Analysis of the performance and efficiency of a turbine for an Ocean Thermal Energy Conversion (OTEC) plant by simulation using the Ansys Fluent program

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This document presents the progress of the simulation of the Curtis type turbine for a prototype of a 1 kWe OTEC plant using the Ansys Fluent program, and compares its operating parameters with those calculated in the theoretical design, mainly the power output and its efficiency. For the simulation of the turbine, the operating conditions of the closed thermodynamic cycle of the OTEC plant were used; This will allow optimizing the times and costs of laboratory experimentation, establishing a methodology that will serve as the basis for future analyzes of the design characteristics of turbines and similar devices for ocean energy utilization systems.

For the design of this experimental turbine, two Curtis stages and one impulse stage are proposed, considering the following operating advantages:

- The turbine is low power.
- The average diameter of the impeller is small and this will reduce the tensile stresses on the blades.
- The design allows minimizing energy losses from the flow through the impellers, minimizing the loss of turbine efficiency.
- This design facilitates the construction of the turbine.

METHODOLOGY

The simulation of the flow in the Curtis type turbine in the Ansys Fluent program was carried out considering the refrigerant R152a (difluorethane) in the saturated vapor state as a working fluid and a static mesh in the turbine geometry. The simulation process in the Ansys Fluent program was carried out with the following 4 stages:

1. Construction of the turbine geometry.
2. Discretization of the control volume.
3. Selection of mathematical models and establishment of operating conditions (initial and boundary conditions).
4. Simulation and analysis of results.

In the first stage, the assembly of each of the components of the Curtis turbine was carried out, as can be seen in Figure 1.

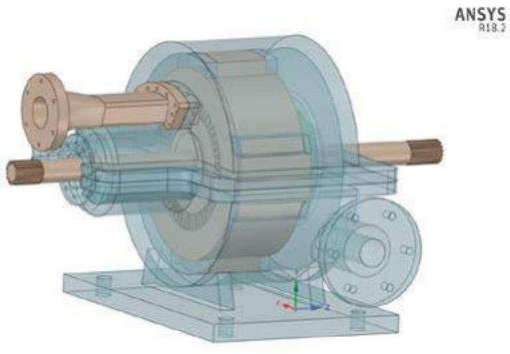

Fig. 1 Assembly of the components of the Curtis Turbine

From the geometry of the turbine, the control volume representing the volume of the working fluid was constructed and its discretization was carried out obtaining 24,391,815 mesh elements as shown in Figure 2. Subsequently, mathematical models were selected for the calculation of steady state flow properties, and the properties of the working fluid in a saturated vapor state were established.

RESULTS

The average values of the speeds at the inlet and the outlet of the turbine can be seen by means of flow stream lines through the turbine in Figure 3. The power at the inlet and outlet of the turbine were determined from the speeds, the density of the working fluid and the corresponding areas, obtaining an efficiency of 99.8%, as shown in Table 1.

Table 1. Power of turbine

	Area $[m^2]$	Velocity $[\frac{m}{s}]$	Power [W]
Inlet	0.00017	15.6581	1805.499
Outlet	0.00008	19.8821	1.934e-3

Fig.2. Discretization of turbine control volume

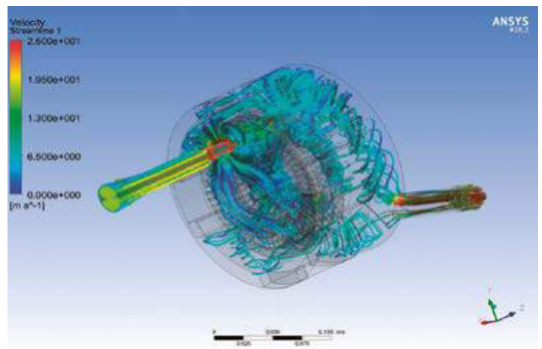

Fig.3. Streamlines of the flow in the turbine

FUTURE WORK

The results obtained during the first stage of the project are planned to be improved by carrying out the following considerations:

- Perform a simulation of the turbine with a dynamic mesh that allows the movement of the rotors to improve the approximation to the real behavior of the flow.
- Consider the phase change of the working fluid.

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