Centrifugal Pump Axial Thrust on a Closed Impeller

Axial hydraulic thrust on a single-suction closed impeller without balance holes, from the side-space pressure with rotating fluid and the inlet momentum.

Method: Side-space pressure with fluid rotating at half impeller speed (rotation factor 0.5)

Input parameters

Unit system: SI

Parameter	Value	Unit
Flow	100.00	m³/h
Pump head	55.000	m
Speed	2,950.0	rpm
Impeller outside diameter	250.00	mm
Wear ring (seal) diameter	130.00	mm
Hub (shaft sleeve) diameter	50.000	mm
Static pressure rise of the impeller as a share of the head	75.000	%
Liquid density	998.00	kg/m³

Calculated results

Parameter	Value	Unit
Side-space pressure at the wear ring above suction	2.6799	bar
Pressure force on the back shroud	2.7886	kN
Inlet momentum force	0.068088	kN
Net axial thrust towards the suction	2.7205	kN

Notes for this case

• The liquid in the gaps between the shrouds and the casing rotates at about half the impeller speed, so its pressure falls inward from the impeller outlet as $p(r) = p_2 - \rho\omega^2(r_2^2 - r^2)/8$. Outside the wear ring the front and back shrouds see the same pressure and cancel; inside it the back shroud still sees this pressure while the front sees suction pressure, so the net force over the ring between hub and wear ring pushes the impeller towards the suction. The inlet momentum $\rho Q^2/A$ acts the other way. Balance holes with a back wear ring, or back vanes, remove most of the force; multistage pumps use a balance drum or disc.

Formula and method

$$p(r) = p_s + R_p \rho g H - \frac{\rho\omega^2}{8}\left(r_2^2 - r^2\right), \quad F_a = \int_{r_h}^{r_w} \left[p(r) - p_s\right] 2\pi r \, dr - \frac{\rho Q^2}{\pi\left(r_w^2 - r_h^2\right)}$$

Variables

Q	Flow	m³/s
H	Pump head	m
n	Speed	rad/s
D_2	Impeller outside diameter	m
D_w	Wear ring (seal) diameter	m
D_h	Hub (shaft sleeve) diameter	m
R_p	Static pressure rise of the impeller as a share of the head	-
ρ	Liquid density	kg/m³
$p_w - p_s$	Side-space pressure at the wear ring above suction	Pa
F_p	Pressure force on the back shroud	N

F_m	Inlet momentum force	N
F_a	Net axial thrust towards the suction	N

Method and standards

Axial thrust.

Assumptions and limits

- Rotation factor 0.5; no leakage flow effect; static pressure rise as a share of head.

References

Side-space pressure with fluid rotating at half impeller speed (rotation factor 0.5)

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

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