MITSUBISHI TURBOCHARGER AND ENGINE EUROPE B.V.

Dynamics of rotors on hydrodynamic bearings

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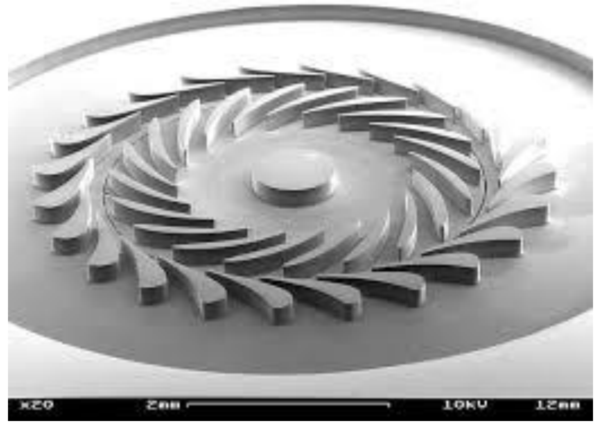
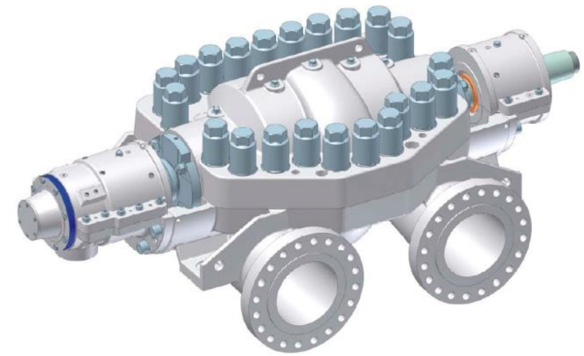
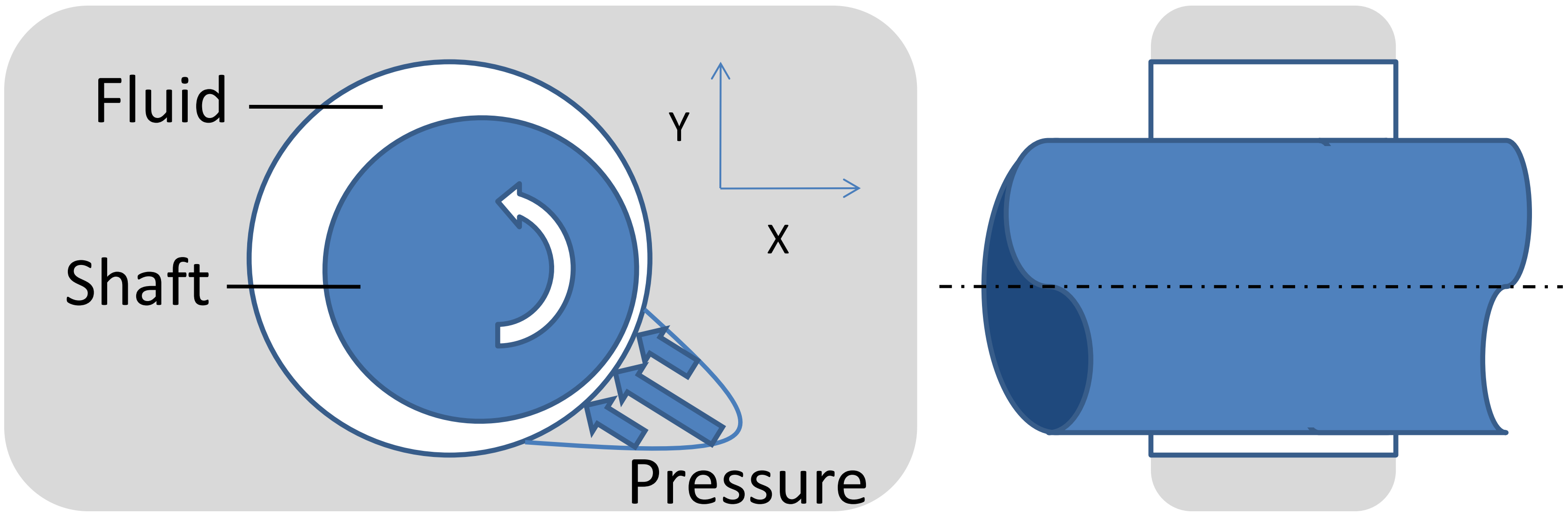
Rotors on hydrodynamic bearings



