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PhD research

Erosive Wear Determination through Modeling of Particle-Laden Flows using iLES/uDNS Spectral Methods

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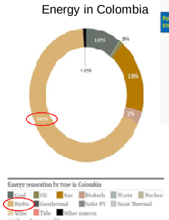
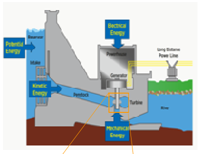
Engineering

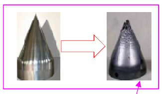
Energy in Colombia



Hydropower plant

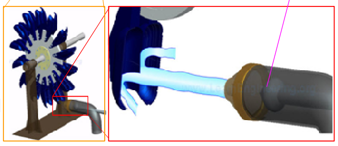


Erosion inside the turbine (needle)



Installed hydropower capacity: 11,392 MW (2015) [1]

Operation and Maintenance cost: £1'250.000/year [2]



Pelton turbine

Aim & Objectives

The aim of the projet is to characterize the erosive wear in the needle of a pelton turbine by solving a particle-laden flow model through iLES/uDNS Spectral Methods

Objectives

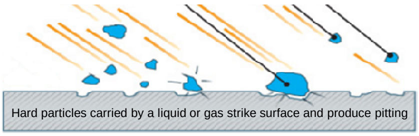
- To develop a model to predict the flow near to the needle using uDNS/iLES spectral methods with an appropriate parameter selection.
- To evaluate the transport of particles in the flow using a one-way model
- To assess the erosive wear rate with an established model integrating over the surface of interest the effects of impact of the particles.

Why Nektar++ ?

Why not?

- ❖ High order spectral solver.
- ❖ iLES implementation for incompressible flows
- ❖ Mesh capabilities.
- ❖ Complete framework to implement new problems.

Physics



Hard particles carried by a liquid or gas strike surface and produce pitting

Erosive wear = Particles Movement [3] + Mechanical Interaction [4]

Particles Movement [3]:

1. Micro erosion by smaller particles than 60µm in the streamlines.

1. Secondary flow vortex erosion or horseshoe vortex in places where vortex and secondary flow are presented

1. Accelerations normal to streamlines of particles bigger than 500µm.

Mechanical Interaction [4]:

- ➢ Abrasive erosion
- ➢ Surface fatigue
- ➢ Brittle fracture
- ➢ Ductile deformation

Methodology

To develop a model to predict the flow…

1. To study the different models of particle-laden flows and select the appropriate one to the flow under study.
2. To study LES methods and particularly iLES spectral methods to solve Navier-Stokes equations.
3. To determine the parameter values of SVV to specific conditions under simulation.
4. To implement the model of flow near to the needle using Nektar++ and the appropriate SVV parameters.

To evaluate the transport of particles in…

1. To study a transport model of particles with an established velocity field.

$$\frac{d\vec{x}_p}{dt} = F(\vec{u}, \rho, \rho_p, c_d, \ldots)$$

2. To implement the model using the Nektar++ library.

3. To evaluate the particle-laden model suitable by comparison of case of study available on the literature.

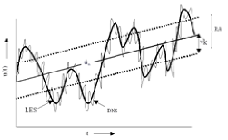
To assess the erosive wear rate…

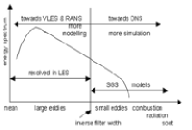
1. To study the different models to evaluate the erosive wear rate and to select the proper one for the conditions of flow and materials.

$$\frac{dW}{dt} = \int_s F(|u_c|, \alpha, \dot{m}, d_p, \ldots) ds$$

2. To implement the model using the Nektar++ library

Numeric





✓Due the importance of small scales, RANS methods are not best alternative.

✓DNS , of course, is prohibitive because of computational cost.

✓LES is the best option, however it still have high computational cost. The straightforward implementation of the Spectral Vanishing Viscosity method mixed with the convergence of the Spectral methods could be a the final solution

Open research field

✓There are several studies about erosive wear determination on hydraulic machinery [5–12] but none of them use LES to model the flow. This is important because the small scales, smaller than the resolved using RANS, have an important role in the phenomenon. [3,4,13,14]

✓There are several studies of particles-laden flow using DNS [15–20] and LES [21] methods, and even DNS using spectral methods [13,22,23] but modeling a laboratory simple geometry test not an engineering application.

✓There are not evidence of the use of spectral methods to evaluate the erosive wear rate.

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