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Performance of New Diffuser Design for an Axial Flow Pump

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

In an axial-flow pump unit, energy is lost from the pump system due to the swirl of the liquid between the vanes and leaving the stator. A combined stator-diffuser has been designed for the purpose to reduce this swirl and the corresponding loss of energy. Previous experimental investigations indicated that the new stator-diffuser design does reduce the swirl still present in the flow exiting from the pump unit when compared with a conventional design wherein the stator is followed by a separate diffuser. However the efficiency of the modified pump unit was slightly reduced. One of the reasons for this reduction in efficiency has been identified where a sudden enlargement at the outlet of the diffuser introduces secondary flow creating large fluid swirl.

To reduce the secondary flow dimensional, theoretical, computational fluid dynamics (CFD) and experimental measurements have been performed to determine the performance effects of the new design diffuser combined with an additional tail piece. The tail piece is fitted to the outlet of the new diffuser to eliminate the sudden enlargement. Theoretical calculations determined that the five vane impeller did not match the new diffuser, whereas the eight vane impeller did match the new diffuser design. Impellers with five and eight vanes were used during laboratory testing.

CFD and laboratory experiments were performed to verify that the tail piece addition would produce improved performance. The theory was confirmed from the experiments that the five vane impeller is not the correct impeller for use with the new diffuser with the tail piece however testing with the eight vane impeller efficiency improved by 3.9%, when compared to the standard pump test.

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Nomenclature

Symbol	Description	Unit
Q	Flowrate	L/s
H	Head	m
H_p	Pumping head	m
H_L	Head loss	m
p	Pressure	Pa
NPSH	Net Positive Suction Head	m
v	Velocity	m/s
v_r	Velocity reduced	m/s
C	Absolute velocity	m/s
C_m	Axial velocity	m/s
C_u	Tangential absolute velocity	m/s
W	Relative velocity	m/s
W_u	Tangential relative velocity	m/s
L	Lift	
C_L	Lift coefficient	
D	Drag	
C_D	Drag coefficient	
ρ	Density	kg/m^3
g	Gravity	m/s^2
η	Efficiency	
N	Rotational Speed	rpm
Ns	Specific speed	
A	Area	m^2
d	Diameter	m
E	Energy	J
Re	Reynolds number	
P	Power	W
P_p	Pump input power	W
P_w	Pump output power	W
t	Time	s
T	Torque	Nm
U	Mean velocity	m/s
V	Volume	m^3
z	Height above reference plane	m

λ	Pipe friction loss coefficient	
ω	Angular velocity	rad/s
L_r	Impeller radial length	m
l	Length	m
b	Outlet width	m
BEP	Best efficiency point	
F	force	N
m	mass	kg
β	Outlet angle	°
α	Inlet angle	°
σ	Solidity	

Table of Contents

List of Figures

List of Tables