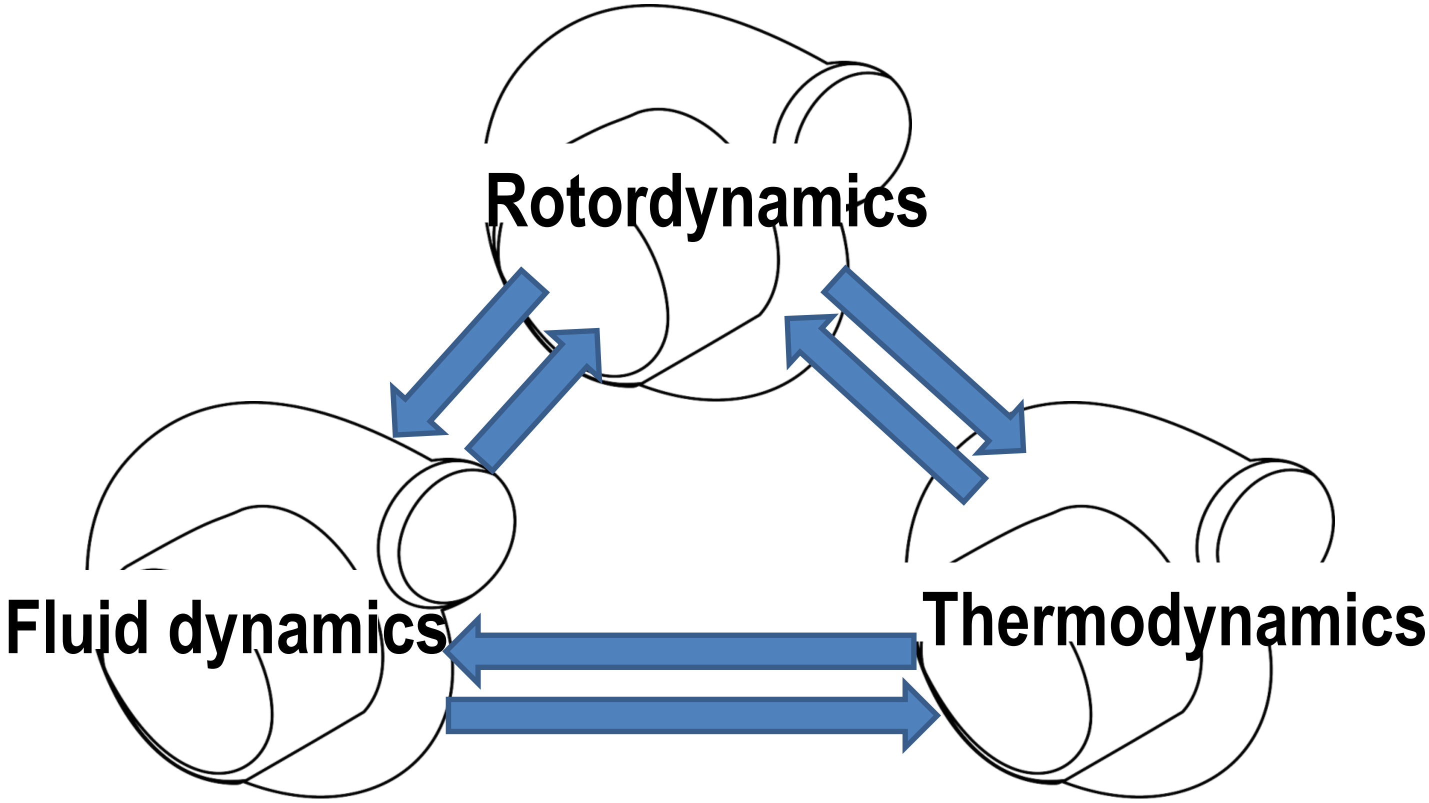


The problem: instability of the rotor-bearing system



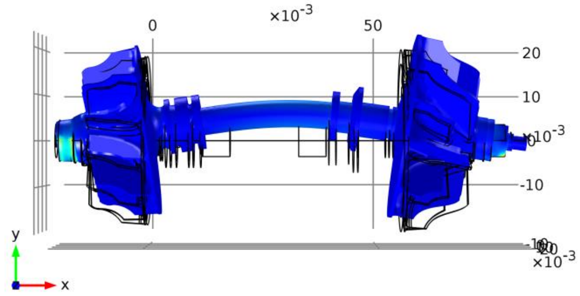
$$\begin{bmatrix} K_{XX} = \dfrac{\partial F_X}{\partial X} & K_{XY} = \dfrac{\partial F_X}{\partial Y} \\ K_{YX} = \dfrac{\partial F_Y}{\partial X} & K_{YY} = \dfrac{\partial