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DESIGN - DEVELOPEMENT OF HYDRAULIC SCHEME FOR AUTO OPERATION OF MIV FOR HYDRO TURBINE

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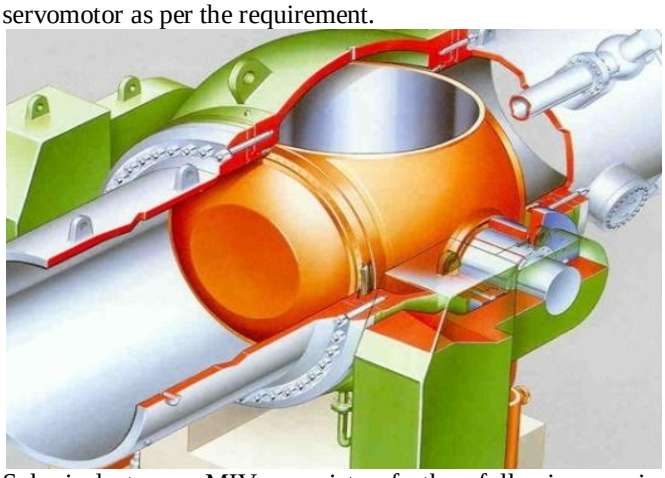
Abstract: In the Francis & Pelton type turbine, a main inlet valve is provided before the turbine for the safety & maintenance purpose of the machine. Depend on the water head acting on the turbine main inlet valve are of two types: Butterfly type & Spherical type. For running the machine, main inlet valve is to be opened as per its operating procedure i.e. sequence of opening & closing. After opening the MIV, flow of water is further controlled by the G.V. to rotate the turbine at desired speed & also to control the load of the machine. Spherical type Main inlet valve consist the various components like Bypass Valve, Maintenance Seal, Service seal Spherical Valve. For opening the MIV, first bypass valve is to be opened. After opening the MIV, water start filling in the downward direction & the pressure of the downstream become almost equal to the upstream pressure. After equalization of upstream & downstream pressure, maintenance seal is opened and then service seal is opened. After opening the service seal, main inlet valve is opened. After opening the main inlet valve bypass valve is closed. In the closing sequence of MIV, first MIV will be closed after that maintenance seal & service seal is closed. MIV can be operated in auto mode as well as in manual mode also. For the auto operation of MIV an electrical control panel is provided for opening /closing the MIV as per the above sequence of operation by receiving the single pulse command of opening or closing. For opening and closing in manual mode an operator has to press the plunger of respective valve in the above sequence of operation.
In this dissertation, an attempt is made to design a hydraulic scheme by which auto operation of MIV is possible in auto mode as well as in manual mode i.e. in manual mode also only by pressing a single plunger whole sequence of operation of MIV opening & closing is followed. New developed hydraulic scheme is verified theoretically & found that it is meeting the above requirements & also energy consumption is very less

I. INTRODUCTION

Main inlet valve (MIV) works as the isolating valve in the water conductor system. It is located before turbine and allows water flow from penstock to turbine. MIV is used as a safety device in the hydropower plant. MIV acts as closing valve and cuts the flow of water during an emergency trip. MIV is also used for maintenance purpose of the turbine. Inlet valve is of two types:

a) Butterfly type (up to 200m Head)
b) Spherical type (More than 200m Head)

Normally the opening of the valve takes place when the pressure on the either side is equal or differs insignificantly. The equalization of water pressure is brought by filling the spiral casing through solenoid operated by pass valve. Normally the trunnion of MIV is connected to two or single double acting cylinder (Servomotor).For the operation of these servomotors, high pressurized oil is applied either in the opening chamber or in the closing chamber of servomotor as per the requirement.



Spherical types MIV consist of the following main components:

a) Maintenance seal
b) Service seal
c) Bypass valve
d) Spherical valve

For the auto operation of the main inlet valve following components are required:

a) Pressure pumping set.
b) Pressure receiver or piston accumulator
c) Solenoid operated DCV for the Bypass valve
d) Solenoid operated DCV for maintenance seal.
e) Solenoid operated DCV for service seal.
f) Solenoid operated DCV for Main inlet valve.
g) Differential Pressure switch across the spherical valve
h)Pressure gauge before MIV i.e. upstream side.
i) Pressure gauge after MIV i.e. downstream side.
j) Hermetically sealed/Proximity type limit switch used for the position feedback of Bypass valve, maintenance seal, service seal, Main inlet valve.

