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Review Article

Transfer Pump Selection for Oyama Hotel

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Abstract

Transfer Pump Selection for Oyama Hotel. The calculation and selection of the transfer pump has been carried out in the clean water installation of the Oyama hotel building. Transfer pump is required to move (lift) clean water from the ground water tank to the roof tank. The pump selection method is based on calculation of pump capacity and head. Pump capacity calculation is based on water demand during peak hours. Pump head calculation is based on static head and friction loss in the piping. From the results of the calculations, the capacity is 20m3/hour and the pump head is 9 bars.

Keyword: transfer pump, pump capacity, pump head.

1. INTRODUCTION

Buildings of all types and sizes use pumps for fire protection, heating, cooling and for domestic water distribution. While these pumps do not generally represent a large fraction of the total building cost or energy budget, careful selection of the pump type and size will reduce both the first cost of the building, and the cost of operating the building over the years. More importantly, proper selection of the pumps will make the building more valuable by providing reliable, sustainable service at low cost.

In the Oyama hotel building, clean water from PDAM is stored in the ground water tank first, and then pumped to the roof tank using a transfer pump. From the roof tank then distributed to all floors. Services for the top 4 floors use a booster pump, the rest use a gravity system.

2. CENTRIFUGAL PUMP

2.1 Major Components

A centrifugal pump consists of three major components:

- The volute, pump casing or pump body is the mostobvious component. It contains the pumped fluidunder pressure.
- The impeller is the rotating element inside the volute. It applies work to the system fluid.
- The driver is the source of power for the impeller. In building service applications, it's typically an electric motor.

2.2 Centrifugal Impellers

A centrifugal impeller increases total fluid head by applying work to the liquid. "Centrifugal" means "moving away from the axis".

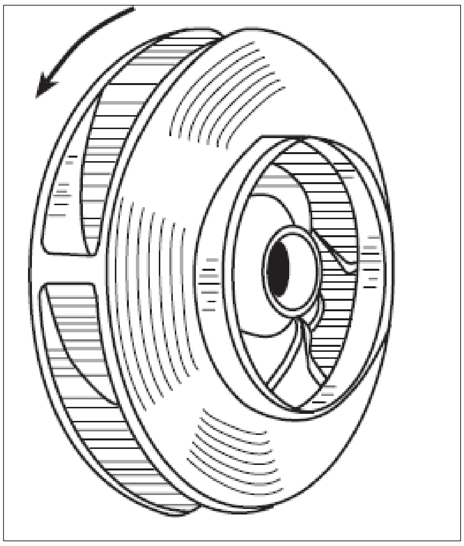

Fig. 01: Typical centrifugal impeller

2.3 Impeller Type

Many impeller designs are used in building service pumps. One of the simplest is the "open impeller".

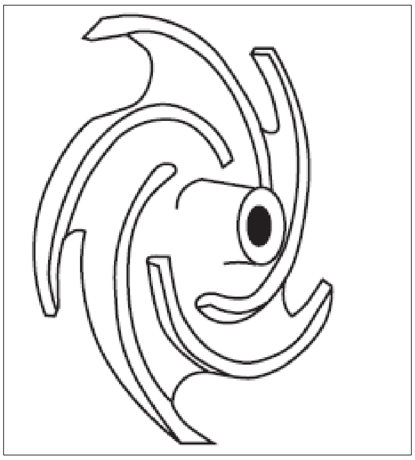

Fig. 02: Open impeller

Open impellers are essentially nothing but a hub and curved vanes. They are often very small, non-metallic, and inexpensive, for use in small pumps. They are not very efficient since water can freely circulate parallel to the hub axis as well as at right angles to the axis…the desired direction.