F_Y}{\partial Y} \end{bmatrix} \square \begin{bmatrix} + & + \\ - & + \end{bmatrix}$$

Modeling approach

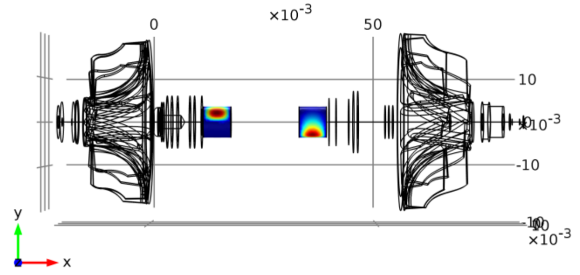


Modeling approach

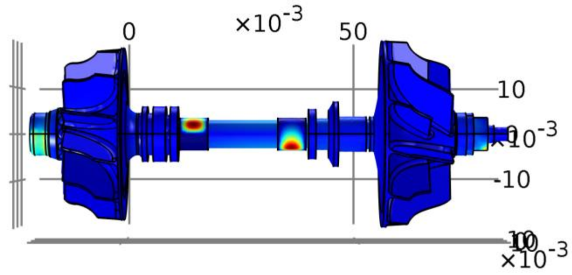
- Analysis of the rotor



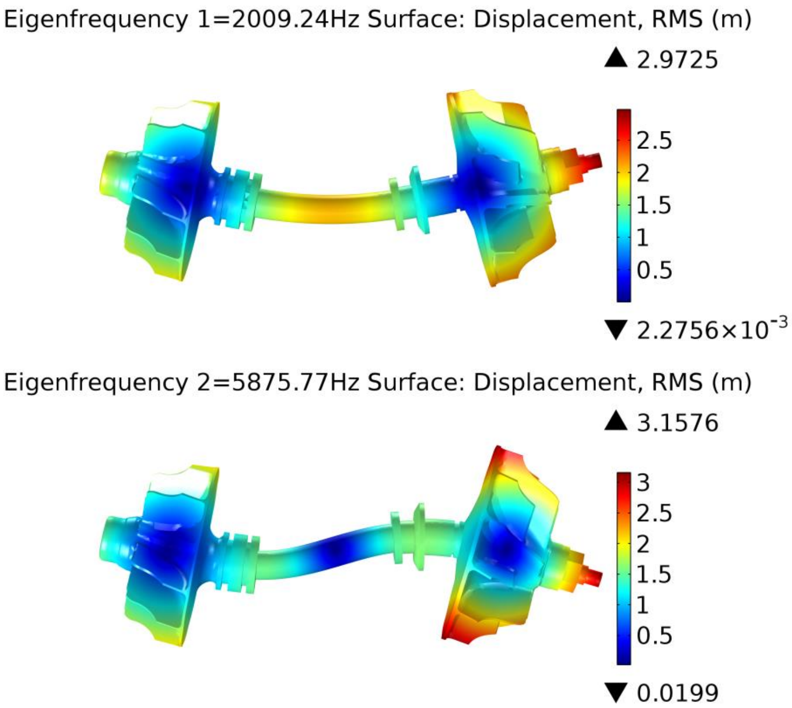
- Analysis of the hydro-dynamic bearings