MIV electrical control panel: For the auto & safe operation of the main inlet valve, above instrument of high quality should be used. Also a reliable source of oil pressure unit is required to operate the MIV servomotor, Bypass valve, service seal, and maintenance seal. For the sequential operation (Normal opening, Normal closing & emergency

closing) of MIV a reliable electrical control panel or some hydraulically operated reliable system is required.

Normal opening sequence of MIV is as follow:
a)Upon receiving the open command from the SCADA, first Bypass valve opens & water start filling in the downstream side i.e. spiral casing/distributor.
b) When downstream pressure become more than or equal to 80 % of upstream a differential pressure contact operates.
c) Using the pressure switch contact, opening command energizes the respective solenoid of maintenance seal & service seal to disengage from the MIV in the same sequence.
d) After opening the maintenance seal & service seal, the Main inlet opens fully.
e) After fully open of MIV, bypass valve is closed & then hydro machine can be start for power generation.

Normal closing or Emergency closing sequence of MIV is as follow:
Upon receiving the normal closing command or emergency closing command, first MIV is closed.
After fully closed of MIV, then maintenance seal & service seal is closed.

II. INPUT DATA

DATA REQUIRED FOR CALCULATION OF ENERGY CONSUMPTION IN BOTH THE CASES I.E. AUTO OPERATION OF MIV THROUGH ELECTRICAL CONTROL PANEL & AUTO OPERATION OF MIV THROUGH HYDRAULICALLY OPERATED OR ROLLER OPERATED DIRECTION CONTROL VALVE.

EXISTING MIV HYDRAULIC CONTROL PANEL DATA

S.No.	Description of Items	Capacity	Quantity
1.	Solenoid operated valve for MIV	Size NG32, coil voltage : 220 VDC Solenoid rating: 26 W Leakage: 2 CM^3/MIN	1 No. Valve 2Nos. solenoid
2.	Solenoid operated valve for Bypass valve	Size NG6, coil voltage : 220 VDC Solenoid rating: 26 W Leakage: 0.5 CM^3/MIN	1 No. Valve 2Nos. solenoid
3.	Solenoid operated valve for maintenance seal	Size NG6, coil voltage : 220 VDC Solenoid rating: 26 W Leakage: 0.5 CM^3/MIN	1 No. Valve 2Nos. solenoid
4.	Solenoid operated valve for service seal	Size NG6, coil voltage : 220 VDC Solenoid rating: 26 W Leakage: 0.5CM^3/MIN	1 No. Valve 2Nos. solenoid
5.	Duplex filter	200 LPM at 0.5 Bar	1 No.
6.	LED Light	10 W	2 Nos.

EXISTING MIV ELECTRICAL CONTROL PANEL DETAIL

S.No.	Description of Items	Capacity	Quantity (Nos.)
1.	Supply monitoring relay	220VDC, 3 NO+ 2NC Power consumption =10W	1
2.	DC-DC converter	220VDC to 24VDC Power consumption= 5 W	1
3.	Auxiliary contactor	220VDC, 4 NO+ 2NC Power consumption= =10W	10
4.	Auxiliary contactor	220VDC, 6 NO+ 2NC Power consumption= =10W	14
5.	Auxiliary contactor	220VDC, 4 NO+ 4NC Power consumption= =10W	26
6.	Timer	220VDC ON Delay, 0-60Sec, 2NO+2NC Power consumption= =4W	7
10.	Timer	220VDC ON Delay, 0-60Min, 2NO+2NC Power consumption= 4 W	1
11.	Miniature circuit breaker	5A, DP, 220VDC Power consumption= = 10W	1
12.	Miniature circuit breaker	10A, DP, 220VDC Power consumption= = 10W	1
13.	Miniature circuit breaker	10A, SP, 220VDC Power consumption= = 10W	2
14.	Space Heater	240 VAC , Power consumption= 60W	1
15.	Panel illumination lamp	5 W	2 Nos.

STATUS OF AUXILLARY RELAY OF MIV ECP.