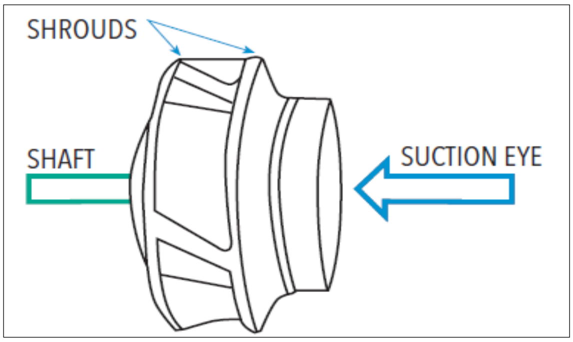

Fig. 03: Closed impeller

The impeller in Figure 3 has discs, or "shrouds" that direct the liquid to flow more efficiently at right angles to the axis, or "radially" across the shroud. It's called a "closed impeller", and because of its better efficiency, it's much more widely used, especially in larger pumps that can handle larger flow rates, and therefore require greater energy input. The impeller in Figure 03 is also called a "single suction impeller" since all the liquid inters the "suction eye" on the same side of the impeller. This will exert large axial forces on the bearings that support the shaft.

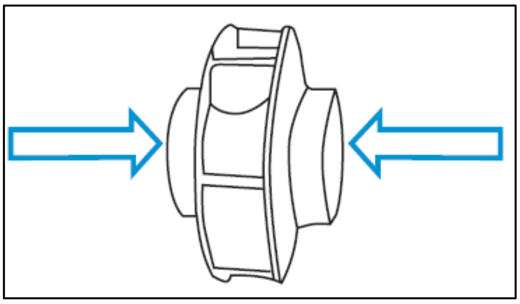

Fig. 04: Double Suction Closed Impeller

A "double suction" impeller is often used to minimize axial forces on the pump shaft. If the liquid enters both sides of the impeller equally, the axial forces cancel, meaning that the shaft bearings don't need to oppose any significant axial loading. There are several other good reasons for using double suction impellers to handle higher flow rates.

Fig. 05: Non-Clogging Impeller

Some building pumps like sewage ejectors and sump pumps must handle large solids that would clog a closed impeller. These pumps would use a "non-clogging" impeller like the one in Figure 05. Notice that it has no shrouds and only a few vanes. Some impellers in sewage pumps can actually grind the solids to smaller pieces that can flow through the pump and piping.

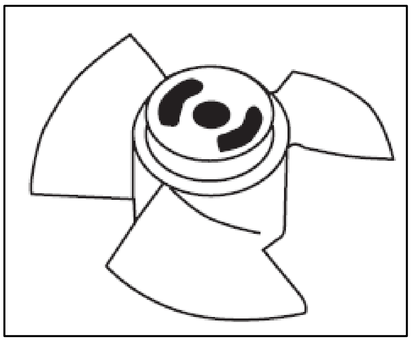

Fig. 06: Axial Flow Impeller

Occasionally, axial flow impellers can be found in building pumps. Impellers like this apply work by the lifting action of the vanes, much like a ship's screw, so the liquid enters and leaves the impeller parallel to the shaft. For comparable sizes, axial flow impellers can't apply as much work as the other impellers we've discussed, but there are applications where they can be useful.

2.4 Impeller Trim

It is often useful to tailor the impeller performance to match the system requirements. The term "impeller trim" meansreducin g a full diameter impeller by cutting away some of the shrouds and vanes on a lathe. The reduced diameter impeller rotating at full rpm will apply less work to the fluid, making it more suitable for a system that doesn't require the total fluid head provided by the full diameter impeller.

2.5 Volute Types

An impeller increases the velocity component of the total fluid head; the volute directs the liquid and converts the velocity head component to pressure head. "Volute" comes from the Latin word for "scroll"; a snail's shell has the shape of a volute.

