Power Management in Paper Industry on Pulp Pump

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Abstract

Power management. Power management is effected by reduction of Mechanical, Hydraulic and Thermal losses, by incorporating high efficiency pumps, Metallurgy optimisation, and selection of suitable pump and systems. The selection of suitable pumps and systems and the Pumping problems with solution and power management. Power management are discussed here. Power management can bring in more than Rs. 18,00,000/- cost reduction by conserving 4,32,000 KWhr/Annum for a 30, tonnes paper mill.

INTRODUCTION

Pumps are most important rotating equipment for transfer of water, pulp, chemicals, effluent, etc. in paper industries.

Now Indian pump industry's development is at its best. Consistent R&D on Hydraulics and Improved mechanical reliability, developments in Metallurgy, results with high hydraulic efficiency and increased life of pump performance.

How pump efficiency can be improved ?

Hydraulic efficiency: Hydraulic efficiency is the ratio of effective head to the internal head

$$\eta_h = \frac{He}{Hi} = \frac{Hi \quad hp}{He + hp} = \frac{He}{Hth}$$

Now because of closest range in pumps, the ratio of the effective head internal head is improved.

Volumetric Efficiency: The Impeller Discharge is mostly capitalized because of reduced recirculation in the casing.

$$\eta_v = \frac{Qr}{Qi} = \frac{Qr}{Qr + Ql}$$

Internal Efficiency: The internal efficiency of a pump is defined by the expression.

$$\eta_I = \frac{Pe}{Pi} = \eta_v . \eta_h$$

As the hydraulic efficiency and volumetric efficiency of the pump is improved, simultaneously internal efficiency also increased.

Internal discharge: The internal Discharge is rate of the flow through the impeller. Hence it is sum of the real discharge Qr and the internal leakage flow Ql through the unavoidable clearance gaps between the impeller and pump coating.

$$Ql = Qr + Ql$$

The clearance between impeller, casing and casing cover are reduced as much as possible and the leakage flow is also reduced.

The Internal Power: The Internal power is the total power imported to the liquid by the impeller at the rated flow.

$$Pi = rl\ QiHi + Phf = rl\ (Qr + Ql)\ (He + hp) + Phf$$

where Phf denotes the power consumed in overcoming hydraulic fractional resistance of the rotating impeller transfer to the liquid in form of thermal energy.

The internal power is equal to the shaft power less the power Rr used to overcome the mechanical frictional resistance of the pump (Bearings, glands). The internal power consumption/power loss is reduced by the design of smoother root of impellers and increased surface finish of the internal portion of impellers.

Mechanical efficiency

The mechanical efficiency hm is the ratio of internal power to the power input at the pump shaft.

$$\eta_m = \frac{Pi}{Psh} \quad \frac{Psh - Pmf}{Psh}$$

The transmission losses are minimised by using low friction bearing (axial, radial), reduced overhang distance and minimised gland packing friction with the sleeves, reduced shaft deflection at impeller end (i.e. not to exceed 0.05 mm).

Overall efficiency

As hydraulic efficiency volumetric efficiency, internal efficiency and mechanical efficiency are improved, the over all effciency is also improved. The overall efficiency of the pump is the liquid horse power to the power input at the pump shaft.

High efficiency motors

Now most of the manufacturers are manufacturing energy efficient motors, this motor efficiency is achieved by reducing core losses (Rr-losses) Bearing losses (anti friction Bearings).

The motor efficiency is improved by 5 to 8% compared with old version motors. These motors are also designed to take care of mechanical reliability. By installing variable speed drivers for existing motors, the power can be reduces by 5%. Increased pump velocity, reduced hydraulic losses, closest ranges makes paper industry extremely interested in pumps for the purpose of conserving energy by using efficient pumps.

