Investigation of the Standardized a Cross Flow Turbine Used the Numerical Simulation and Experimental Results

Priyono Sutikno[1,2], Dara Seyhak[1], I Nengah Diasta[1,2], Arfie Ikhsan Firmansyah[3], Zulkarnain[3]

1 Fluid Machinery Laboratory, Faculty of Mechanical and Aerospace Engineering, Institut Teknologi Bandung, Indonesia
2 Research Center for New and Renewable Energy, Center for Research and Community Services ITB, Bandung Indonesia
3 Research Center for New Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources, Jakarta, Indonesia

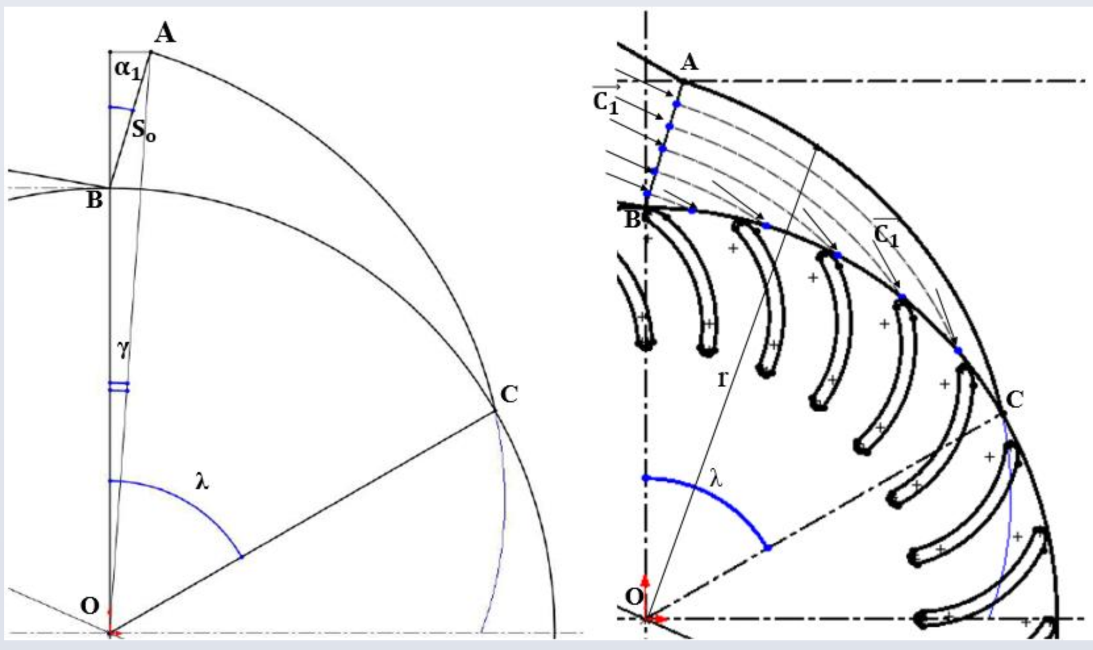
ABSTRACT

A Standardized Cross Flow Turbine is a turbine constructed from the standard size pipe for the turbine blades. Further the turbine runner has dimension depend on this pipe size for the blade. These condition is facilitated the small enterprise to construct the turbine, where can cover a range of the head with only small number of the variation of runner size. The size of runner to cover that a range of head has been investigated presented in form of table runner diameter in function of range of head available. The belt and pulley transmission ratio can serve the rotational speed need for generator.

