Abstract

Due to the increase of applications of using pumps as turbines, it is very important to get true practical information related to this subject. The aim of this work is to model an inline centrifugal pump in direct mode as a pump and in reverse mode as a turbine “PAT” experimentally and computationally and to study the relation between their performance curves in both modes. In addition, the validity of different correlations concerning pump and turbine performance with the inline centrifugal pump type is studied.

The experimental setup is comprised of an inline centrifugal pump that is coupled directly with a DC motor. The performance of the pump direct mode is tested by controlling a delivery valve opening and an electronic load controller “ELC” to control the speed of rotation of the motor in order to predict its performance curves at various speeds of rotation. In addition, the pump is tested in the reverse direction as a turbine by controlling its delivery valve opening and adjusting the electronic load controller “ELC” in order to predict the performance curves at the same speeds of rotation of the direct mode. Hence, the relation between the two sets of the performance curves is studied.

Computational Fluid Dynamics (CFD) using the commercial code FLUENT was used to predict pump and pump as turbine performance curves at several speeds of rotations. It shows the behavior of the flow through the pump and PAT and illustrates the losses in the volute casing in pump case. The computational results are validated and verified using the experimental results. The effect of the outlet pipe shape was studied carefully.

The comparison between the computational and experimental results show a good agreement in the trend behavior, but still the deviation between their values is distant. Therefore, this problem needs further research to reduce this gap between them. The trend of the computational results are validated with the experimental ones which assure the CFD tool as a reliable solution for complicated problems.

The obtained results reveal that:

- A pump could be operated as a turbine at different speeds of rotation without mechanical problems.
- An inline centrifugal pump which is considered a special type with low power could operate effectively as a turbine.
- The shape of the volute casing has a great effect on the results at the pump mode.
- The comparison between the computational and experimental results shows good agreement at the turbine mode and shows a slight deviation at the pump mode.

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Nomenclature

ALCC	Annual life cycle cost
BEP	best efficiency point
ELC	Electronic load controller
HPRT	Hydraulic power recovery turbines
IFOA	The Foxboro Integral Orifice Flow Meter Assembly
IGC	Induction generator controller
η	effeciency
N_s	Specific speed
PAT	pump as turbine
Ω	Angular velocity
β	The ratio between the orifice bore diameter and pipe diameter
H	head
Q	flowrate
U	relative velocity vector in a rotating frame of reference
k	turbulent kinetic energy
r	position vector from the origin of rotation to the point of interest
ε	rate of dissipation of turbulent kinetic energy
μ	dynamic viscosity of the fluid
π	Dimensionless power
ρ	Density
ψ	Dimensionless head
ϕ	Dimensionless flowrate

Superscripts

$'$	fluctuating component
$\bar{}$	mean component

Subscripts

TE	Estimated Turbine-mode
p	Pump
T	turbine
h	hydraulic