Other Points for Efficiency Improvement

Pump sizes enable to reduce the hydraulic losses and increase the pump efficiency. High pump velocity also reduces the return flow through pipe during operation. Improvement in metallurgy of pump construction reduces wear and tear due to corrosion and errosion, which also enables to maintain the impeller clearance to achieve the designed parameter. Duplex stainless steel material type CD4MCU, SS 2324, CB7CU1 are good corrosion/abrassion resistance materials. Increased surface finish in casing/impeller reduces the frictional loss inside the pump by which the pump efficiency can be increased by 3%. By reducing the shaft deflection on stuffing box leakage can be controlled and friction can be reduced which reduces the transmission losses.

Hydraulic Sealing

Stuffing box leakage is one of the hydraulic/ mechanical loss which effects the over all efficiency. Continuous leakage also affects the atmosphere badly. Instead of conventional glade packing, now the hydraulic sealing is innovated.

Design of Hydraulic Sealing

"Back to back impeller and expeller arrangements" arrests liquid entry through the stuffing box.

$$Pst = Ps + 20\% \ Pd$$

Stuffing box pressure is calculated as above. The expeller pressure is designed to over come

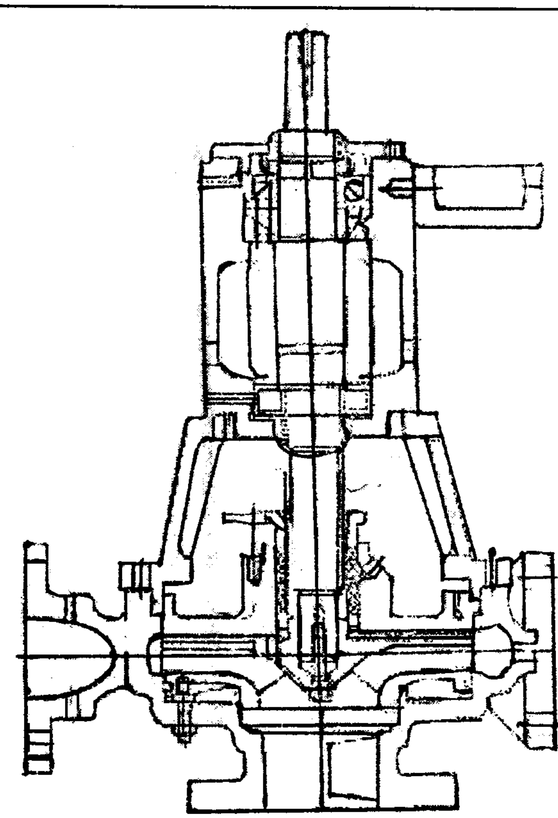

Fig. 1

the pressure of stuffing box. By this, sealing arrangement transmission loss can be reduced by 10 to 15%.

Selection of Suitable Pumps in Paper Industry

Pumps are selected normally based on the following factors:

Suitability

Impeller type selection should be based on liquid, Consistency, Fibre length, etc. Wrong selection of impellers (though it is efficient) will lead to continuous maintenance problems like Jamming or nonperforming.

Energy Efficiency

Once impeller model is decided, then comes the selection of best efficiency pump as it is directly related to power.

a) Pump should be selected always nearest to the best efficiency point. The capacity range of pump should be 60 to 120% of the best efficiency point.

b) Selecting pump in the full diameter of the impeller reduces the option of increasing the capacity and head further. Hence it is desired to select the pump 5% below the maximum Impeller diameter.

c) Selecting pump in minimum impeller diameter increases the hydraulic losses which results into low efficiency.

Mechanical Reliability

Prime factor of pump selection for the trouble free operation. A model constructional view of a good mechanical reliable pump is furnished in Fig. 1.

Cost effective

Cost of the pump based on the above factors, also varies according to the manufacturer.

After sales service

After sales service is also very important factor for pump manufacturers reputation with the user for the trouble free operation.

Selection of suitable pumps and systems

Two case studies on "system selection" and "Pump selection" are presented here.