A numerical and experimental analysis of the standardized cross flow turbine types were simulated using the 2D-CFD steady state flow. The standardized runner based on 3" diameter of blades and the runner outside diameter is 192 mm and the angle of relative velocity is 30° at the angle of nozzle of 16°. The simulation model was simulated with three types of discharge angle of nozzle (60°, 70° and 80°) and varies with three different numbers of blades (24, 28 and 32). The simulations result has Cross Flow turbine efficiency of 78% at admission discharge nozzle angle of 60° and number of blades of 28. An experimental investigation adequate aspect related to the torque, rotational speed, mass flow rate, and efficiency of turbine. The efficiency curves that plotted from the experimental result has a peak efficiency of 77%. The Standardize Cross Flow Turbine experimental and simulation result showed a good agreement, which can be readily used for a fast and reliable design of a cross flow turbine. The pipe size of 3 Inches gave runner diameter of 192 mm has the optimum admission discharge angle of 60° and number of blades of 28 can serve the potential head range between 6 to 30 meters and produce the power specific between 7.91 to 109.92 kW/m of turbine width and rotational speed is range of 409 to 915 rpm.

TURBINE DESIGN

This Cross Flow Turbine has the simple construction and considered as impulse turbine with partial admission discharge nozzle. The main advantages of the standardized cross flow turbine are its low cost manufacture and operation, and favorable performance at part load condition and easy to maintenance.

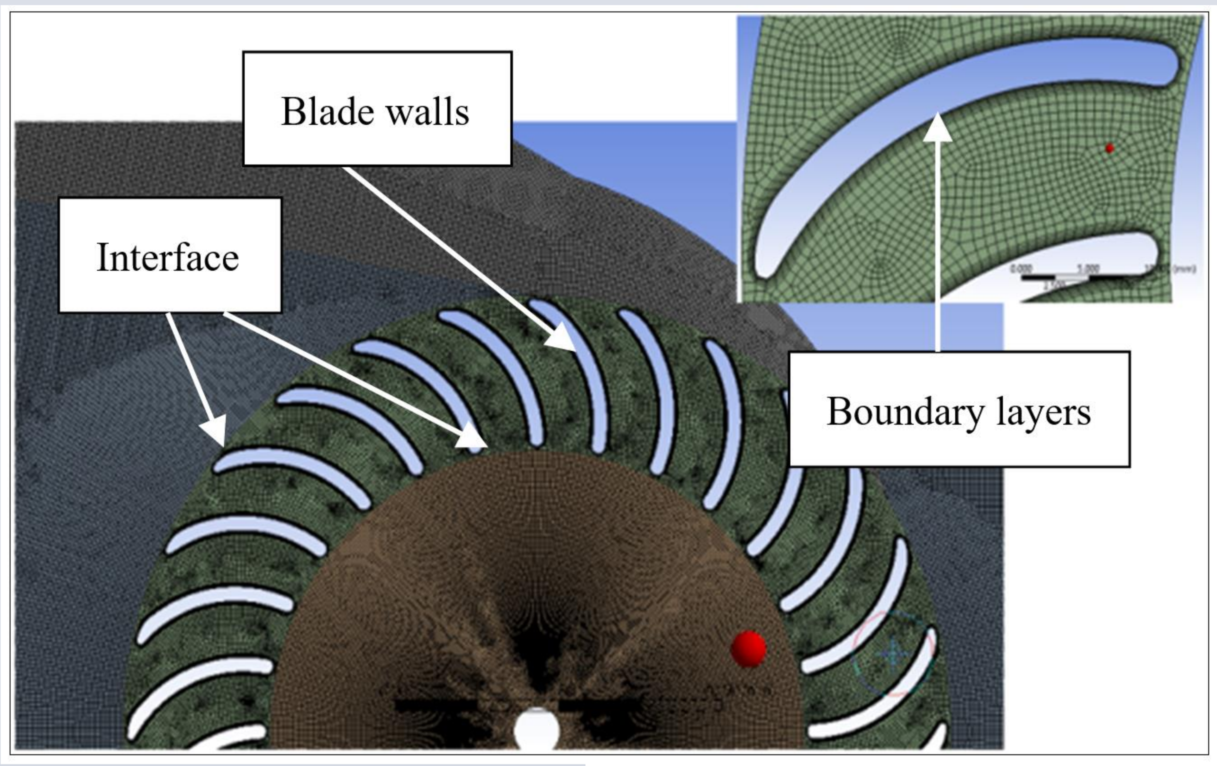


Nozzle shape entering and outlet and turbine blade design

The dimension of runner rotor is depends on the diameter of pipe used as blades and its function of rotational speed of runner needed is in function of the head available.