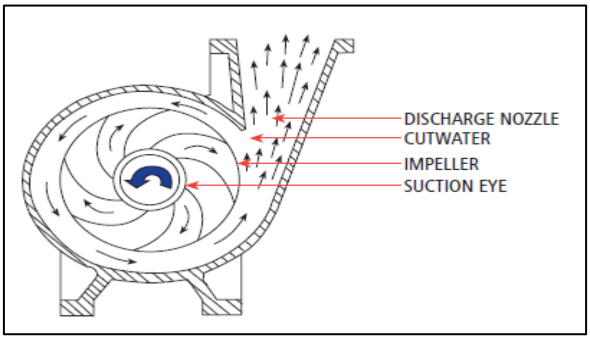

Fig. 07: Impeller and Volute Interaction

In Figure 07, the circular impeller accelerates the liquid from the suction eye toward the rim. The bold arrow represents impeller rotation, the smaller arrows the direction of liquid flow. The volute shape results in a narrow gap between the impeller and volute at the "cutwater", or "throat", increasing in area in the direction of flow. This gap of constantly increasing cross sectional area captures the high velocity liquid leaving the tips of the impeller vanes, and directs it to the discharge nozzle at approximately constant velocity. At the cutwater, there's only one vane's discharge, but the flow rate increases in the direction of rotation as each vane discharges more liquid into the gap. In order to keep the velocity constant, the area available for flow must increase. Flow entering the discharge nozzle is constant, the sum of all the vane flows. The increasing cross sectional area in the "diverging" nozzle results in a decrease in overall liquid velocity, converting the velocity head to pressure head. The overall effect of the pump is to apply work to a pound of liquid at lower suction pressure, then discharge it as a pound of higher pressure liquid at the discharge.

2.6 Pump Types

Pump manufacturers have developed many volute and impeller combinations in order to meet the requirements imposed by different systems. "Pump selection" is the process of matching, as well as we can, the characteristics of the pump to the requirements of the system. In order to do that, we must know what kinds of pumps are typically available for use in building service systems.

a. Single Suction Pumps

One of the most common types is the end-suction, base mounted, flexibly coupled pump shown in Figure 08.

Fig. 08: Single suction pump

b. Close-coupled pumps

The single suction impeller is installed directly on the motor shaft, it has no coupler, so it's called a "closecoupled" pump.

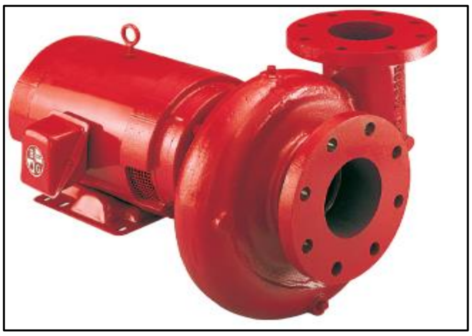

Fig. 09: Close-coupled single suction pump

c. In-Line Pumps

The single suction impeller can also be used with in-line mounted volutes like the ones in Figure 10.

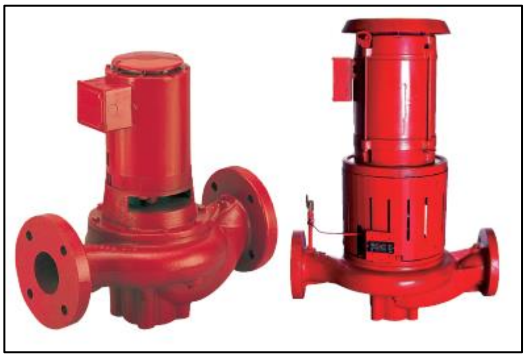

Fig. 10: In-Line single suction pump

d. Multi-Stage Pumps

Some pumps use several impellers "in series" in order to apply more work, thus develop greater discharge head.

Fig. 11: Multi-Stage Pumps

e. Vertical Turbine Pumps

Vertical turbine pumps are usually multistage.

Fig. 12: Vertical Turbine Pumps

f. Double suction pumps

Single suction impellers are limited in terms of the flow rate they can handle, so double suction impellers must be used for high flow applications. The horizontal split case pump, was developed long ago for this kind of service.

