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THEORETICAL ANALYSIS ON EFFECT OF BLADE DISCHARGE ANGLE ON ENERGY TRANSFER FOR BACKWARD CURVED VANE, RADIAL OUTWARD FLOW TURBO MACHINE

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ABSTRACT

In this research work, the theoretical analysis is made on radial outward flow turbo machine. Based on the literature survey results it is found that radial outward flow turbo machines are power absorbing turbo machines with centrifugal type, centrifugal effect at outlet is twice that of inlet and flow velocity is constant throughout the flow. Based on this conditions and taking inlet blade angle(β_1) as 45° the results shows that, for different values of blade discharge angle(β_2):- i) β_2< 26.5° ,work done is positive and machine acts like turbine, ii) β_2= 26.5° there is no work done, iii)26.5° > β_2 machine acts like work absorbing device, such as pump, fan, compressor etc..,

Keywords: Energy transfer ($\dot{E}$), Centrifugal type, Blade discharge angle (β_2), Power absorber, Turbine

1. INTRODUCTION

The work done by the turbo machine is calculated by Euler's energy equation, If the work done is positive on substituting the values to Euler's energy equation, then the turbo machine is power developing device like turbine. If the work done is negative on substituting the values to Euler's energy equation then the turbo machine is power absorbing device like fan, pump etc..,

The radial outward flow machines are centrifugal type and are power absorbers like centrifugal compressor or centrifugal pump these are the devices which converts mechanical energy into pressure energy, for centrifugal machines there is no inlet guide blade, i.e tangential component of absolute velocity at inlet is zero, the centrifugal effect at outlet i.e, outlet blade velocity is twice that of inlet, and flow velocity is constant throughout the flow of working fluid.

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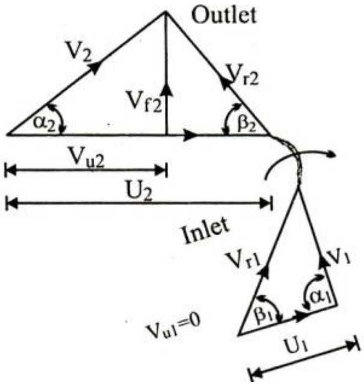
2. METHODOLOGY

2.1 Expression for work done per kg of working fluid for radial outward flow turbo machine in terms of blade discharge angle (β_2).

The velocity triangle for radial outward flow backward curved vane turbo machine is given by,

Where,
V_1 = absolute velocity of the working fluid at inlet.
V_2 = absolute velocity of the working fluid at outlet.
V_{r1} = relative velocity of the working fluid at inlet.
V_{r2}= relative velocity of the working fluid at outlet.
V_{f1} = flow velocity of the working fluid at inlet.
V_{f2} = flow velocity of the working fluid at outlet.
V_{u1} = tangential component of absolute velocity of the working fluid at inlet.
V_{u2} = tangential component of absolute velocity of the working fluid at outlet.
U_1 = absolute velocity of the blade/runner at inlet.
U_2 = absolute velocity of the blade/runner at outlet.
α_1 = fluid angle at entry/ Inlet nozzle angle.
α_2 = fluid discharge angle at outlet.
β_1 = blade angle at inlet.
β_2 = blade angle at exit.
gc = Newton's proportionality constant = 1 (kg- m) / (N- sec^2)



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Conditions for radial outward flow machine,

i) $V_{u1} = 0$
ii) $V_{f1} = V_{f2} = V_f$
iii) $U_2 = 2\times U_1$
iv) $\beta_1 = 45°$.

From Euler's energy equation,
The total energy transfer in the rotor $(\hat{E}) = (v_{u1}u_1 - v_{u2}u_2)/g_c$. J/kg ………. (1)
from inlet velocity triangle, $V_{u1}= 0$ and $V_1 = V_{f1} = V_{f2} = U_1= V_f$
from outlet velocity triangle, $U_2 = 2\times U_1= 2\times V_f$
Substituting these conditions in equation (1),
On simplifying we get,
$\hat{E} = 2V_f^2 (\cot\beta2 - 2) / g_c$ ………. (2)
Since flow velocity is constant taking $V_f = 1$ m/sec we get
$\hat{E} = 2 (\cot\beta2 - 2) / g_c$
This is the equation of Energy transfer for radial outward flow turbo machine in terms of blade discharge angle (β_2).

