- (max 2 pages)
- vi. All should be submitted within 1 pdf file of no more than 10 pages.
- vii. Applications must be submitted through this [Google Form](#) selecting the appropriate reference number for the job offer.



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Benefits:

- Monthly allowance of 1870 euros for PhD
- Travel allowance
- University fee
- Carte de séjour fee
- Campus France management fee
- Registration to the French social security scheme

Selection process:

The final selection is made by a dedicated selection committee of scientific experts after a pre-selection phase by the French principal investigator. Decisions will be transmitted by the Embassy of France to CEFIPRA.

Criteria for applicants’ selection:

Academic excellence

- Excellence of the Academic background, Academic records, Honors, Letters of support, Participation to international research projects, exchange programmes and conferences.

Motivation and qualities

- Academic maturity: appropriation of the thesis project (stakes and contexts) • Quality of the presentation (oral expression, skills for synthesis, English level) • Maturity of the professional project: capacity to project her/himself within five years in terms of career development.

About CEFIPRA:

Indo-French Center for the Promotion of Advanced Research (CEFIPRA/IFCPAR) is an Indian body which promotes scientific cooperation between France and India in advanced fields of Science and Technology. It is supported by the Department of Science and Technology, Government of India and the Ministry of Europe and Foreign Affairs of the French government