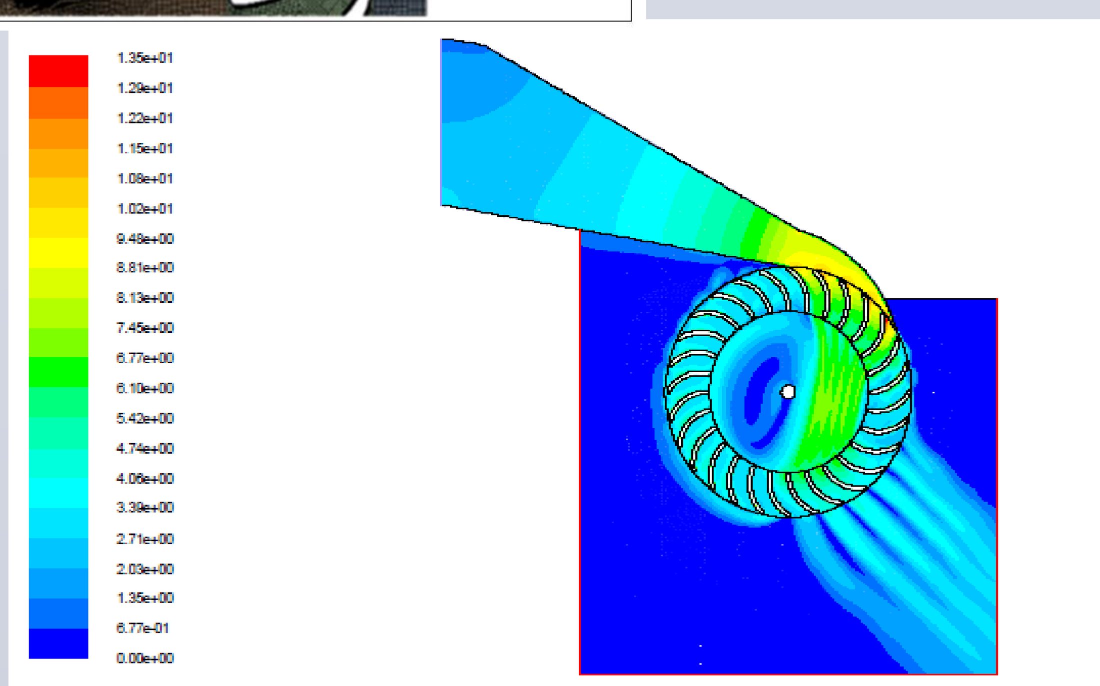
SIMULATION

The numerical simulations through ANSYS FLUENT were conducted to verify how nozzle and runner blades effect to the efficiency of Cross Flow Turbine. The Shear-Stress Transport (SST) *k-ω* model is used. The feature makes the SST *k-ω* model more accurate and reliable for a wider class of flow to evaluate adverse pressure gradient.



Detail of the meshing of the runner blade

This meshing used for ANSYS FLUENT simulation to performed a turbine performance and fluid characteristic inside the turbine

