Pump Affinity Laws (Speed and Impeller Trim)

New flow, head and power of a centrifugal pump when the speed changes or the impeller is trimmed, by the affinity laws.

Method: ANSI/HI 1.3 (centrifugal pump application, affinity rules)

Input parameters

Unit system: SI

Parameter	Value	Unit
Flow	100.00	m³/h
Head	80.000	m
Shaft power	30.000	kW
Speed	2,950.0	rpm
Impeller diameter	250.00	mm
New speed	2,400.0	rpm
New impeller diameter (same as above = no trim)	250.00	mm

Calculated results

Parameter	Value	Unit
New flow	81.356	m³/h
New head	52.950	m
New shaft power	16.154	kW
Combined ratio N_2D_2 / N_1D_1	0.81356	

Formula and method

$$k = \frac{N_2\,D_2}{N_1\,D_1} \qquad Q_2 = k\,Q_1 \qquad H_2 = k^2\,H_1 \qquad P_2 = k^3\,P_1$$

Variables

Q_1	known flow	m³/s
H_1	known head	m
P_1	known shaft power	W
N_1	known speed	1/s
D_1	known impeller diameter	m
N_2	new speed	1/s
D_2	new impeller diameter	m
Q_2	new flow	m³/s
H_2	new head	m
P_2	new shaft power	W
k	combined ratio of speed and diameter	–

Method and standards

The affinity rules as given in ANSI/HI 1.3 for a centrifugal pump: corresponding points on the curves at two speeds, or with a trimmed impeller in the same casing, have the same efficiency and scale with the ratio of speed times diameter.

Assumptions and limits

- Corresponding points only: the result is a point on the new pump curve, not the new operating point; that is where the new curve meets the system curve.
- Efficiency unchanged; valid for moderate speed changes and trims up to about 20 %. No efficiency scaling (such as Moody's) is

applied, and no warning is given for large speed changes: below about half speed the efficiency falls and the power is higher than $k^3 P_1$.
- Same liquid; NPSH required scales roughly with speed squared and must be checked separately.

References
• ANSI/HI 1.3 (centrifugal pump application, affinity rules)

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/mechanical/pumps/pump-affinity-laws

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Reopens the calculator with the inputs of this report.