شبكة المعلومات الجامعية

سامية محمد مصطفى

بسم اللّه الرحمن الرحيم

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شبكة المعلومات الجامعية

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التوثيق الالكتروني والميكروفيلم

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جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

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بعض الوثائق الأصلية تالفة

بالرسالة صفحات
لم ترد بالأصل

Ain Shams University Faculty of Engineering
Mechanical Power Engineering
Department

Numerical Study of a Small-Scale Turbomachine Device

A Thesis Submitted in Partial Fulfilment for the Requirements of the Degree of Master of Science in Mechanical Engineering

By

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<u>STATEMENT</u>

This thesis is submitted in partial fulfillment for the degree of Master of Science in Mechanical Power engineering, to the faculty of engineering, Ain Shams University.

The work included in this thesis was carried out by the author, primarily at the laboratories of the Mechanical Power Department, Faculty of Engineering, Ain Shams University.

No Part of this thesis has been submitted for degree or qualification at any other university.

Signature

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Board of Supervisors

The undersigned certify that they have read and recommended to the Faculty of Engineering, Ain Shams University, for acceptance a thesis entitled **"Numerical Study of a Small-Scale Turbomachine Device"**, submitted by **Ahmed Hamdi Abd-Elwahab Elhennawi**, in Partial Fulfillment for the Requirements of the Degree of Master of Science in Mechanical Engineering.

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Abstract

Rotary positive displacement pumps take a wide range of usage due to its compact size. Moreover, they provide an approximately constant flow at a fixed speed. The sliding-vane pump is a type of rotary positive displacement pumps which have a varied application including fuel pumping, power steering system, circuit lubrication system and automatic transmission system. Fluid behavior costs a lot to be seen inside the pump during operation experimentally. Otherwise, numerical programs which depend on Computational Fluid Dynamics (CFD), became an adequate tool to design and optimize the pump. The basic challenge is that the flow volume changes continuously over the time. Therefore, numerical solver must be able to deform and generate the mesh every time-step. The objective of the current thesis is to investigate the sliding vane pump performance numerically and validate the results with experimental work. A three-dimensional model is used to perform this task. ANSYS-Fluent 16.0 is used to solve Reynolds Averaged Navier Stokes equations (RANS) and turbulence model equations. The precise numerical model includes a wide range of issues, from grid generation to turbulence modeling. These issues have been taken into consideration and the numerical results are compared with the results of the experiment which conducted in the lab. The model has given a similar result to the experiment results, with a deviation less than 6% in the flow rate. Accordingly, different parameters are used to examine the performance of the vane pump including the number of vanes and the gap height between the vane tip and stator, at different rotational speeds and pressures. Numerical results for the model with eight-vanes and the model of 0.1 mm gap height gave the largest flow-rate and the best performance as well.

Keywords

CFD, Vane pump, Dynamic mesh; Finite volume; Turbulence model

Nomenclature

b_p	Brake power	[*W*]
C_H	Head coefficient	[-]
C_p	Power coefficient	[-]
C_Q	Discharge coefficient	[-]
D_1	Rotor diameter	[*m*]
D_2	Housing diameter	[*m*]
d_h	Hydraulic diameter	[*m*]
H	Pump head	[*m*]
k	Turbulent kinetic energy	[m^2/s^2]
I	Turbulent intensity	[-]
N	Rotational speed	[rp*m*]
H	Turbine height	[*m*]
p	Static pressure	[*pa*]
p_D	Discharge pressure	[*bar*]
P_{out}	Output power	[*w*]

Q	Discharge	[*litre/min.*]
Q_D	Normalized discharge	[-]
Q_{out}	Outlet discharge	[m^3/s]
R	Normalized speed	[-]
Re	Reynold's number	[-]
s	Source term	[N/m^3]
S_{ij}	Deformation rate tensor	[ ]
T	Temperature	[°*c*]
t	Vane thickness	[*mm*]
u, v, w	Velocity components in x, y, z directions	[*m/s*]
$\forall$	Pump volumetric displacement	[m^3/rev]
w	Pump width	[m*m*]

Greek letters

γ	Gas content ratio	[-]
μ	Dynamic viscosity	[*Pa.s*]
μ_t	Turbulent or eddy viscosity	[*Pa.s*]
ρ	Density	[kg/m^3]
$\bar{\rho}$	Mean flow density	[kg/m^3]
δ_{ij}	Kronecker operator	[-]