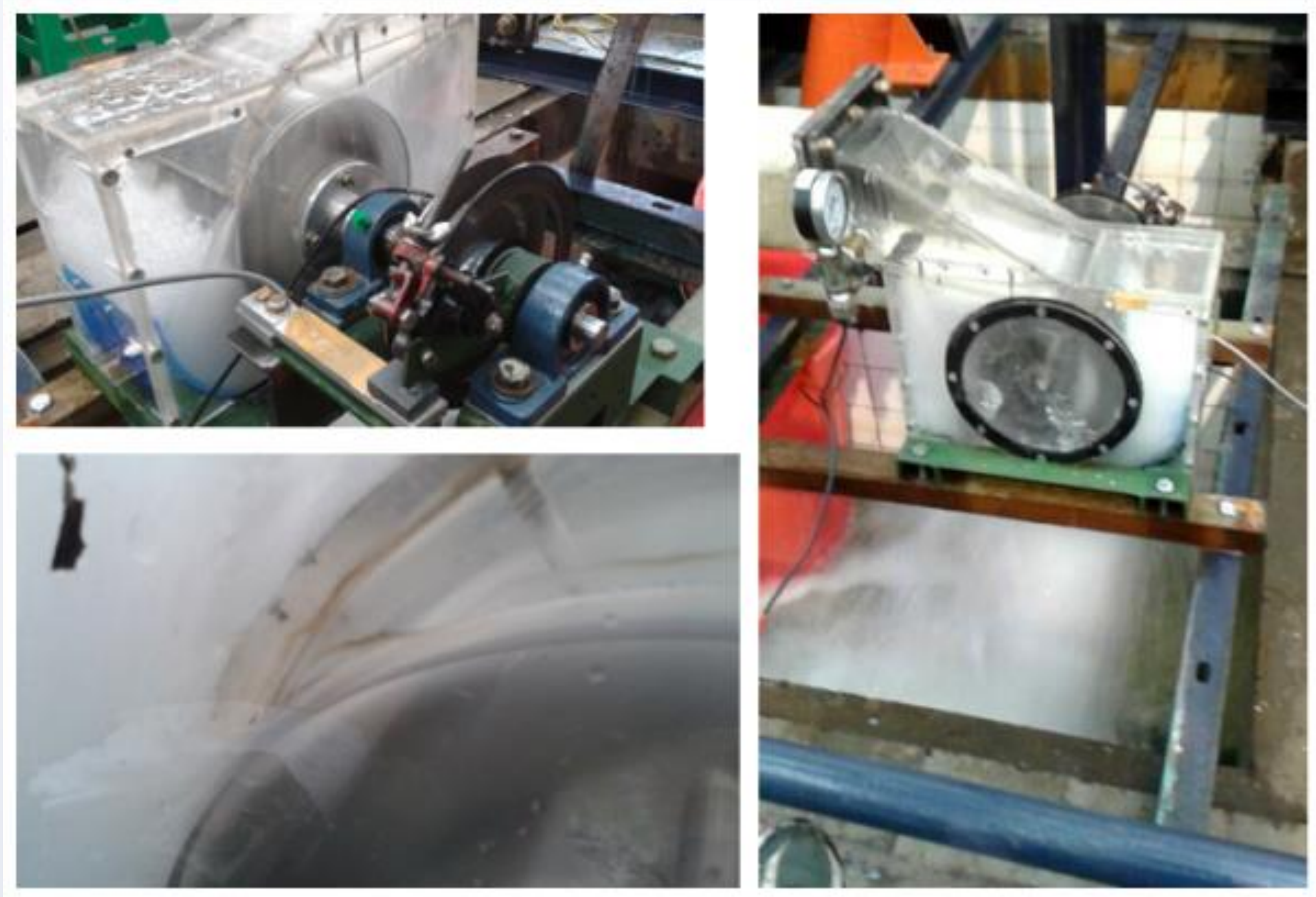


Contour of velocity magnitude

the best turbine design shows the flow pattern across the runner not crossing the center of the rotation where placed the turbine shaft.

The efficiency of Cross Flow Turbine was calculated as ratio of power created by the runner by multiplying the torque and the rotational speed dividing by the hydraulic power as difference total pressure inlet and outlet turbine multiplying by flow rate.