PUMP TYPE : APO 100/320	IMPELLER TYPE : 3V-0
SIZE IN mm :150X100	IMPELLER NO. : 3201/3-0

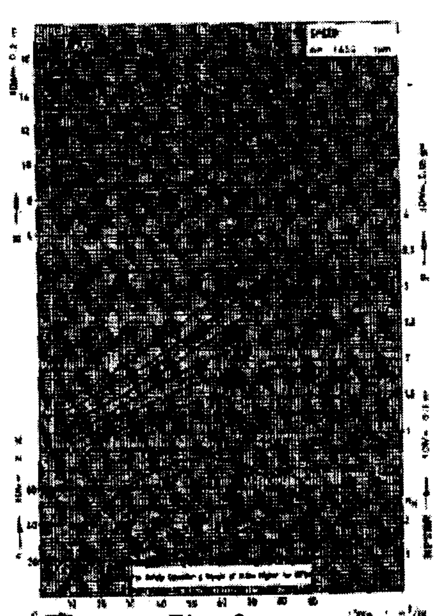

Fig. 2

Perfomance tested are based on viscosity 1sct., Specif gravity 1			
CAPCITY	M³/hr	MOTOR RATING	HP
HEAD	Meter	MOTOR SPEED	1470 RPM
EFFICINCY	%	CURVE NO.	L 100-005 (M)

PUMP TYPE : AEC - C -65/20	IMPELLER TYPE : CLOSED
SIZE IN mm :100X65	IMPELLER NO. : C 20065/M

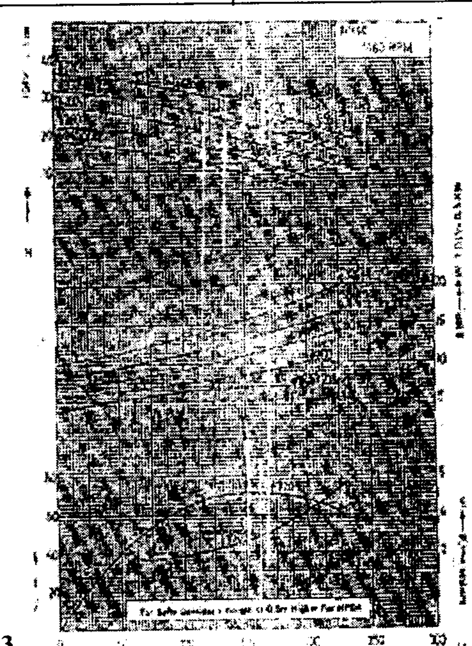

Fig. 3

Perfomance tested are based on water ov viscosity 1 cst., Specific gravity 1.			
CAPCITY	M³/hr	MOTOR RATING	HP
HEAD	Meter	MOTOR SPEED	1450 RPM
EFFICINCY	%	CURVE NO.	A 65-3 (M)

