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Investigations on the performance of centrifugal pumps in conjunction with inducers

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KEYWORDS

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Abstract An inducer is an axial flow impeller with blades that wrap in a helix around a central hub. An inducer serves as a small booster pump for the main impellers. Usually inducers have between 2 and 4 vanes, although they may be more, the inducer imparts sufficient head to the liquid so that the NPSH requirement of the adjacent main impeller is satisfied.

Although the inducer usually has a lower NPSH requirement than the main impeller, it can, and often does, cavitate during normal operation, the key is that there is so little horse power involved with an inducer that there is virtually no noise, vibration, or resulting mechanical problems.

An inducer invariably has higher suction specific speed (S) than an adjacent impeller (S) is a dimensionless term that describes the inlet characteristics of a pump.

1. Introduction

An inducer is an axial flow impeller with blades that wrap in a central hub. An inducer serves as a small booster pump for the main impeller [1].

Usually inducers have between (2) and (4) vanes, although there may be more [2].

Although the inducer usually has a lower NPSH requirement than the main impeller, it can, and often does, cavitate during normal operation [3]. The key is that there is so little horsepower involved with an inducer that there is virtually no noise, vibration, or resulting mechanical problems. Meanwhile, the higher horsepower main impeller sees sufficient head to operate without cavitation [4].

An inducer invariably has higher suction specific speed (S) than an adjacent impeller (S) is a dimensionless term that describes the inlet characteristics of a pump [5].

A pump equipped with an inducer may operate at 1/2–1/3 the NPSHR levels of a non-inducer version of the same pump, at the same conditions [6].

Inducers have been developed to improve the required net positive suction head requirements (NPSHR) [7].

The inducer mounts on the threaded area of the rotor assembly (taking the place of the impeller nut) Fig. 1 and operates as a low (NPSHR) axial flow impeller in series with the

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Nomenclature

A	cross_sectional area of flow (m^2)	R	radius (m)
B	impeller width (m)	t	time (s)
$B.P.$	brake power (w)	T	torque (N m)
C	absolute velocity of flow in the channel (m/s)	s	suction (–)
d	pipe diameter (m)	S	specific speed (–)
D	impeller diameter (m)	v	velocity (m/s)
F	force (N)	V	volume (m^3)
g	gravitational acceleration (m/s^2)	X	axial clearance (m)
H	total head (effective head) (m)	Y	radial clearance ratio = Y/D (dimensionless)
Hm	manometric head (m)	Z	number of impeller blades
Hms.	manometric suction head (m)	β_1	inducer inlet blade angle (degree)
Hmd.	manometric delivery head (m)	β_2	inducer outlet angle (degree)
Hn	normal head (effective head) (m)	λ	specific weight (N/m^3)
I	distance between suction and delivery pressure gauges (m)	η	pump overall efficiency
		W	impeller angular velocity (m/s)
M	momentum to fluid by impeller per second ($kg\ m/s^2$)	ρ	density (kg/m^3)
		Φ	flow coefficient = $\frac{Q}{nD^3}$
n	shaft speed (rps)	Ψ	head coefficient = $\frac{gH}{n^2D^2}$
N	shaft speed (rpm)	π	power coefficient = $\frac{B.P.}{\rho n^3 D^5}$
P1	P2 pressure on suction, discharge sides (N/m^2)		
Q	volume flow rate or pump capacity (m^3/s)	η	overall efficiency = $\frac{\rho gQH}{B.P.}$

main pump impeller. The inducer can be added to any of the standard models by removing the impeller nut and replacing it with the inducer. This feature will achieve field reduction of the (NPSHR). The inducer has a built-in locknut to prevent loosening or spinning-off during rotation check. Total dynamic head and capacity are not affected by the inducer and all standard modification and accessories can be specified on the pump with inducers [8].

There are two types of inducers.

(1) Axial inducer:

This type of inducer Fig. 1 reduces the (NPSHR) of the pump throughout the entire operating range [9].

(2) Helical inducer:

A helical inducer Fig. 2 will lower the (NPSHR) more than an axial inducer for a specific flowrate, but care must be taken that the flow remains within the operating range of the inducer [10].

Inducers are single stage axial flow helixes installed in the suction eye of centrifugal pump impellers to lower the (NPSHR) of the pump. This allows use of increased rotating speed for a given NPSHA or a lower NPSHR for a given speed. Shallow blade inlet angles are used to draw liquid into the inducer channels, which are shaped to impart enough energy to provide sufficient NPSH for the main impellers to avoid detrimental cavitation [11].

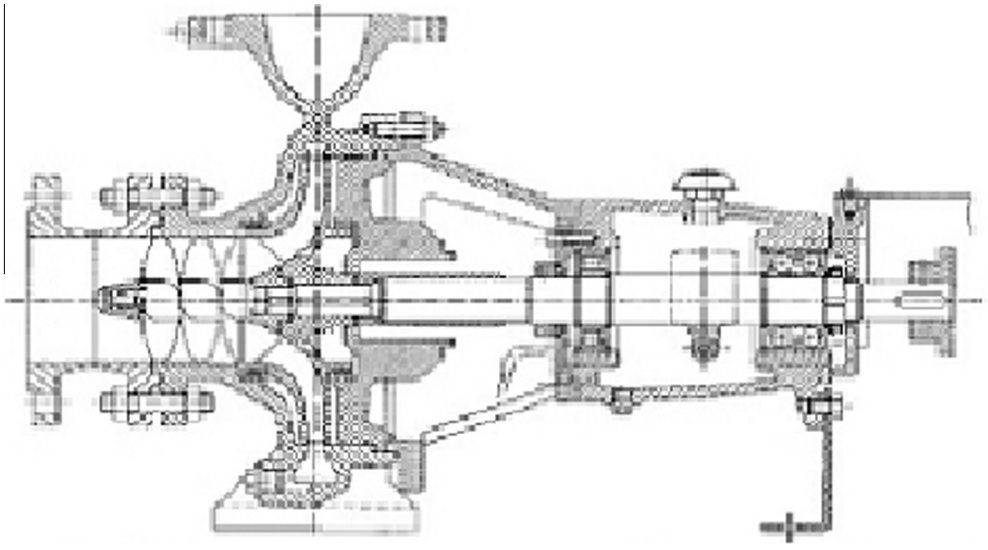

Figure 1 Centrifugal pump–with helical inducer.