

Development of Pico-Hydel Power Technology using Pump as Turbine

A report submitted in partial fulfilment of the requirement for the award of degree
of
Bachelor of Technology
in
Mechanical Engineering
by

Hoshiyar Singh Meena
Sunay Gupta

under the supervision of
Prof. P.M.V. Subbarao
Department of Mechanical Engineering
Indian Institute of Technology Delhi



Mechanical Engineering Department
Indian Institute of Technology Delhi
May, 2013

TABLE OF CONTENTS

CERTIFICATE.....	ii
ABSTRACT.....	iii
ACKNOWLEDGEMENTS.....	iv
LIST OF SYMBOLS.....	v
LIST OF FIGURES.....	vi
LIST OF TABLES.....	vii
1. INTRODUCTION AND OBJECTIVE.....	1
1.1. Introduction.....	1
1.2. Motivation.....	1
1.3. Project Objectives.....	2
2. LITERATURE REVIEW.....	3
2.1. An Overview.....	3
2.2. Earlier work done at IIT Delhi.....	3
3. PROJECT APPROACH.....	4
3.1. Methodology Adopted.....	4
3.2. Setting up of Experimentation Rig.....	4
3.3. Experimentation Procedure:.....	9
4. WORK ACCOMPLISHED.....	11
4.1. Experimentation without guide vanes.....	11
4.2. Effect of Various Parameters on PAT Performance.....	30
4.3. Experimentation with Guide Vanes:.....	32
4.4. Scaling Up of PAT.....	38
5. CONCLUSION.....	41
6. FUTURE SCOPE OF WORK.....	43
7. REFERENCES.....	44

CERTIFICATE

The work presented in this report has been carried out by us for the course Major Project Part 1 & Part 2. The report accurately reflects the work done by us. All the material taken from other sources has been fully acknowledged.



Hoshiyar Singh Meena

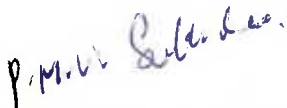
2009ME10582



Sunay Gupta

2009ME10628

Hoshiyar Singh Meena and Sunay Gupta have worked under my supervision. I have read this report. It accurately reflects the work done by the students.



Prof. P.M.V. Subbarao

Department of Mechanical Engineering

Indian Institute of Technology-Delhi

New Delhi

ABSTRACT

To exploit vast Pico-hydro resources available especially in hilly regions, PAT is a potential alternative solution. It consists of a centrifugal volute pump in reverse direction acting as a turbine, while the motor works as a generator after suitable changes. PAT can be proved to be of great use for benefit of the society however this technology is yet to be refined further for its better practical implementation. Their performance curves are not available and poorly understood. The aim of this project is to find out the characteristic curve of a given PAT, analyse experimental results and use them to introduce modifications in the existing PAT design in order to improve its efficiency.

Keywords: PAT (Pump as Turbine), Centrifugal Pump, Impellers, Dynamometer, Head, Flow rate

ACKNOWLEDGEMENTS

We would specially like to thank our supervisor, Prof. P.M.V. Subbarao for giving us an opportunity to work in such an interesting and socially significant project which can transform the lives of people in rural India. This project encompassed great learning and we are grateful to him for his useful suggestions and other supports to overcome our difficulties.

We would also like to thank our examiner Prof. S.V. Veeravalli for his invaluable suggestions which made us think more critically and analyse situations in a more realistic manner. His response to our project was very encouraging and that kept us motivated throughout.

Also, this project would not have been possible without help of Mr. Raj Verma, who is a project assistant in Dept. of Mechanical Engineering. His presence and support has always given us an optimistic view to our project for which we are thankful to him whole heartedly.

At last, we would like to take this opportunity to thank our parents for what we are today and also for playing a pivotal role in shaping our future.

Hoshiyar Singh Meena

Sunay Gupta

Date: 10th May, 2013

LIST OF SYMBOLS

Symbol	Description
η_{max}	Max efficiency of pump
Q_t	Average flow rate through the pump (m^3/s)
Q_{bump}	Maximum flow rate through the pump (m^3/s)
H_t	Average head of water above pump (m)
H_{bump}	Head of water above pump at maximum efficiency (m)
Q_{bep}	Flow rate corresponding to best efficiency point of pump (m^3/s)
H_{bep}	Head corresponding to best efficiency point of pump (m)
N_p	Rotational speed (rpm) when running pump
$N = N_t$	Rotational speed (rpm) when running turbine
η	PAT efficiency
P_{input}	Input power (W)
P_{output}	Output power (W)
$T_2 - T_1$	Difference in torque measured using brake dynamometer (N-m)
ω	Angular velocity (rad/s)
ρ	Density of water
H	Pressure head (m)
Q	Flow rate (m^3/s)
W_1	Weight 1
W_2	Weight 2
W_3	Weight 3
W_4	Weight 4
D_p	Diameter of Pulley
β_1	Inlet impeller blade angle
$D = D_{imp}$	Diameter of Impeller
U_{imp}	Speed of tip point of impeller
V_1	Inlet velocity of water in PAT
ω_{imp}	Rotational speed of impeller
A	Inlet Area of casing
δ	Outlet angle of guide vane

LIST OF FIGURES

Figure 3-1. CAD Model of Experimental setup	4
Figure 3-2. Casing to support pump (before construction).....	5
Figure 3-3. Pump as Turbine (PAT) (i) side view, (ii) top view	5
Figure 3-4. Impellers (i) backward vane closed type, (ii) forward vane closed type	6
Figure 3-5. Experimental set-up	7
Figure 4-1. Brake dynamometer used in the setup	16
Figure 4-2. New shaft design with bearings	18
Figure 4-3. Efficiency vs. RPM plot for 4 blade forward closed vane impeller at various heads.	21
Figure 4-4. Efficiency vs. RPM plot for 6 blade forward closed vane impeller at various heads.	23
Figure 4-5. Efficiency vs. RPM plot for 8 blade forward closed vane impeller at various heads.	26
Figure 4-6. Efficiency vs. RPM plot for 8 blade forward closed vane impeller at various heads.	29
Figure 4-7. Efficiency vs. Number of blades (impeller) at same initial conditions.....	30
Figure 4-8. Velocity triangle for guide vane	33
Figure 4-9. Guide vanes fixed with the pump casing	33
Figure 4-10. Efficiency vs. RPM plot for 8 blade forward closed vane impeller with 5 guide vanes	35
Figure 4-11. Efficiency vs. RPM plot for 8 blade forward closed vane impeller with 4 guide vanes	37

LIST OF TABLES

Table 4-1. PAT characteristics	11
Table 4-2. Observations for Experiment 2	13
Table 4-3. Cause and Effect Relationship	14
Table 4-4. Experimental observations with 10 blade forward vane type impeller	17
Table 4-5. Experimental observations for 4 blade forward closed vane impeller	19
Table 4-6. Experimental observations for 4 blade forward closed vane impeller	21
Table 4-7. Experimental observations for 8 blade forward closed vane impeller	24
Table 4-8. Experimental observations for 10 blade forward closed vane impeller	27
Table 4-9. Experimental observations for 8 blade forward closed vane impeller with 5 guide vanes	34
Table 4-10. Experimental observations for 8 blade forward closed vane impeller with 4 guide vanes	36