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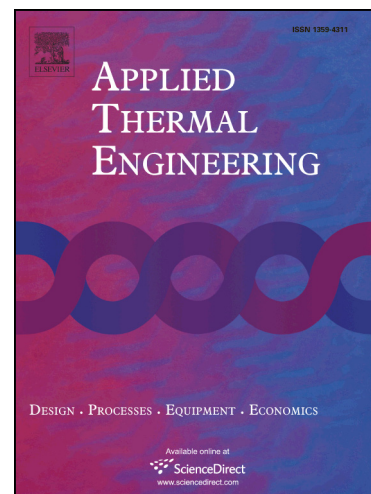
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# Numerical Analysis of Small Scale Axial and Radial Turbines for Solar Powered Brayton Cycle Application

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## Abstract

In the current work two types of turbines, axial and radial turbine, with their three configurations, Single Stage Axial, Dual Stage Axial and Single Stage Radial turbines, for solar Brayton cycle applications have been parametrically investigated with the aim of figuring out their performance in terms of efficiency and power output. The mean line design for each turbine was effectively completed in order to figure out the initial guess for the dimensions, the power output and the efficiency. Consequently, the Computational Fluid Dimension CFD analysis was employed for the sake of visualising the 3-Dimensions behaviour of the fluid inside the turbine as well as determining the main output like the power output and the efficiency at different boundary conditions. These boundary conditions were selected to be compatible with a small scale solar powered Brayton cycle. An evaluation for some types of losses such as tip clearance and trailing edge losses as well as the total loss coefficient of the rotor of each configuration, in terms of pressure losses, has been established as well. The current paper deals with Small Scale Turbines SST ranged from 5 to 50 kW as a power output. The outcomes showed that the Dual stage axial turbine performances better at the off design conditions. By contrast, the single stage radial turbine achieved higher power output during the same operating conditions. The results of the CFD analysis have been successfully validated against the experimental work done by the researchers for small scale (axial) compressed air turbine in the lab.

**Keywords:** 1D& 3D analysis, Single stage and dual stages, Axial turbine, Radial turbine, Brayton cycle.

## 1- Introduction

In spite of the ease of use technical solutions, about 1.3 billion people are still suffering from the lack of having any form of electricity and around 3 billion people are still using open fires for cooking. In spite of the fact that renewable energy is considered one of the main solutions because it is cheap, available, sustainable and environmentally friendly, solar radiation which hits our earth's surface is still not successfully harnessed. Recently, this type of energy is getting more attention by researches, designers and provides companies. As researchers, many papers that include in details different techniques and methods on how to achieve maximum advantages from the solar energy have been published. The considerable benefits from renewable energy and the accelerated importance of its role cannot be denied. As stated by Makower et al [1], that about \$51 billion and \$52 billion was spent, as an investment, by each China and the USA only in 2011 in spite of the world economic crisis. Moreover, by 2026, it is expected to have about 26% from the overall electricity consumed in the worldwide comes from the renewable energy while it was only around 13% in 2012 [2]. One of the main methods to benefit from the renewable energy is to use it in some power cycles such as Brayton, Rankine and even in the hybrid cycles which have been recently used in different scales. Because of its relative low maintenance and initial cost and simple construction, Small Scale Turbines

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