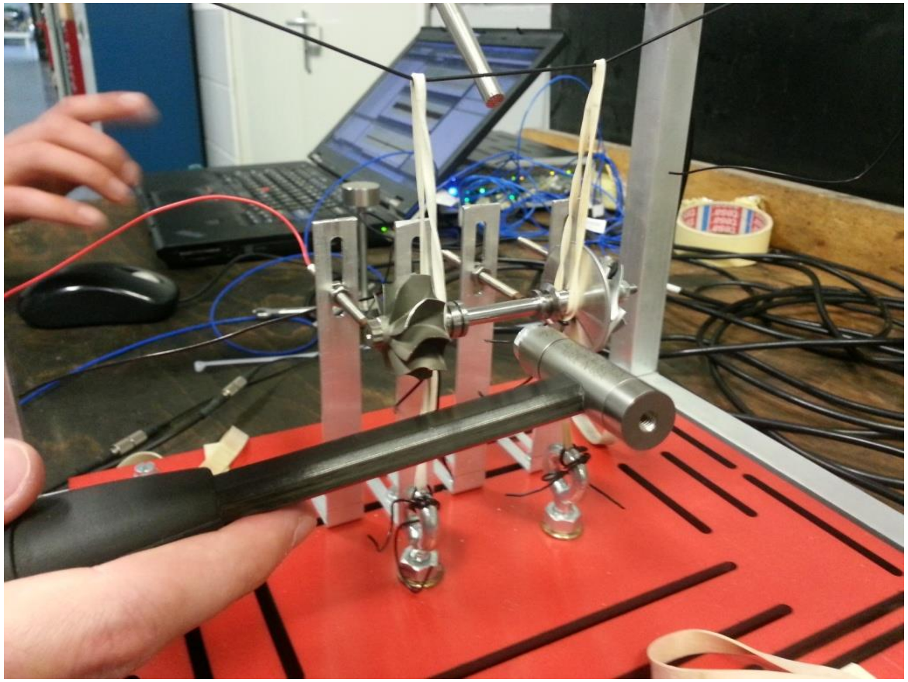


- Analysis of the coupled rotor-bearing system

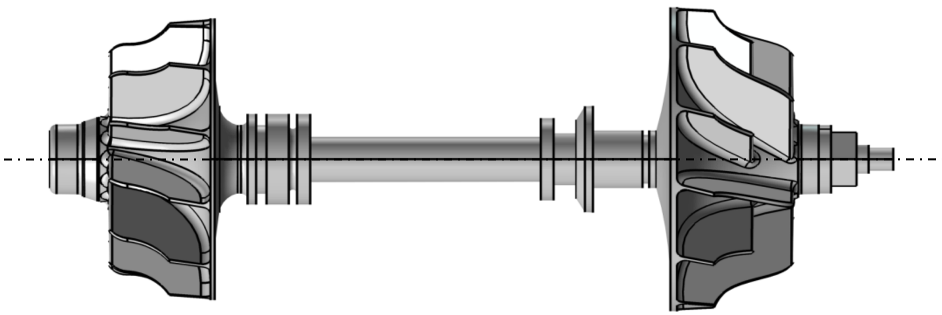


Analysis of the rotor: modal analysis

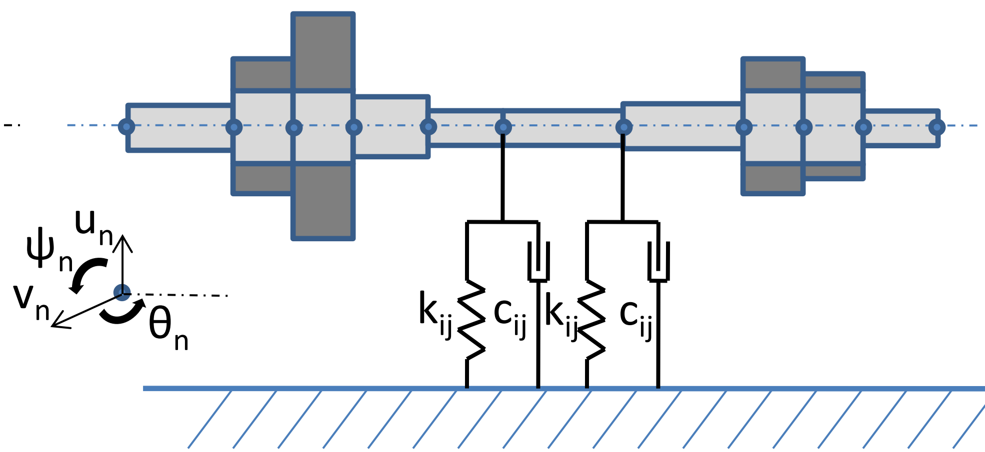