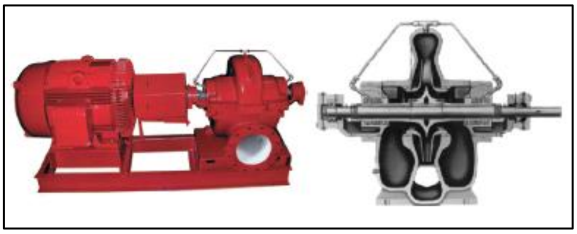

Fig. 13: Horizontal Split Case, Double Suction Pump

3. TRANSFER PUMP SELECTION

A pump that lifts or transfer water from a ground water tank into an elevated water tank or roof tank is called a transfer pump.

Transfer pumps are generally driven by electric motors of the centrifugal pump type, end suction type or vertical multistage type. In a system with a elevated water tank or roof tank usually the pump capacity is taken equal to the water demand at maximum hours.

The diameter of the suction pipe is usually determined so that the velocity of the water flow is between 2 and 3 m/s. In low pressure pumps the velocity in the outlet pipe is usually between 2 and 3 m/s (sometimes up to 4 m/s), and in high pressure pumps it is between 4 and 5 m/s (sometimes up to 6 m/s).

The force that pushes water into the pump is caused by the vacuum at the suction side of the pump, and the air pressure above the water level in the lower water tank. If the air in the tank under the pressure is 1 atmosphere, or 10.33 m of water column, then theoretically the pump will be able to "suction" water as high as 10.33 m. In reality, there are several things that will cause the water to not rise that high, namely the air pressure in the bottom tank is not 1 atm, friction losses in the inlet pipe and inlet, the saturated vapor pressure of the water, and so on, so that the maximum lift height is around 6 to 7 meters only. The higher the elevation, the lower the barometric pressure of the air, so the maximum lift height is lower as well. The higher the temperature of the water, the higher the saturation pressure of the steam, so the lower the maximum lift height. This lift height is very important for placing the pump, up to how high it is above the water level of the lower tank.

Pump head can be expressed by the following formula:

$$H = H_s + H_d = H_{fsd} + \frac{v^2}{2g}$$

$$H = H_a + H_{fsd} + \frac{v^2}{2g}$$

Where

H	: Total head (m)
Hs	: Suction head (m)
Hd	: Discharge head (m)
Ha	: Potential head (m)
Hfsd	: Friction/losses head (m)

4. CALCULATION

4.1 Capacity Calculation

Daily water demand:

No.	Descriptiion	Occupant	Water Demand	
		Prsn	(ltr/prsn/day)	Total (ltr/Day)
1	**BASEMENT**			
	- BOH	9	100	900
	- Security	2	100	200
	Linen	2	100	200
	Receiving	2	100	200
	General storage	2	100	200
	- Ruang Kontrol	2	100	228
				1,928

No.	Descriptiion	Occupant	Water Demand	
		Prsn	(ltr/prsn/day)	Total (ltr/Day)
2	**1st Floor**			
	- BOH	22	100	2,200
	- Restauran & Cafe	264	30	7,920
				10,120
3	**MEZZANINE Floor**			
	- Saleable Area	36	30	1,087
	- Preparation	12	30	372
				1,459
4	**2nd Floor**			
	- Parking	68	5	339
	- BOH Hotel	38	100	3,800
				4,139
5	**3rd Floor**			
	- Parking	68	5	339
				339
6	**4th Floor**			
	- Ballroom	152	30	4,567
	- Restaurant	54	30	1,629
				6,196
7	**5th Floor**			
	- Meeting Room	280	30	8,400
	- Musholla	41	30	1,225
	- Storage	2	100	200
				9,825
8	**6th Floor**			
	- SPA	23	30	678
	- Fitness	17	30	515
				1,193
9	**7th Floor**			
	- Guestroom	38	250	9,500
				9,500
10	**8th Floor**			
	- Guestroom	38	250	9,500
				9,500
11	**9th Floor**			
	- Guestroom	38	250	9,500
				9,500
12	**10th Floor**			
	- Guestroom	38	250	9,500
				9,500