2.1.1 Graph of Energy transfer for various values of blade discharge angle.

The graph is plotted by taking blade discharge angle along x-axis and energy transfer along y-axis and the graph obtained is as shown in figure 2.1. From the graph it is observed that the value energy transfer is positive when the blade discharge angle is less than 26.5°, the value energy transfer is zero when the blade discharge angle is equal to 26.5°, the value of energy transfer is negative when blade discharge angle is greater than 26.5°.

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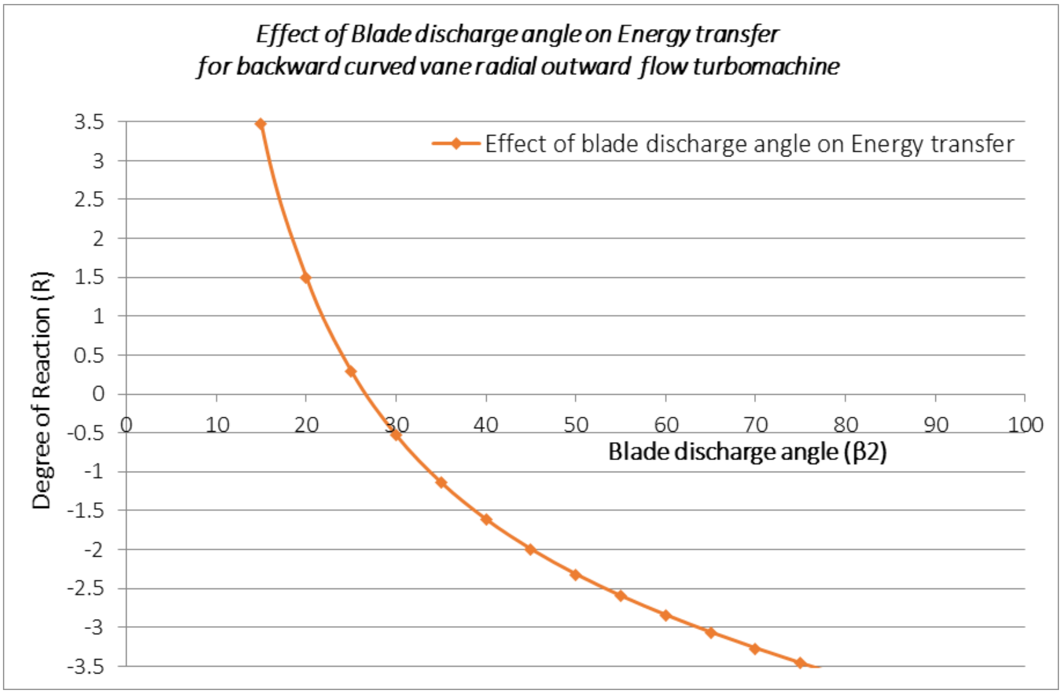

Fig 2.1:- Graph of Energy Transfer (Ḗ) v/s blade discharge angle (β_2)

3. RESULTS AND CONCLUSION

Figure 2.1 shows the curve of variation of energy transfer for various values of discharge blade angle.

Discharge Blade angle (β_2)	Energy transfer (Ḗ)	Remarks
i)$\beta_2 < 26.5°$	Positive	Machine acts like turbine.
ii)$\beta_2 = 26.5°$	0	No energy transfer by the machine.
iii)$\beta_2 \geq 26.5°$	Negative	Machine is power absorbing.

Table 3.1: - Results and Conclusion

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References

1) Philip P. Walsh / Paul Fletcher, Gas Turbine Performance, John Wiley & Sons, 2004.
2) O. E Balje, Turbomachines - A Guide to Design Selection and Theory," John Wiley & Sons, 1981.
3) S. L. Dixon, Fluid Mechanics and Thermodynamics of Turbomachinery, 4th Edition, Pergamon Press, London, 1998
4) Principles of turbomachinery – R.K.Turton, second edition, ISBN 0-412-60210-5 1995.
5) Fundamentals of Turbo machinery – B.K.Venkanna, ISBN-978-81-203-3775-6, july 2012.
6) A text book of Turbo Machines – Dr.M.S.Govinde Gowda, Dr.A.M.Nagaraja eight edition 2014.