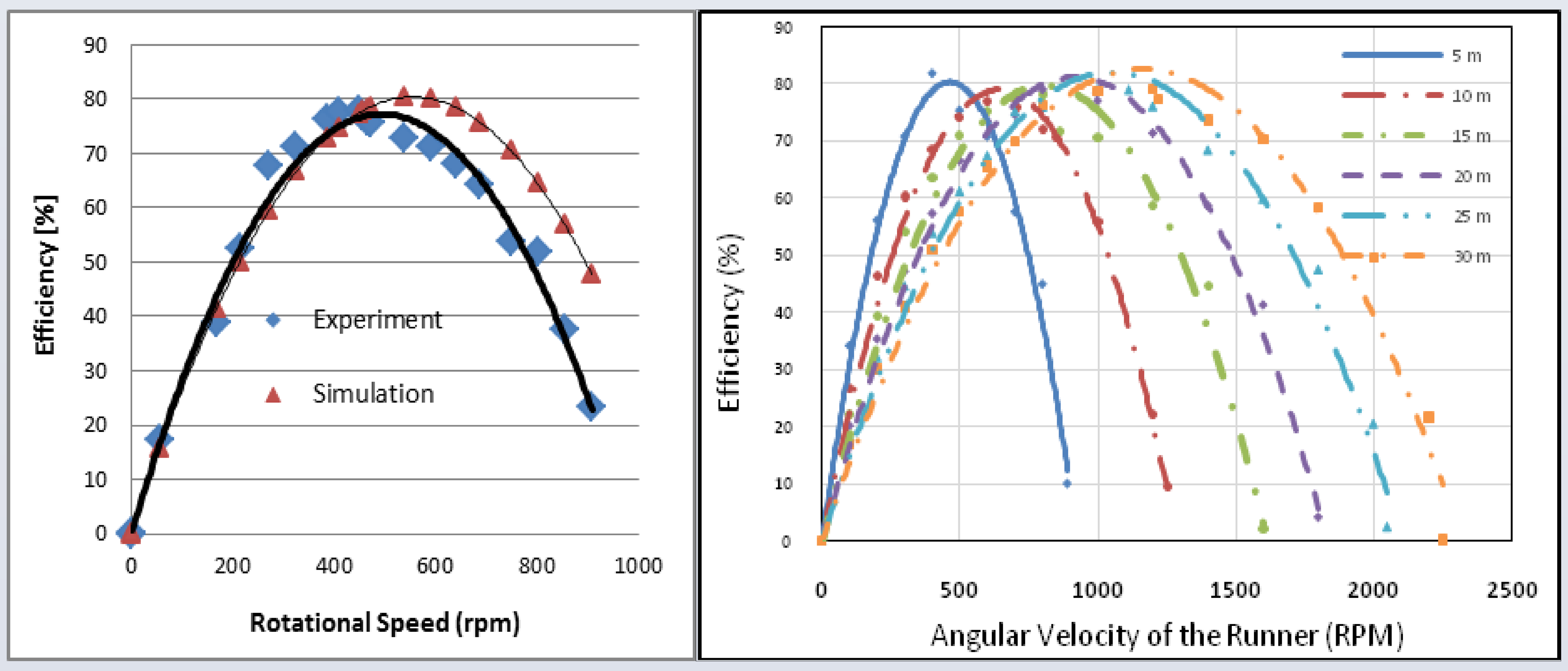
EXPERIMENT



Measurements equipments and brake dynamometer, rpm meter and flow pattern inside.

The experimental set up equipped by tachometer, strain gage dynamometer, pressure differential between inlet and outlet turbine and flow rate meter using the orifice. All parameter measurements are calibrated and acquired by NI 6225 DAC connected directly to the laptop and recorded by the LabView Software.

RESULTS



Comparison results between experiments and numerical simulation

The result of comparison between experiment and simulation has small differences than we can extent the numerical simulation with the same dimension of runner with variation of head from 5 m to 30 m. The optimum efficiency will rest the same value and the optimum rotational speed will be shifts depend on the head

CONCLUSIONS

1. The numerical simulation is accordance with the experimental results.
2. The Cross Flow Turbine can be standardized with respect to the potential head and simple to fabricate.
3. The optimum diameter of runner is depends on the diameter of pipe for the blades.
4. The runner of cross flow turbine can serve range of potential head available (6 to 30 m) and give a range of power specific and rotational speed optimum.

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