Abstract

The flow in a pump-turbine operating at off-design conditions in generating mode, in the so-called “S-shaped” region of characteristics, is dominated by one stall cell rotating with the impeller at sub-synchronous speed in the vaneless gap between the impeller and the guide vanes. It is the result of flow separation developed at the inlet of the impeller channels that leads to their blockage [1]. Moreover, at low positive discharge condition, the stalled impeller channels are found to pump, leading to backflow and vortices development in the guide vanes region [2]. Pressure-synchronized PIV measurements in the guide vanes region confirm the outflow at the impeller inlet. The flow state in the guide vanes region turned out to be similar to the one in reverse pump mode, Fig. 1. Moreover, it is found that the pumping phenomenon in the guide vanes channels is performed with the help of a vortex. This corresponds to the way in which the flow may change the direction by 180°, going from the vaneless gap to the upstream side of guide vanes. To sum up, at the low positive discharge condition, the flow alternates between turbine and reverse pump modes during one rotating stall revolution. The rotating instability generates hydraulic unbalance and strong structural vibrations.

Keywords: pressure, PIV, pump-turbine, off-design, generating mode, runaway, instability, rotating-stall.

Fig. 1 – Schematic of experimental setup for PIV measurements; average velocity streamlines in the guide vanes for reverse pump mode condition [2].

References