S.No.	Description of Items	Active during open position of MIV	Active during open position of MIV
1.	Auxiliary contractor BV-1	NO	YES
2.	Auxiliary contractor SS-2	NO	YES
3.	Auxiliary contractor SS-1	NO	YES
4.	Auxiliary contractor MIV2	NO	YES
5.	Auxiliary contractor MIV1	YES	NO
6.	Auxiliary contractor	NO	YES

	PNS-1X		
7.	Auxiliary contractor LSSSC-1X	NO	YES
8.	Auxiliary contractor LSSSC-2X	NO	YES
9.	Auxiliary contractor LSSS0-1X	YES	NO
10.	Auxiliary contractor LSMSC-X	NO	YES
11.	Auxiliary contractor GVCX	NO	YES
12.	Auxiliary contractor PS1-1X	YES	YES
13.	Auxiliary contractor EC1	NO	NO
14.	Auxiliary contractor EC2	NO	NO
15.	Auxiliary contractor MIV-2X	NO	NO
16.	Auxiliary contractor MIV-1X	NO	NO
17.	Auxiliary contractor LSBPC-1X	YES	YES
18.	Auxiliary contractor LSBPO-1X	NO	NO
19.	Auxiliary contractor LSMIVC-1X	NO	YES
20.	Auxiliary contractor LSMIVC-2X	NO	YES
21.	Auxiliary contractor LSMIVO-1X	YES	NO
22.	Auxiliary contractor LSMSO-X	YES	NO
23.	Auxiliary contractor PS2-2X	YES	NO
24.	Auxiliary contractor MIVSOUPS-1X	YES	YES
25.	Auxiliary contractor MIVOPUS-1AX	YES	YES
26.	Auxiliary contractor MIVOPUS-1AX	YES	YES

MACHINE AVAILABILITY DETAIL FOR ONE YEAR

S.No.	Description	Detail
1.	Machine run continuously	3 months (Rainy season)
2.	Machine run12-15 Hour per day	4 months (winter season)
3.	Machine run max 6 Hour per day	4 months (Summer season)
4.	Machine under maintenance	One month

From the above data MIV will be open for 4320 Hr. (approx.) in a year & MIV will remain in closed position for 3600 Hr. (approx.) & there will be no supply & oil pressure for 720 Hr. (approx.)

III. DESIGN & ANALYSIS OF NEW HYDRAULIC SCHEME FOR AUTO OPERATION OF MIV BY ELECTRICALLY & MANUALLY

AUTO OPERATION PHILOSOPHY OF MIV

Opening sequence: First bypass valve to be open, After opening the bypass valve, water from upstream flows towards downstream & pressure in downstream become almost equal to upstream pressure due to this pressure switch operate. After equalization of upstream & downstream pressure, maintenance seal opens. After opening of maintenance, service seal opens. After opening of service seal, MIV opens fully. After fully opening of MIV, bypass valve closed.

Closing sequence: First MIV closes fully, Service seal & maintenance seal closed.

The auto operation i.e. open, close & emergency close of MIV is carried out through hydraulic control panel under the supervision of electrical control panel. Presently for the auto operation of MIV through MIV electrical control panel following items are required: Solenoid operated direction control valve for Bypass valve, Solenoid operated direction control valve for maintenance seal, Solenoid operated direction control valve for service seal, Solenoid operated direction control valve for MIV through servomotor, Proximity/Hermetically sealed limit switch for the open/close position feedback of bypass valve. Proximity/Hermetically sealed limit switch for the engage/disengage position feedback of maintenance seal & service seal. Proximity/Hermetically sealed limit switch for the open/close position feedback of MIV

Differential pressure switches across MIV.

Various electrical equipment: Auxiliary relay, timer, Miniature circuit breaker, push button, indicating lamp, illumination lamp, space heater.

In new design hydraulic scheme, the above said items is to be replaced by the different types of hydraulically operated

direction control valve like 4 way 2 position detent type valve, 2way 2position detent type valve, 4 way 2 position roller operated spring off set direction control valve. Differential pressure switch will be replaced by the spring operated plunger which is used to operate the roller operated direction control valve. While replacing the electrical component by the suitable hydraulic or roller operated direction control valve, opening & closing auto sequence operation of MIV must be performed without any hindrance.

