World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:13, No:04, 2019

Numerical Investigations of Unstable Pressure Fluctuations Behavior in a Side Channel Pump

Authors : Desmond Appiah, Fan Zhang, Shouqi Yuan, Wei Xueyuan, Stephen N. Asomani

Abstract : The side channel pump has distinctive hydraulic performance characteristics over other vane pumps because of its generation of high pressure heads in only one impeller revolution. Hence, there is soaring utilization and application in the fields of petrochemical, food processing fields, automotive and aerospace fuel pumping where high heads are required at low flows. The side channel pump is characterized by unstable flow because after fluid flows into the impeller passage, it moves into the side channel and comes back to the impeller again and then moves to the next circulation. Consequently, the flow leaves the side channel pump following a helical path. However, the pressure fluctuation exhibited in the flow greatly contributes to the unwanted noise and vibration which is associated with the flow. In this paper, a side channel pump prototype was examined thoroughly through numerical calculations based on SST k-ω turbulence model to ascertain the pressure fluctuation behavior. The pressure fluctuation intensity of the 3D unstable flow dynamics were carefully investigated under different working conditions 0.8QBEP, 1.0 QBEP and 1.2QBEP. The results showed that the pressure fluctuation distribution around the pressure side of the blade is greater than the suction side at the impeller and side channel interface (z=0) for all three operating conditions. Part-load condition 0.8QBEP recorded the highest pressure fluctuation distribution because of the high circulation velocity thus causing an intense exchanged flow between the impeller and side channel. Time and frequency domains spectra of the pressure fluctuation patterns in the impeller and the side channel were also analyzed under the best efficiency point value, QBEP using the solution from the numerical calculations. It was observed from the time-domain analysis that the pressure fluctuation characteristics in the impeller flow passage increased steadily until the flow reached the interrupter which separates low-pressure at the inflow from high pressure at the outflow. The pressure fluctuation amplitudes in the frequency domain spectrum at the different monitoring points depicted a gentle decreasing trend of the pressure amplitudes which was common among the operating conditions. The frequency domain also revealed that the main excitation frequencies occurred at 600Hz, 1200Hz, and 1800Hz and continued in the integers of the rotating shaft frequency. Also, the mass flow exchange plots indicated that the side channel pump is characterized with many vortex flows. Operating conditions 0.8QBEP, 1.0 QBEP depicted less and similar vortex flow while 1.2Q recorded many vortex flows around the inflow, middle and outflow regions. The results of the numerical calculations were finally verified experimentally. The performance characteristics curves from the simulated results showed that 0.8QBEP working condition recorded a head increase of 43.03% and efficiency decrease of 6.73% compared to 1.0QBEP. It can be concluded that for industrial applications where the high heads are mostly required, the side channel pump can be designed to operate at part-load conditions. This paper can serve as a source of information in order to optimize a reliable performance and widen the applications of the side channel pumps.

Keywords : exchanged flow, pressure fluctuation, numerical simulation, side channel pump
Conference Title : ICMPFD 2019 : International Conference on Mathematical Physics and Fluid Dynamics
Conference Location : Athens, Greece
Conference Dates : April 08-09, 2019