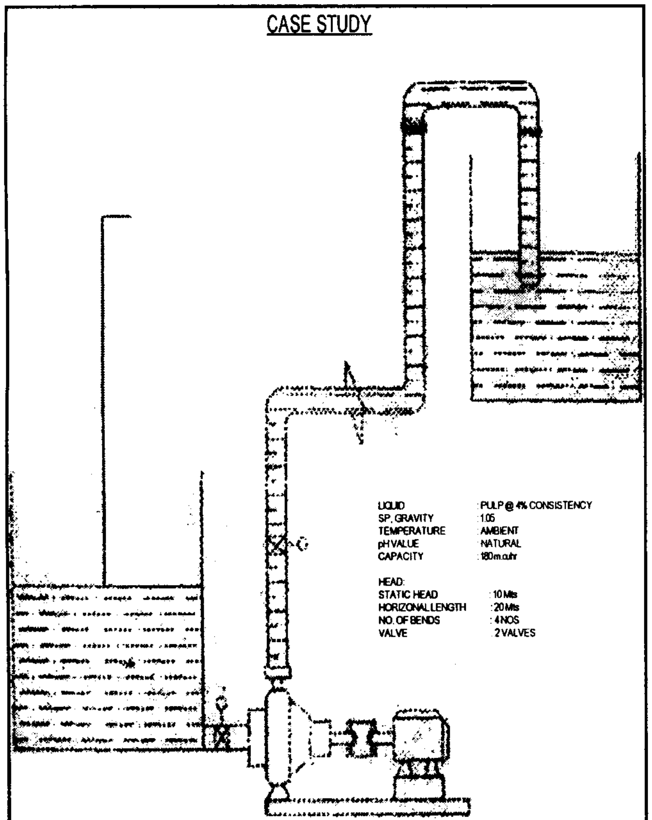

Fig. 4

After sales service

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Selection of suitable pumps and systems

Two case studies on "system selection" and "Pump selection" presenteded here.

Case Study 1

A new pump selection for a 50 tonnes Paper mill for handling pulp stock. Liquid: Pulp @ 4% consistency; Capacity: 150 cum/hr.

Head : Static head - 11 meters, Horizontal Length- 20 meters No. of bends 4 nos.: Valves: 2 nos.

Frictional loss study based on Hydraulic Institute Pulp friction table: 1 cum/hr.: 4.4 GPM: 150 cum/hr = 660 GPM

Step -1

Total Friction head : (Horizontal friction loss + Fitting loss)

Step - 2

Valve and fitting loss : K x $V^2/2g$

where K is the friction factor, $V^2/2g$ is the velocity of the travelling media.

Fitting loss: K:0.18, $V^2/2g$:0.81 = 0.14 per bend; (4x0.14=0.56 meters) A1.

Step-3

Flanged gate valve : k:0.1; $V^2/2g$:0.81 = 0.081 per valve (2 x 0.081) = 0.16 meters) A2. Total Fitting Loss: A1 + A2 i.e. = 0.72 meters.

Total Horizontal length: 20 meter travelling length + fitting loss.

Friction loss using 6" M.S. Pipe

Friction loss for 20 meters at 6" pipe: 35 meters per 100 meters : 20.72 x 35 / 100 = 7.2 meters.

Total Dynamic head: Static head + Friction head: 11 + 7.2 = 18.252 mts. Total head rounded of 20 meters.

Power Calculation and Selection of the Suitable Pump

Suitable pump selection curve enclosed, Pump model: APO 100/32@67% Efficiency

$$BKW = \frac{Q.\ H.\ Sg}{367,\ \eta}$$

$$\frac{150 \text{ cum/hr} \times 20 \text{ meters} \times 1.05 \text{ (Specific gravity)}}{367 \text{ (Constant)} \times 67\% \text{ (Efficiency)}}$$

BKW : 12.81 KW, HP = BKW/0.746, BHP: 17.7

Recommended Motor rating : 20 HP

Summary of 6" Pipe : Head - 20 meters; BHP : 17.7

Friction loss study for 8" Pipe for above parameter:

Fitting loss factor for fittings : K:0.15 meters.

Velocity $V^2/2g$: 0.27 meters, loss per bend : 0.16 meters.

Valve loss: K-0.08 mts.; Velocity: 0.27 Mts.: Valve loss : 002/meter 0.02 x 2 = 0.04 Mts.

Horizontal friction loss : 20 + 0.04 + 0.16 = 20.2 meters

Loss per 100 meters in 8" pipe size: 18 meters per 100 meters = 3.7 meters.

CASE STUDY 1 POWER AND INITIAL COST COMPARISION FOR CENTRIFUGAL, PUMP AND SYSTEMS

Sl. No.	Capacity cum/hr	Pipe size inches	Total Dynamic head in mts.	Pump type	Break Killo-watt	Fitings cost in Rs.	Pump cost Rs.	Power cost per year	Initial cost Rs.	Pay back period compared with
1.	150	6"	20	APO	12.81	14,250.00	35,000.00	4,48,350.00	49,250.00	
				100/32						1 & 2
2.	150	8"	15	APO	9.9	20,350.00	35,000.00	3,46,500.00	55,350.00	21 days
				100/32						1 & 3
3.	150	10"	14	APO	9.53	33,740.00	35,000.00	3,33,550.00	68,740.00	61days
				100/32						2 & 3
										353 days

Highlights:

Compared with 6" & 8" Pipes 8" pipes are saving 2.91 KW power & pay back with 21 days.

