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Demand Side Management Deficacy in Pump Selection – Challenges and Solutions

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ABSTRACT: Demand side management, is one of the important tools in the conservation of energy from the utility point of view. It matches the load demand with the generation by various techniques like peak clipping, valley filling, load shifting, load building or conservation. Practically the load can be a HVAC system or a lighting system or pumping system. This paper mainly discusses the importance of demand side management of the utility systems by notifying various reasons for poor selection of pumps and how this selection is affecting energy consumption. This paper explains various ways to operate the pumps at their best efficiency point with existing system with the help of practical data taken in an energy auditing project and thereby decreasing energy consumption of system.

KEYWORDS: Energy Efficiency, Demand Side Management, Pumps, Energy consumption.

I. INTRODUCTION

Pumps being critical equipment in a process or industrial or building systems, they often suffer poor selection or mismatch of pumps for the specific purpose they serve which leads to major part of the energy consumption of that system. With the increased usage of Chillers, which uses pumps in the form of primary pumps and condenser pumps require more time to operate. Thermal exchange of coolant shall be carefully matched with condensed water. If not matched often occurs due to flow rate mismatch which may be poor selection of pumps, more no. of cycles occur. It increases power consumption and reduces life of pumps. This time can be reduced by various ways that are discussed below, Demand side management (DSM) strategies have the goal maximizing the end use efficiency and to avoid or postpone construction of new generating plants. DSM implementation procedure involves load curve generation to identify peal load contributors. The peak load can be reduced by planning and operating energy efficient programs which has the following benefits.

II. PUMP SELECTION CRITERIA

Pumping system has three important parameters to be taken into account while selecting a pump. The parameters are rate of discharge as required by the process, total head of the system, rated power which can be obtained by rate of discharge and head of the system. The behaviour of a pump with respect to flow rate can be shown as below

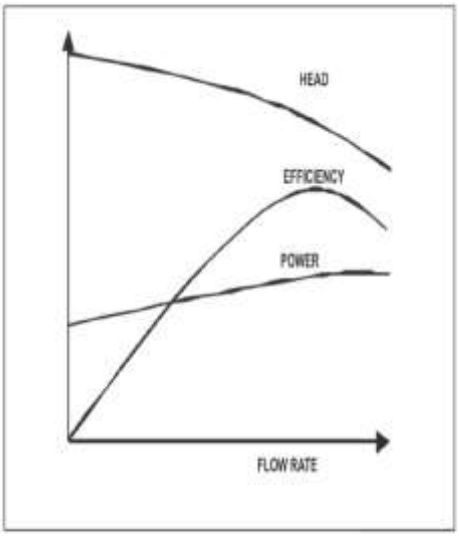

Fig.1. Characteristics of Pump with Respect To Flow Rate

From the fig 1 it is evident that efficiency of the pump is high for a specific head and flow rate. But in most of the cases, the selection of pump is taken as random just increasing “HP” without consideration of head and discharge. As per IS 1172:1992 we can take the average of water consumption for different areas and the quantity of water required can be calculated accordingly.

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Table 2: Water Requirements for Buildings other than Residences as per IS 1172:1993

S.no	Type of Building	Consumption per day in litres
1	Factories which require bathrooms	45 per head
2	Factories without bathrooms	30 per head
3	Hospital including laundry a. No.of beds below 100 b. No. of beds above 100	340 per head 450 per head
4	Nurse's homes and medical quarters	135 per head
5	Hostels	135 per head
6	Hotel	180 per head
7	Offices	45 per head
8	Restaurants	70 per head
9	Cinemas, concert halls and theatres	15 per seat
10	Schools a. Day schools b. Boarding schools	45 per head 135 per head

For a given quantity of water consumption and head, discharge can be estimated by considering friction loss by the valves, bends and the pipe. The rating of pump is calculated as Hydraulic Power, $P_h = Q \times (h_d - h_s) \times \rho \times g / 1000$

Where, h_d = Discharge head in meters

h_s = Suction head in meters

ρ = density of the liquid in kg/m^3

g = acceleration due to gravity m/s^2

Pump shaft power, P_s = Hydraulic Power / Efficiency of Pump

Motor input Power, P_m = Pump shaft power/ motor efficiency

III. PUMP OPERATING POINT

When a pump is installed, its characteristics can be explained graphically by superimposing system curve and pump curve. If the system curve is different from actually calculated, the pump operates at head different than expected.

