50 % Reaction (Parsons) Stage: Velocity Triangles and Efficiency

Velocity diagram, blading work, diagram efficiency, stage enthalpy drop with carry-over and stage power of a symmetric 50 % reaction steam turbine stage.

Input parameters

Unit system: SI

Parameter	Value	Unit
Mean blade speed	160.00	m/s
Fixed-blade (nozzle) exit angle	20.000	°
Velocity ratio V_b/V_1 (0 for the optimum cos α)	0	
Row (nozzle) efficiency	92.000	%
Carry-over efficiency	90.000	%
Steam flow	72.000	t/h

Calculated results

Parameter	Value	Unit
Velocity ratio used	0.93969	
Steam velocity leaving the fixed blades	170.27	m/s
Relative velocity entering the moving blades	58.235	m/s
Moving-blade inlet angle	90.000	°
Absolute velocity leaving the stage	58.235	m/s
Diagram work per kg	25.600	kJ/kg
Diagram (blading) efficiency	93.788	%
Maximum diagram efficiency, 2cos²α/(1 + cos²α)	93.788	%
Isentropic enthalpy drop of the stage	28.195	kJ/kg
Stage (nozzle and blade) efficiency	90.797	%
Stage power	512.00	kW

Notes for this case

• Symmetric blading: fixed and moving blades have the same profile, so V_2 = V_r1 and $\beta_2 = \alpha$, and the stage drop is shared equally. The optimum velocity ratio is cos α. Carry-over efficiency is the share of the leaving energy recovered in the next stage (0 for a last stage).

Formula and method

$$W_D = (2V_1 \cos\alpha - V_b)V_b, \quad \eta_D = \frac{2(2\rho\cos\alpha - \rho^2)}{1 - \rho^2 + 2\rho\cos\alpha}, \quad \rho_{opt} = \cos\alpha$$

$$(\Delta h_s)_{stage} = \frac{V_1^2 - \eta_{CO}V_2^2}{\eta_n}, \quad \eta_{nb} = \frac{W_D}{(\Delta h_s)_{stage}}$$

Variables

V_b	Mean blade speed	m/s
α	Fixed-blade (nozzle) exit angle	rad
ρ	Velocity ratio V_b/V_1 (0 for the optimum cos α)	-

η_n	Row (nozzle) efficiency	-
η_{CO}	Carry-over efficiency	-
$\dot{m}$	Steam flow	kg/s
V_1	Steam velocity leaving the fixed blades	m/s
V_{r1}	Relative velocity entering the moving blades	m/s
β_1	Moving-blade inlet angle	rad
V_2	Absolute velocity leaving the stage	m/s
W_D	Diagram work per kg	J/kg
η_D	Diagram (blading) efficiency	-
$\eta_{D,max}$	Maximum diagram efficiency, 2cos²α/(1 + cos²α)	-
$(\Delta h_s)_{stage}$	Isentropic enthalpy drop of the stage	J/kg
η_{nb}	Stage (nozzle and blade) efficiency	-
P	Stage power	W

Method and standards

Velocity diagram of a symmetric 50 % reaction stage.

Assumptions and limits

- Symmetric blades; constant axial velocity; mean-diameter analysis.

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/steam-turbines/reaction-stage-50-percent

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.