Hence 6" pipe is taken away from the recommendation compared with 8" & 10 pipes 10" pipe are saving only 37 KW power & Pay back period is almost 1 year. Hence it is prefered to choose 8" However it is purely customers choice wheather to choose 8" or 10"

CASE STUDY 2 POWER / INITIAL COST COMPARISION FOR CENTRIFUGAL, PUMP AND SYSTEMS

Sl. No.	Capacity cum/hr	Pipe size inches	Total Dynamic Head in mts.	Pump type	Efficiency in %	Brake Killo Watt	Fitting cost Rs.	Pump Unit Rs.	Power cost per year	Initial cost Rs.	Pay back period compared with
				Existing							
1.	60	4"	30	5"x3"	33%	14.92	N/A	N/A	5,22,200		Not
		existing									suitable
If new Generation pump is offered for the existing parameter											1 & 2
2.	60	4"	30	AEC	74%	6.62	N/A	40,000.00	2,3,700	40,000.00	86 days
				50/16							
Pump & system selection for 100 cum / hr											
3.	100	4"	51	AEC	76%	18.28	N/A	52,000.00	639800	52,000.00	N/A
				65/20							3 & 4
4.	100	6"	20	AEC	74%	7.36	1,30,075	30,000.00	2,57600	160075.00	100 days
				100/26							3 & 5
5.	100	8"	17	AFC	73%	6.34	1,86,505	30,000.00	2,21,900	216505.00	140 day
				100/26							4 & 5
											230 days

Highlights:

Sl. No. 1 & 2 are the comparision with the old version pump & version pump. By chanding the pump alone can save 8.32 KW. However the required flow is 100 cum/hr. Hence this option is dropped if the pump is used with the same system i.e. 4" size pipe then the TDH is 51 & BKW 18.28 where us customer requirement is to get 100 cum/hr. capacity with out in increasing the existing capacity or with the reduced power compares with the existing one.

6" & 8" are ideally suitable for the required parameter. On long run basis 8" pipe yield us maximum benefit, Hence 8" pipe is recommended.

Total Dynamic head : Static head + friction = 11 + 3.7 = 14.7 = 15 meters.

Selection of pump

Efficiency of pump: 65%; Pump model: APO 100/32

BKW : 150cum/hr x 15 meters x 1.05

367 x 65% : 9.9 BKW

BHP: 9.9/0/746 = 13.27 Recommended motor power: 15 HP

Summary of 8" Pipe selection:

Head: 15 meters; BKW : 9.90; BHP : 15 HP

Friction loss study for 10" Pipe for the above parameter:

Fitting loss: K - 0.14; $V^2/2g$: (0.1 : 0.14 x 0.1) : 0.14 per bend.

Total bend loss: 4 x 0.14 = 0.56 meters

Valve loss: K : 0.07; $V^2/2g$: 0.10 =0.07x0.1:0.007 meters

Horizontal Friction loss: 20 meters + (0.056 meters + 0.007) = 20.063 Mts. = 20.063 x 13/100 = 2.6 meters horizontal loss.

Total Dynamic head: 11 + 2.6 = 13.6 meters rounded off to : 14 meters

Selection of Pump

Pump Model : APP 100/32; Efficiency : 63%

BKW = 150 cum/hr x 14 meters x 1.05/367 x 63% = 9.53 KW = 12.78 HP Motor HP : 15/1450 RPM

Case Study 2

One of our customer asked us to find the solution for their pumping problem.

