MAJOR–II PROJECT REPORT

ON

EFFECT OF ROUGHNESS ON SECONDARY FLOW IN A RECTILINEAR TURBINE CASCADE

By:

DEEPIKA SHARMA
(03/Thr/2010)

Under the valuable guidance of
Dr. SAMSHER
PROFESSOR
DEPARTMENT OF MECHANICAL ENGINEERING

Submitted in partial fulfillment for the award of the Degree of

MASTER OF TECHNOLOGY

IN

THERMAL ENGINEERING

Department Of Mechanical Engineering
Delhi Technological University
(Formerly Delhi College of Engineering)
Delhi – 110042

(June, 2012)

DECLARATION BY THE CANDIDATE

Date:____________

I hereby declare that the work presented in this dissertation entitled **"Effect of Roughness on Secondary Flow in a Rectilinear Turbine Cascade"** has been carried out by me under the guidance of Dr. Samsher, Professor, Department of Mechanical Engineering, Delhi Technological University, Delhi and hereby submitted for the partial fulfilment for the award of degree of Master of Technology in Mechanical Engineering (Thermal) at Delhi Technological University, Delhi.

I further undertake that the work embodied in this major project has not been submitted for the award of any other degree elsewhere.

Deepika Sharma

03/ Thr/2010

M.Tech (Thermal)

CERTIFICATE

It is to certify that the above statement made by the candidate is true to the best of my knowledge and belief.

Dated:——————

Dr. SAMSHER

Professor

Mechanical Engineering Department

Delhi College of Engineering, Delhi-42

ACKNOWLEDGEMENT

This project could not have been reached to this stage without the support of my mentor. I take this opportunity to express our gratitude to **Dr. Samsher** (Professor, Department of Mechanical Engineering Dept, DTU). His commitments, interest and positive attitude for the project has always been undiminished. The numerous discussions in which ideas and opinions were heard and decisions taken accordingly helped me to do my work regarding the project.

Deepika Sharma

03/ Thr/2010

M.Tech (Thermal)

ABSTRACT

The aerodynamics of the flow in a turbine stage (stator/rotor) is a complex issue and always been a subject of research. The flow through a cascade is inherently three dimensional and usually viscous. This characterization leads to the phenomenon of boundary layer. Due to the blade profile the flow becomes unstable and also subjected to separation. Both of these phenomenon leads to development of vortices and these vortices are the source of cross or circulatory flow which is termed as secondary flow.

This report gives a detailed understanding of secondary flow and effect of roughness on secondary flow. Three dimensional geometry of rectilinear cascade of four blades (reaction) is created in the Gambit® 2.2.3 software and flow behavior has been studied using FLUENT 6.2. Air with an inlet velocity of 102m/s is passed through the cascade. The cascade is open to atmosphere at the exit. Initially, both surfaces of the blade of the cascade are kept as smooth and secondary loss is analyzed in the span wise direction. This secondary flow loss is then compared with the blades on which a roughness of 500 µm is applied on suction surface and pressure surface individually as well as on both the surfaces together. It is observed that in a smooth blade average total loss is 14.7% whereas in case of blades having both the surfaces rough this loss gets almost doubled and becomes 27.7%. When roughness is applied to all the suction surfaces only then average total loss is 24.7% and if roughness is present only on the pressure surfaces then average total loss is 18.2%. But the corresponding average secondary loss decreases from 1.7% in case of smooth blades to 1.5% for rough blades. This average secondary loss is 1.9% for the blades on which roughness is present on all the pressure and 1.3% in case when roughness is applied to only suction surfaces of the blades

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOMENCLATURE USED

ρ	Density
u_i	Velocity vector
S_m	Momentum Source Term
P	Static Pressure
ρg_i	Gravitational Body Force
F_i	External Body Force
τ_{ij}	Stress Tensor
δ_{ij}	Kronecker's delta
µ	molecular viscosity
K_{eff}	Effective Thermal Conductivity
$J_{j'}$	Diffusion Flux
S_h	Source term includes heat of chemical reaction
T	Temperature
E	Energy term
h	Enthalpy
$m_{j'}$	mass fraction
u_i	instantaneous velocity
Ø	velocity ratio
κ	turbulent kinetic energy
ε	energy dissipation rate
G_k	turbulent kinetic energy due to mean velocity gradients
G_b	turbulent kinetic energy due to buoyancy
Y_M	contribution of fluctuating dilatation in compressible turbulence to the overall dissipation rate
Pr	Prantl number
M	Mach Number
u_{avg}	mean velocity
P_{2s}	Static pressure at outlet
P_{o1}	Total pressure at inlet
P_{o2}	Total pressure at outlet
T_0	temperature at inlet
T_2	actual temperature at exit

T_{2s} temperature at exit when expansion in the cascade is isentropic.

γ Ratio of specific heats for air

ζ_y Local energy loss coefficient

S span

z blade height

y distance along pitch