Analysis of the rotor: reduction



75.000 volume elements



10 beam elements

Analysis of the bearing: thin film approach

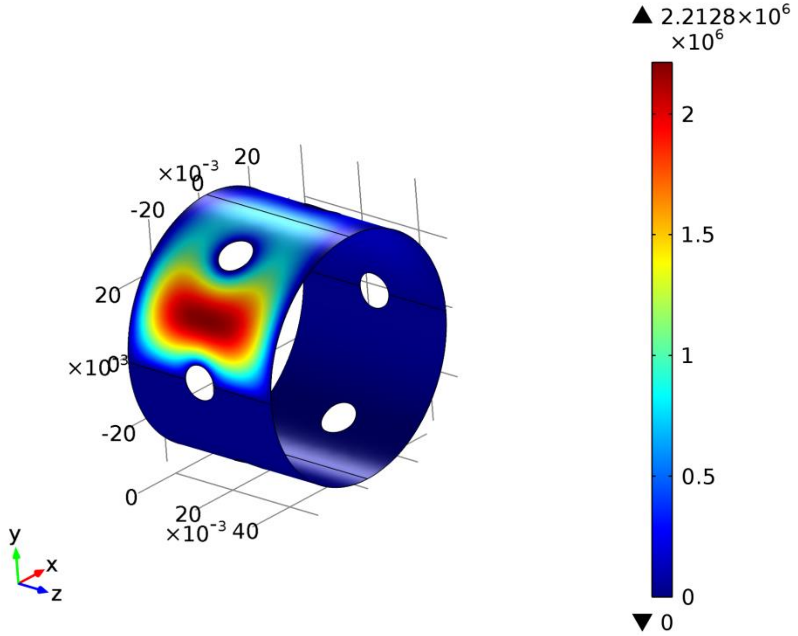
CFD analysis:

