MITIGATION OF DECELERATED SWIRLING FLOW FROM CONICAL DIFFUSERS USING PULSATING WATER JET

Goal of the project:

The fundamental problem addressed in this project is studying a new control method of decelerated swirling flow. The main goal of this project is to evaluate numerically and experimentally the performance of a new flow control method with pulse water injection. The first goal of the project is to mitigate the low frequency plunging oscillations using axially-injected pulsation jets. The second goal is to minimize the injected discharge during this control. This project attempts to deliver answers to the following questions: Is the pulse water injection a valid control method from experimentally point of view? What is the pulse jet parameters which allow the mitigation/elimination of the VR and the maximum pressure recovery in the cone and what is the optimal jet's discharge value? Are there any technical and economical limits of this method? Which are the advantages (if any) of this method with respect to the previous ones (the jet and hydrodynamic feedback)? Which are the disadvantages (if any) of this method with respect to the previous ones (the jet and hydrodynamic feedback)? An existing test rig from Politehnica University of Timisoara is going to be used for experimental investigation of this method (Fig. 1).

Short description of the project:

The new control method consists in injecting a pulsating axial water jet in order to mitigate the low frequency plunging oscillations. The idea of using pulsating jets is yielded by the measured pressure's low-frequency oscillation in the conical diffusers of hydraulic turbines which are operated at part load. These regimes are imposed by the power network requirements. The fixed blade turbines e.g. Francis type, operating at part load present a high level of swirling flow at the inlet of draft tube. When swirling flow from draft tube is decelerating, it becomes unstable giving rise at helical vortex (or vortex rope). Vortex rope is the main cause for the occurrence of pressure fluctuations in draft tube of hydraulic turbines operating at part load. Mitigating the vortex rope phenomenon is an open problem for modern Francis hydraulic turbines. Numerous techniques have been examined for reducing these effects, with success varying widely. Two types of pressure fluctuations associated with the draft tube surge are identified in the literature. The first is an asynchronous pressure fluctuation due to the precession of the helical vortex around the axis of the draft tube. The second type is synchronous fluctuations who give rise to power fluctuations. Consequently, these low-frequency pressure oscillations will be mitigated using the pulsating axial jet control method.

Project implemented by

Politehnica University Timisoara, Research Center for Engineering of Systems with Complex Fluids

Implementation period:

01.10.2015-30.09.2017

Main activities:

1) Objective I: 3D numerical analysis of swirling flow using pulsating jet injection method,
2) Objective II: Manufacturing and implementing on the rig of Rotating Pulsating Jet Device,
3) Objective III: Experimental campaign for pulsating jet parameters optimization,
4) Objective IV: Validation of experimental vs. numerical data.

Results:

The results for 2016 are presented in the list of papers:
1. C. TANASA, T. CIOCAN, S. MUNTEAN and R. SUSAN-RESIGA, (2016), Numerical Assessment of Decelerated Swirling Flow with Vortex Rope from Conical Diffuser Using Pulsating Water Jet, 19th International Seminar on Hydropower Plants, Vienna, 09-11, November.
2. SUSAN-RESIGA Romeo-Florin, MUNTEAN Sebastian, TĂNASĂ Constantin, BOSIOC Ilie Alin, CIOCAN Tiberiu, POPESCU Constantin, (2016), ECHIPAMENT PENTRU CONTROLUL INSTABILITĂȚILOR CURGERILOR CU VÂRTEJ DIN DIFUZORUL CONIC AL TURBINELOR HIDRAULICE, patent application no. A0038/12.05.216 - in romanian.

Applicability and transferability of the results:

A new control method is promoted in this project which attempt to improve the flow control and mitigate the axial pressure pulsations revealed by previous investigations. The decelerated flow control using pulsating jets is a new idea. This new control method will mitigate the low frequency pressure pulsations. These plunging oscillations are dangerous due to the waves traveling along to hydraulic passage. This project will evaluate numerically and experimentally the performance of a new decelerated flow control method: using pulse water injection. Decelerated flow control is a problem experienced by hydraulic turbines when operating far from their best efficiency point as a request from energy market demands. Operating in such a regime (if even possible) causes severe vibrations, efficiency decrease, material fatigue, breaks blades etc. Implementation of a decelerated flow control system able to eliminate vibrations leads to maintenance and operation costs decrease. The method which will be tested on the experimental test rig will be proposed for using in real power plants from the national company SC Hidroelectrica SA Romania, which is partner in different contracts in the field of hydraulic machinery with our institution.

Financed through/by

Unitatea Executiva pentru Finantarea Invatamantului Superior, a Cercetarii Dezvoltarii si Inovarii UEFISCDI

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