



**Corado NINGRE**

Thèse Hydro'Like, 2015 – 2018  
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# Développement d'une méthode de suivi de l'endommagement par fatigue multiaxiale : Application aux turbines hydroélectriques

*Development of a new method for monitoring the multiaxial fatigue damage*

## Context

### New energy context

Integration in the electrical network of several sources of renewable energies (solar, wind)

### Implies extended exploitation modes of hydro turbines

- More frequent start/stop cycles
- Larger power ranges varying from 30% to 100%
- Working out of optimal operating conditions



**Requires new methods for analyzing the multiaxial fatigue life of turbines**

## Method

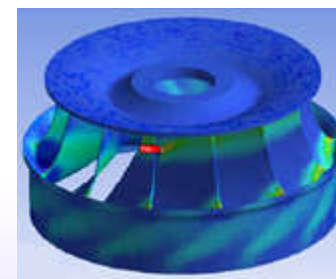
Surroundings of the thesis

### New design of turbines



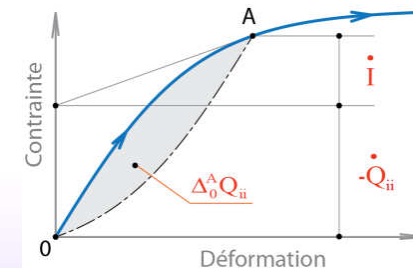
*Francis turbine, Alstom*

### Multiaxial modelling and FEM computation of cyclic behavior



*Major principal stress distribution, Saeed et al. (2009)*

### Scalar thermodynamic parameters for monitoring the damage



*Thermodynamic parameters in stress-strain curve, Tourabi et al. (1996)*

Design review

**Operating fatigue life analysis**

**Fatigue life model**