$$\rho \mathbf{g} - \nabla p + \nabla \cdot \tau = \rho \frac{d\mathbf{V}}{dt}$$

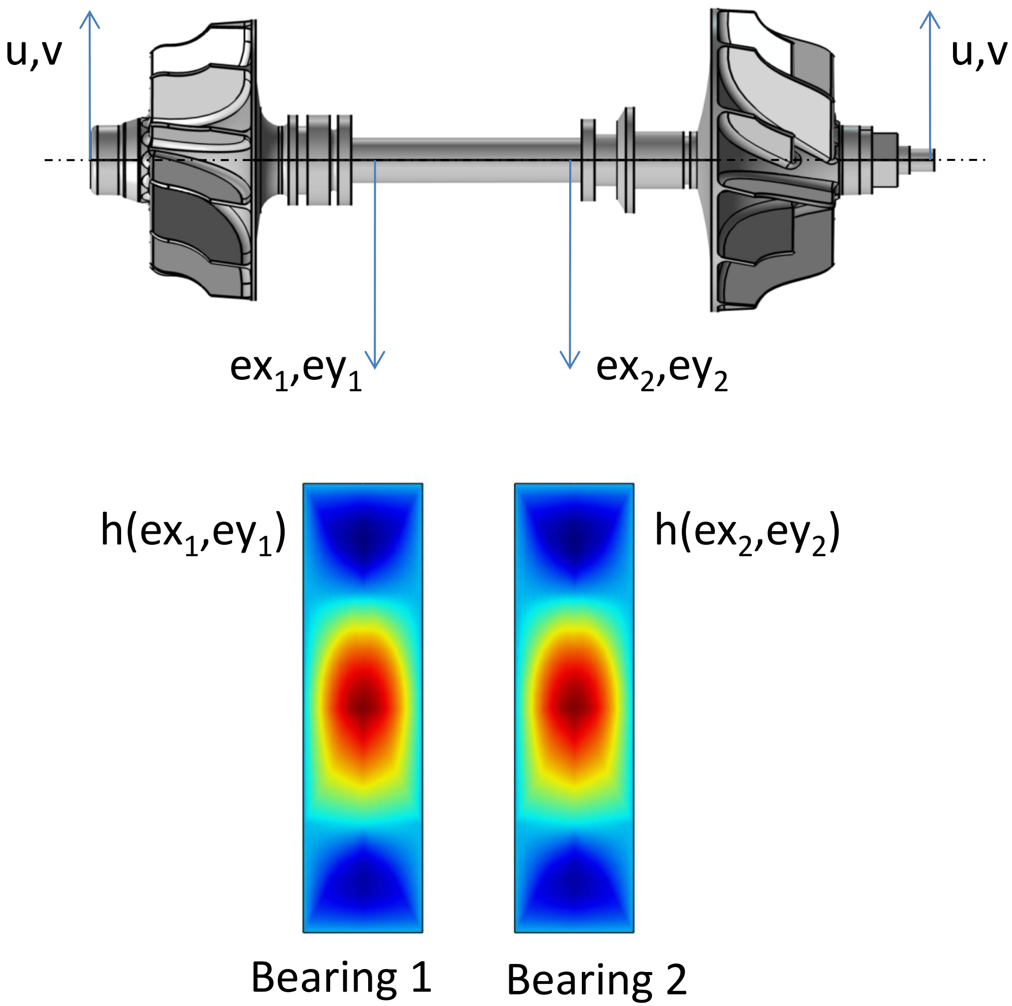
Comsol Thin Film Module:

$$\frac{\partial}{\partial t}(\rho h) + \frac{1}{2}\frac{\partial}{\partial x}\rho h U = \frac{\partial}{\partial x}\left\{\frac{\rho h^3}{12\mu}\frac{\partial p}{\partial x}\right\} + \frac{\partial}{\partial z}\left\{\frac{\rho h^3}{12\mu}\frac{\partial p}{\partial z}\right\}$$

