"Design Criteria of Lift Irrigation Scheme"

Kiran M. Jadhav*, Dr. S.P.Chavan 2

[1]Mr.K.M.Jadhav (M.Tech design Engineering ,Deputy Engineer, water Resources Department, Gov. of Maharashtra, India.

[2]Dr.S.P.Chavan, Professor Department of Mechanical Engineering, Walchand College of Engineering, Sangli, India

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***Abstract**: Irrigation is an essential part of farming. Maharashtra government try to develop best irrigation network for irrigation of all region. But with the help of Gravity fed Canal network it is not possible to provide irrigation at remote area. In now days Lift Irrigation Scheme (LIS) plays an vital role for irrigation of this remote area. In LIS water has lifted from source i.e. Dam, lake or river to the delivery chamber with the help of pumps and distributed to all command area with canal network. The success of LIS is mainly depend on accurate planning, designing and selection of pumping equipment's. For designing of any LIS , design and selection of pump , R.L. of bottom of sump, R.L. of M.D.D.L. in the sump , P.O.L, Static Head , Diameter of rising main etc. all these parameters should be considered . In this paper we will get clear idea about design of Lift Irrigation Scheme (LIS) and clear idea about what care should be take while designing of LIS.*

***Key Words**: LIS, M.D.D.L, P.O.L , Pump*

1. Introduction

Lift Irrigation scheme is used for supply of water to remote area where gravity fed canal network is not work. In LIS pumping stations are used to lift the water to appropriate height with required pressure. In the pumping stations Pump plays a vital role. Pump is 'heart' of all system as it converts mechanical energy to hydraulic energy. For proper working of LIS with high efficiency utmost care must be taken while planning, selecting & designing of pumping equipments & accessories. The following points must be considered to develop a new LIS.[1]

i) Selection of Pumps. ii) Intake Design iii) Layout of the pump house. iv) Selection of valves v) Selection of motors vi) Selection of Starters vii) Selection of capacitors viii) Selection of Control Panel ix) Selection of HT cables x) Selection of auxiliary transformers xi) Delivery pipe & Rising main.

2. Selection of Pumps:

The basic data required for the selection of pump for LIS is collected from civil wing. They provide this data as per actual site condition. Basic Data required for Calculation of Pump Parameters:

2.1 Discharge:

i) Maximum discharge required ii) Minimum discharge required

2.2 Various Control Levels:

i) Normal Water Level ii) MDDL (Minimum Draw Down Level)

iii) Maximum Water Level iv) High Flood Level

v) Discharge Point level vi) Sump Floor level

vii) Motor floor level viii) Valve floor level

2.3 Rising main

i) Rising main Diameter and Thickness ii) Rising main Length

1) Following tabel gives the selection of pumps according to the use of application and according to various duties:

Table 1.1: Selection of Pump for LIS

Sr No.	Pump Type	Suction Capacity to lift			Head - Range			Discharge Range		
		Low 3.5 m	Medium 6m	High 8.5 m	Low 10 m	Medium 10 to 40 m	High above 40 m	Low 30 (L/s)	Medium up to 500 L/s	High above 500 L/s
1.	Centrifugal End Suction	Ok	Ok	Ok	Ok	No	Ok	Ok	Ok	Ok
2.	Centrifugal Horizontal End Axial Split Casing	Ok	No	No	Ok	Ok	No	No	Ok	Ok

3.	Centrifugal Horizantal Multistage	Ok	Ok	No	No	Ok	Ok	Ok	Ok	No
4.	Centrifugal Vertical Turbine	When suction lift is to be avoided			Ok	Ok	Ok	Ok	Ok	Ok
5.	Centrifugal Vertical Submersible	When suction lift is to be avoided			Ok	Ok	Ok	Ok	Ok	Ok

3. Pump Parameters Calculations

3.1 Determination of Pump Horse Power

$$P = \frac{W*Q*H}{75*\text{Pump Efficiency}} \quad \text{............ (Eq. 1)}$$