No.	Descriptiion	Occupant	Water Demand	
		Prsn	(ltr/prsn/day)	Total (ltr/Day)
13	**11th Floor**			
	- Guestroom	38	250	9,500
				9,500
14	**12th Floor**			
	- Guestroom	38	250	9,500
				9,500
15	**13th Floor**			
	- Guestroom	38	250	9,500
				9,500
16	**14th Floor**			
	- Guestroom	38	250	9,500
				9,500
17	**15th Floor**			
	- Guestroom	38	250	9,500
				9,500
18	**16th Floor**			
	- Guestroom	38	250	9,500
		1,477		**9,500**
	TOTAL			**130,199**
	Roundup			**131,000**

Qtransferpump $= 1{,}5\ x\ \frac{131\ m3}{10\ hours}$

$$= 19.65\ {m^3}/{jam}$$

$$\approx 20\ {m^3}/{jam}$$

4.2 Head Calculation

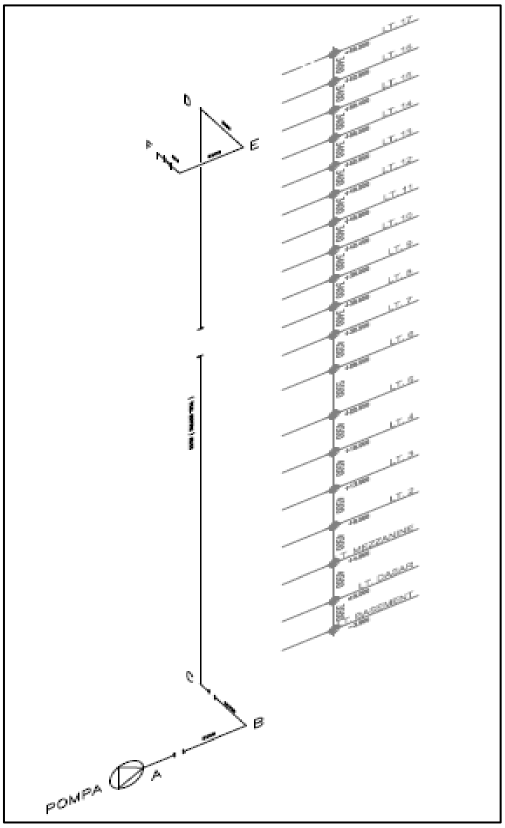

Fig. 14: Transfer pump piping installation

No	Node	Flow (m3/hour)	Roughness Coefficient	Diameter (mm)	FITTING: Elbow 45° (bh)	FITTING: Elbow 90° (bh)	FITTING: Tee 90° branch (bh)	FITTING: Tee 90° Thru (bh)	Valve: Gate (bh)	Valve: Ball (bh)	Valve: Angle (bh)	Valve: Check (bh)	Total Equivalent Length (m)	Friction (m)
1	A - B	20	130	80	0	2	0	0	0	0	0	0	4.8	0.16
2	B - C	20	130	80	0	3	0	0	1	0	0	0	7.68	0.25
3	C - D	20	130	80	0	1	0	0	1	0	0	0	2.88	0.09
4	D - E	20	130	80	0	4	0	0	0	0	0	0	9.6	0.31
5	E - F	20	130	80	0	2	0	0	1	0	0	0	5.28	0.17
Total														0.99
Round														1

No	Node	Flow (m3/hour)	Roughness Coefficient	Diameter (mm)	Pipe Length (m)	Total Equivalent Length (m)	Friction (m)
1	A - B	20	130	80	8	8	0.26
2	B - C	20	130	80	90	90	2.94
3	C - D	20	130	80	69.7	69.7	2.27
4	D - E	20	130	80	3	3	0.10
5	E - F	20	130	80	5.8	5.8	0.19
Total							5.76
Round							6
Grand total							6.74

PERHITUNGAN RUGI GESEK POMPA TRANSFER

Tekanan Statis	:	69.7	m
Tekanan Keluaran	:	10	m
Tekanan Gesek	:	6.74	m
Total Tekanan Pompa	**:**	86.44	m
	≈	**90**	m
		9	bar

Fig. 15: Head calculation

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