Problem: Cusotmer needs 100 cum/hr. Capacity discharge per hour. From the well water for their process requirements against which customer is getting 60 cum/hr. Details are given below:

Existing detail :	**Customer requirement**
Capacity : 60 cum/hr.	100 cum/hr

Pump head designed: 30 meters

Pump size : 5" x 3" (Old version pump)

Pipe size 4"

Head: Static head: 15 meters; Horizontal Length: 330 meters. No of bends: 4 Nos.; No. of valves: 2 nos.' Foot valve: 1 no. Exsisting pump efficiency estimates: 39%

Existing motor HP: 20HP/1450 RPM;

HEAD REQUIRED FOR PUMPING 100 cum/hr with 4" pipe:

Total Horizontal Length: 330 meters.

Fitting loss valve: K-023, $V^2/2g$: 1.91; Vl = 0.43 valve

Total valve loss: 4 x 0.43 = 1.72 = 0.52 meters.

Gate valve loss: K : 0.16 $V^2/2g$: 1.91; V2 = 0.3 = 0.9 meters,

Foot valve Loss: K: 0.8; $V^2/2g$: 0.667; V3= 0.53 meters.

V1 + V2 + V3 = 1.86; Total fitting loss: 1.86 Mts. Rounded off 2.0 mts.

Total Horizontal Length: 330 + 2 = 332.

Total friction head: 332 x 10.2 mts (Loss per 100 Mts.) = 40.5

Total Head: Static head + Friction head = 15 + 40.5 = 50.5 meters.

Rounded off: 51 meters

Suitable pump for 100 M^3/hr and the total head 51 meter if the pump is operated with the exsisting pipe system pump type: AEC-C-80/20: Size : 125x80: efficiency: 70% BHP: 26.6, Motor rating: 30 HP/1450 RPM.

Friction loss study for 6 "pipe for the above parameter:

Fitting loss: No. of bends: 4; K:0.18; $V^2/2g$: 0.371 = 0.18 x 0.371 = 0.06 per bend Total bends loss: V1 : 4 x 0.06 = 0.26 meters.

Valve loss: K: 0.1, $V^2/2g$: 0.371; V2:2x0.037 = 0.074 meters.

Foot valve: K: 0.8; $V^2/2g$: 0.0371; V3: 0.29 meters

V1 + V2 + V3 = 0.624 meters.

Horizontal length: 330 + 0.624 = 330.62

Horizontal frictional loss for 6" pipe: 1.31 meters/100 meters. Total Friction head: 331: 1.31x100 = 4.33 mts.

TDH = Static head + Friction head = 15 + 4.3 = 19.33 Rounded off: 20 meters.

Suitable pump selection:

Pump type: AEC = C - 100/26; efficiency: 74%; BHP: 9.87 HP Recommended motor: 12.5 HP/1450 rpm.

Friction loss study for 8" Pipe for the above parameter:

Fitting loss: No. of bends: 4; K: 0.15: $V^2/2g$: 0.129 = 0.15 x 0.129 = 0.019 per bend; Total bend loss: V1 : 4 x 0.019 = 0.077 meters

Valve Loss: K: 0.08 x 0.129 : V2 0.010 x 2 = 0.020 meters

Foot valve: K: 0.8 x 0.129 = V3 0.10 meters

V1 + V2 + V3 = 0.019 meters.

Horizontal length:330+0.019=330.19

Horizontal firctional loss for 8" pipe: 0.34 meters/100 meters.

Total friction head: 331 ×1.31/100 = 1.12 mts.

TDH = Static head + Friction head = 15 + 1.12 = 16.12 rounded off: 17 meters.

Suitable Pump Selection:

Pump type : AEC - C -100/26; Efficiency: 73%; BHP: 8.5 HP

Recommended motor : 10 HP/1450 RPM:

From above case study it is clearly seen that the old version pumps consume high power and the new version pumps largely save power and mechanical reliability is also comparably improved. From the pump aspect it is observed that minimum 30% power can be saved compared to old pumps. If the pipe line selection is also perfect, then on long run the user can save power cost by 50 to 60% from the present power bill.

