Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

STUDY OF HYDRAULIC RUNNER CRACKS DUE TO SIDE CHAMBER NON-UNIFORMITY

Jonathan Nicolle[1*], Pierre-Luc Richard[1], Guillaume Dubois[2]
[1]Hydro-Québec Research Centre, Varennes, Canada
[2]Expertise Ingénierie et Standardisation, Exploitation et Infrastructures d'Hydro-Québec, Montréal, Canada
*nicolle.jonathan@hydroquebec.com

ABSTRACT

After multiple years of service, major cracks were detected on the crown of a hydraulic turbine runner built in the 50s and refurbished in the late 90s. This led to unit dismantling and shutdown for an extended period to allow for repairs. As an operator, this was quite surprising as similar units of the same powerplant did not show any structural problem after 20 years of operation. As most of the blades were affected, manufacturing defects were ruled out early on.

To better understand the root cause of this issue, a fluid and structural numerical study was performed. 3D scans of the runner and discharge ring were used to rebuild the geometry. The computational fluid dynamic study rapidly pointed out to pressure fluctuations generated on the runner band exterior due to the non-uniformity of the flow on the lower labyrinth seal chambers. These fluctuations were enhanced by unit re-assembly constraints and geometrical features of the runner itself such as the balancing groove and runner band extension. Subsequent structural finite element analysis involving rotating loads confirms that, even if the loads were applied at the band, the stress concentration happened at the crown. Even without considering usual loads to the blades such as rotor-stator interactions, vortex rope or stochastic loads coming from the main flow, the stress level induced by the side chamber pressure alone could explain cracking. Subsequent analysis focused on finding solutions that minimize on-site machining and reconstruction constraints in order to confidently put the turbine back in operation.