Where , P = Horse power required to drive the pump

Q = Discharge per pump m^3/ Hr

H = Total head in meters

W = Specific Weight of liquid for water 1000 Kg/ m^3

As the pump efficiency for centrifugal pump is found optimum in the range of 2000-3000 US units [1]

3.2 Determination of Total Head

Total Head = Static Head + Dynamic Head in MWC

Dynamic Head = Frictional Head + Velocity Head

a) Static Head = Discharge Level – Pump operating Level or Normal Water Level

Assumption to calculate static head – i) Discharge level is centreline of rising main at delivery point .

ii) Pump Operating Level (POL) = MDDL + (2/3)(FRL – MDDL) .... (Eq. 2)

where – MDDL = Minimum draw down level

FRL = Full Reservoir level in pump sump

3.3 Determination of Dynamic Head

In Dynamic Head Loss includes Frictional and Velocity Head loss

a) Frictional Head Loss:

When Fluid is flowing through pipelines there is friction occurs between the fluid and walls of the pipe line and some head loss occurs is called frictional head loss.

To calculate frictional head loss in rising main modified Hazen's Williams formula is used [3]

Hf1 = L x (Q/ Cr)1.81 / 994.2 (D)4.81 .... (Eq.3)

Hf1 = frictional Head Loss in Rising main

L = Length of rising main in meters

Q = Discharge in m^3/sec

Cr = Pipe roughness coefficient

D = Pipe dia in Meter

b) Head Loss due to Bends and Valves in rising main –HF2 [4]

Hf2 =(K n V^2 / 2g) in MWC .... (Eq. 4)

Where ,

n = No of valves or bends

V = Velocity in rising main in m/s

g = gravitational acceleration = 9.81 3/s^2

K = Constant

c) Velocity Head Loss (Hf3)

Hf3=(V^2 / 2g) MWC .... (Eq. 5)

Where,

Hf3 = Velocity head loss at Exit MWC

V = Velocity in rising main m/s

g = gravitational acceleration = 9.81 3/s^2

3.4 NPSHA calculation :

NPSHA stands for Net Positive Suction Head. To avoid cavitation at the inlet of the pump, pump system has to be designed such that pump suction will have adequate energy. This energy made available from atmospheric pressure and water head available on pump suction side. NPSHA is calculated as below-

NPSHA @ NWL = (Patm –Pvap +- Submergence ....(Eq. 6)

= (Patm –Pvap +- (NWL – SBL –Impeller eye clearance in MWC)

NPSHA @ MDDL = = (Patm –Pvap) +- Submergence

= (Patm –Pvap) +- (MDDL – SBL –Impeller eye clearance in MWC)

Where, Patm = atmospheric pressure

Pvap =Vapour Pressure

Impeller Eye Clearance = 2D (D = Bell mouth Dia. in m)

To avoid the cavitation at suction of pump NPSHA must be greater than NPSHR(Net Positive Suction Head Required) [1]

3.5 Thoma's Cavitation Parameter:

If the pressure at any point inside the pup drops below the vapour pressure of the liquid at correspondent temp. the liquid starts vaporises and vapour bubbles forms. These cavities or vapour bubbles carried out inside the impeller, as cavities may collapse with tremendous impact on side wall of the pump. This phenomenon called cavitation. This causes Noise and Vibration inside the pump. The Scientist named Thoma developed a equation to predict Cavitation. [2]

i) Thoma Available

a) Thoma available @ NWL = (NPSHA @ NWL / Total head per stage)

b) Thoma available @ MDDL = (NPSHA @ MDDL / Total head per stage)

ii) Thoma Critical

ThomaCritical =6.3x10^-6(Nq)^4/3 …………… (Eq. 7)

Where , Nq = Pump Specific Speed in US units

To avoid cavitation inside the pump Thoma available must be greater than Thoma Critical.