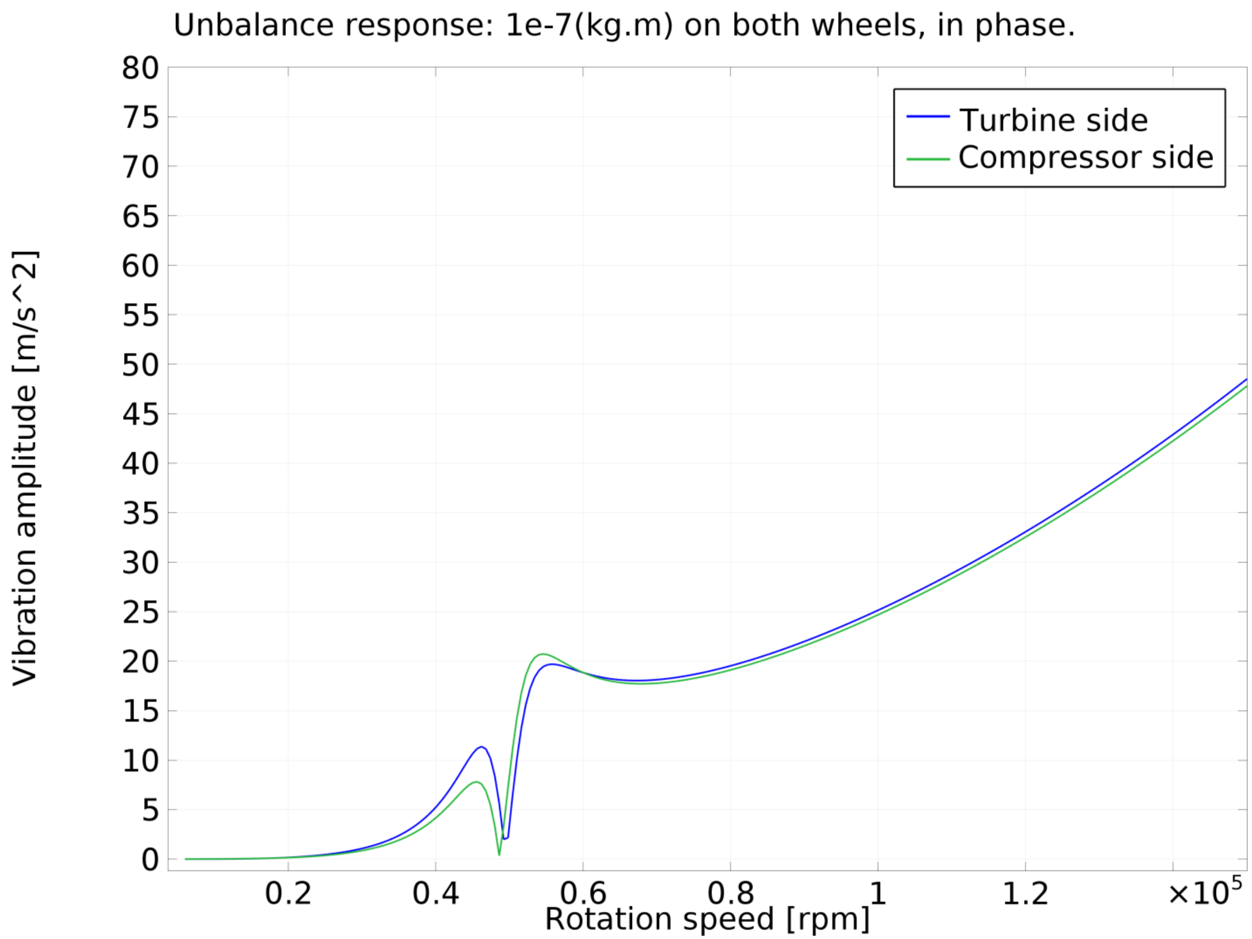
Assumptions always need to be checked



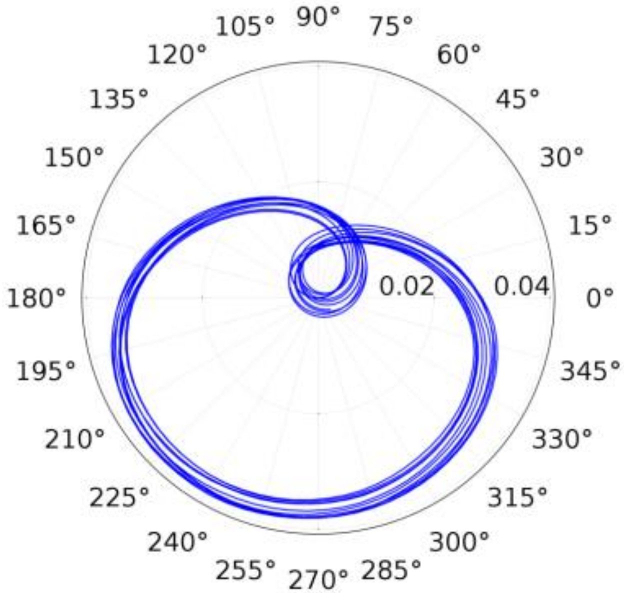
Coupling

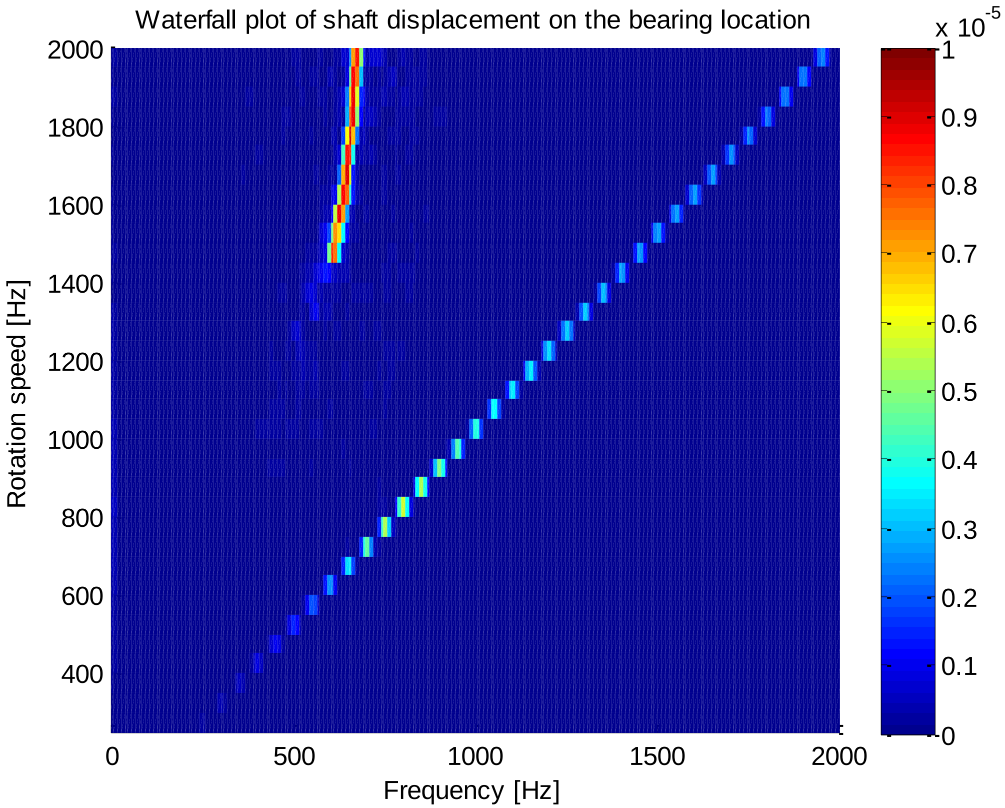


Analysis of the coupled rotor-bearing system: the effect of unbalance



Analysis of the coupled rotor-bearing system: sub-synchronous vibrations





Conclusions

- Rotors on hydrodynamic bearings show self-induced vibrations due to fluid-structure interaction
- The response of the non-linear rotor-bearing system can be analyzed using run-up simulations over the full operating range, and shows many interesting/dangerous non-linear vibration phenomena