CONCLUSION

Selection of pipes, fittings and other present losses (pumping liquid passing through Pressure equipment like Boiler, Refiner, Turbo seperator, Digestor) must be calculated while deciding the TDH. Friction head should be reduced as to bare minimum as possible. Selection of high efficiency pumps based on the operating duty is the critical point for energy saving. Detailed dialogue by the pump user with manufacturer, during selection of pump will yield best result. There is scope of conserving energy by minimum 40% in the existing system by reducing the friction head and by changing the old pumps with high efficiency digital age pumps. From our various analysis by adopting the above, a 30 tonnes paper mill can save 50 to 60 units/hour only on pumps. In terms of value it is Rs. 18 lacs.

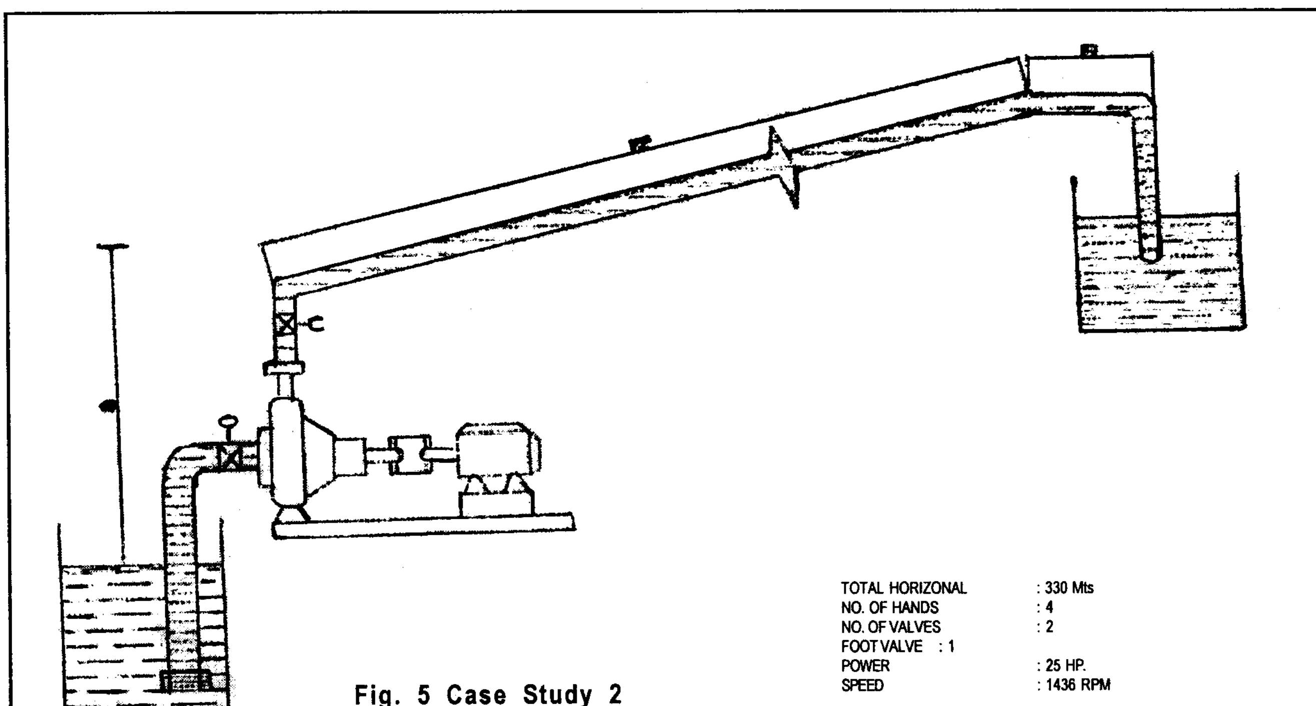

Fig. 5 Case Study 2