3.5 Pump Specific Speed

Specipic Speed of a pump in US unit is speed of geometrically similar pump which delever 1 gallon of water per minute through head of 1 feet.

$$Nq = \frac{N\sqrt{Q}}{H3^{3/4}} \quad \text{……………… ………………………… (Eq. 8)}$$

Nq = Pump Specific Speed in US unit

N = Shaft RPM

Q = Discharge of Pump gallons/min. (for double suction take Q/2)

Suction Specific Speed (Ns)

$$Ns = \frac{N\sqrt{Q}}{NPSHA3^{3/4}} \quad \text{…………………………… (Eq. 9)}$$

N= Shaft RPM (Slip RPM)

Q = Discharge of pump in gallon / min.

4 . Pump Design

4.1 Design of Bell Mouth

Bell mouth id fitted below the pump impeller to have streamline flow to the pump and to avoid separation of flow with minimum loss. [3]

D = Diameter of bell mouth calculated as below

$$D = \sqrt{\frac{1.27*Q}{V}} \quad \text{……………… ………………………… (Eq. 10)}$$

Where,

Q= Pump discharge in m^3 / sec

D= Bell mouth diameter in meter

V = Velocity at bell mouth (i.e. 1.5 m/sec as per water supply manual)

4.2 Design of Column Pipe Diammeter

Column pipe is pipe through which liquid goes up . For V.T Pump

Q = ($\pi/4$)x [(Dc)^2-(Do)^2] x V ………………………..(Eq. 11)

Where ,

Dc = Inside dia of column pipe

Do= Outside dia of shaft enclosing tube in meter

V= Velocity in m/sec i. e. upto 2 m/sec

4.3 Design of Column Pipe Thickness

Colum pipe will work as a closed pressure vessel at shut off head, hence thickness of column pipe designed considering column pipe as a closed pressure vessel .

$$Tc = \frac{P*Dc}{200*F*j-P} + c \quad \text{……………… ……………………….. (Eq. 12)}$$

P = Design Pressure in column pipe kg / cm^2

Pdesign = (1.5 x Shutt of head in MWC / 10) Kg/cm^2

Dc = Inside Dia of column pipe in mm

F = Allowable safe stress for column pipe material in kg / mm^2

J = Welding factor 0.7

C = corrosion allowance Kept 1.5mm

4.3 Design of Delevery Pipe Diameter (Dd)

Q = $(\pi/4)$ x (Dd)^2 x V ………………. …………. (Eq. 13)

V = Velocity in delivery pipe in m/sec. should be below 2.5 m/sec

4.3 Design of line shaft Diameter

Line shaft connects the head shaft of motor to the impeller shaft of the pump.

Td = $\frac{F*N*Dl^3}{5.01*10^8}$ + C ……………………..(Eq. 14)

Where ,

P= Motor power in Kw

N = Shaft RPM (Slip RPM)

F = Shaft stress of line shaft material kg/ cm^2

Dl = Diameter of line shaft

C= Corrosion allowance (kept 3 to 4 mm)

LIS Pump House Photo

5. Conclusion:

From above case study we can concluded that while design of a LIS there is need to be take care of so many parameters. Selection and design of pump is main part in LIS. While selection and design of pump for LIS following conditions must be full filled.

i) When online boosting is to be done then horizontal split case centrifugal pumps are used.

ii) When there is large variations in suction level Vertical Turbine pumps are selected. VT pump requires less floor space and Compact design.

iii) Pump Specific Speed should be in range 2000-3000 US units for maximum pump efficiency.

iv)Suction Specific speed should be less than 8500 US units for given specific speed.

v) NPSHA should be greater than NPSHR to avoid cavitation. NPSHA is at least 0.5 MWC higher than NPSHR.

vi)To avoid cavitation Thoma available must be greater than Thoma Critical. Thoma available depends on site conditions and Thoma critical depends on Pump design and Pump Specifc speed. So while designing of pump this criteria must be full filled.

vii) Velocity at bell mouth must be less than 1.5 m/sec.

vii) Velocity in the delivery pipe must be less than 2.5 m/sec.

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BIOGRAPHIES

Mr. K.M. Jadhav,(M. Tech Design Engineering) working as a Deputy Engineer, Water Resources Department Government of Maharashtra.