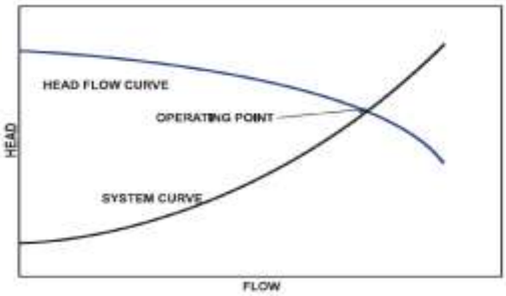

Fig 3: Selection of Operating Point

An error in the system curve calculation leads to undersized pump calculation which is less than optimal for actual head losses and adding safety margins leads to oversized pump leads to operation of excessive flow rate which increases energy usage and reduces pump life.

IV. EFFICIENT PUMP SYSTEM OPERATION

A pump is selected based on how well the pump curve and system head flows match. The operating point is identified as the where the system curve and pump curve intersect. Once flow requirements are optimized, then the pumping system can be analysed for energy conservation opportunities. Common symptoms that indicate opportunities for energy conservation opportunities are shown below.

Table 3: Reasons and Solutions for Common Problems During Pumping Operation

Symptom	Likely Reason	Best Solutions
Throttle valve-controlled systems	Oversized pump	Trim impeller, smaller impeller, variable speed drive, two speed drive, lower RPM
Bypass line (partially or completely) open	Oversized pump	Trim impeller, smaller impeller, variable speed drive, two speed drive, lower RPM
Multiple parallel pump system with the same number of pumps always operating	Pump use not monitored or controlled	Install controls
Constant pump operation in a batch environment	Wrong system design	On-off controls
High maintenance cost (seals, bearings)	Pump operated far away from BEP	Match pump capacity with system requirement

V. SOLUTIONS TO IMPROVE SYSTEM EFFICIENCY

a. By varying pump speed

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The dependency of parameters on the pump speed can be represented as,

$$Q \propto N$$

$$H \propto N^2$$

$$P \propto N^3$$

Where,

Q = Discharge rate
H = head of the system
P = Power consumption
N = speed

b. By Impeller Trimming

c. Using parallel Pumps to meet demand

d. Using flow control valve: Valves introduces additional resistance (meter) and head is decreased.

VI. STUDY OF PRACTICAL CASE

Table 4: Audit data of a chiller plant at Hyderabad, Telangana

Chiller No	Flow rate of coolant	Specific heat of coolant	Evaporator Inlet	Evaporator Outlet	% Loading	Net Refrigeration Capacity, Tr	S
	M, Kg/Hr	C, Kcal/ Kg-Hr	T1,°c	T2, °c		M*C* (T1-T2)/3024	Kw/Ton
1	410000	1	12.7	8.4	72.1	583.0026455	0.87
2	720000	1	12.4	9	57.1	809.5238095	0.55
3	821000	1	13	9.3	66.2	1004.530423	0.50
4	580000	1	13	9	59.3	767.1957672	0.63
5	640000	1	12.5	9	57.7	740.7407407	0.60

It can be noted that, for the same system i.e., head and load being the same for the chillers 2,3 where flow rates were optimized as per the requirement KW/Ton was low which means energy consumption of pumps for every ton of refrigeration was reduced. For the chiller 1, the pumps were not optimized and flow was unable to match the required load, KW/Ton was more. Here VFDs were used to control the pump speed to match the load requirement of the system.

VII. CONCLUSION

Matching energy generated of the grid with respect to load is always challenging with ever increasing demand. Demand side management is one of the important aspects in planning of expansion or construction of power plant. In the process of demand management, pumps are the critical power consumption equipment that suffer from poor selection criteria. The present system can be updated with necessary actions so that best efficiency of the system can be achieved which has social, customer as well as utility benefits.

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