New design hydraulic scheme shown in figure-1consist the following items for the auto operation of MIV.

a) Solenoid operated direction control valve (Device no. SOV) for receiving open & close command from auto sequencer.

b) Hydraulic operated direction control valve (Device no. BPV)

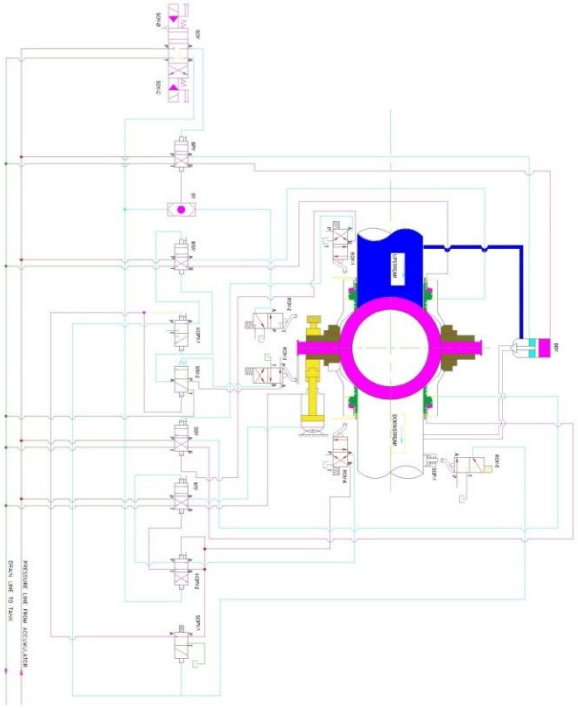


FIGURE-1 for opening & closing the bypass valve.

c) Hydraulic operated direction control valve (Device no. MSV) for opening & closing the maintenance seal.

d) Shuttle valve (Device no. SV)

e) Hydraulic operated direction control valve (Device no. HOPV-1) for blocking the line and also to set reset the other hydraulically operated valve as per the scheme.

f) Hydraulic operated direction control valve (Device no. SSV-2) for blocking the line and also to set reset the other hydraulically operated valve as per the scheme.

g) Hydraulic operated direction control valve (Device no. SSV) for opening & closing the service seal.

h) Hydraulic operated direction control valve (Device no. MIVV) for opening & closing the MIV valve.

i) Hydraulic operated direction control valve (Device no. HOPV-2) for blocking the line and also to set reset the other hydraulically operated valve as per the scheme.

j) Hydraulic operated cum spring reset direction control valve (Device no. SOPV-1) for blocking the line and also to set reset the other hydraulically operated valve as per the scheme.

k) Spring operated plunger (Device no. SOP-1) operated when the water pressure is greater than the setting of spring.

l) Roller operated cum spring reset direction control valve (Device no. ROV-1) is used for detecting the position of maintenance seal, when it operated it will further allow next item to operate as per hydraulic scheme.

m) Roller operated cum spring reset direction control valve (Device no. ROV-2) is used for detecting the open position of MIV, when it operated it will further allow next item to operate as per hydraulic scheme.

n) Roller operated cum spring reset direction control valve (Device no. ROV-3) is used for detecting the close position of MIV, when it operated it will further allow next item to operate as per hydraulic scheme.

o) Roller operated cum spring reset direction control valve (Device no. ROV-4) is used for detecting the position of service seal, when it operated it will further allow next item to operate as per hydraulic scheme.

p) Roller operated cum spring reset direction control valve (Device no. ROV-5) is used for detecting the position of spring operated plunger, when it operated it will further allow next item to operate as per hydraulic scheme.

q) Red line indicates pressure line.

r) Green line indicates drain.

s) Magenta &cyan color indicates control line.

In the figure-1, position of different valve is as follow:

Position of valve (Device no. SOV): As there is no command, valve is in it mid position. In this position, port 'A'&'B' is connected to port 'T' & port 'P' is blocked.

Position of Valve (Device no. BPV): In this position, Port 'A' is connect to port 'T' & port 'B' is connected to port 'P' due to this bypass valve is in closed position.

Position of Valve (Device no. MSV): In this position, Port 'A' is connect to port 'T' & port 'B' is connected to port 'P' due to this maintenance seal is in closed position.

Position of Valve (Device no. SSV): In this position, Port 'A' is connect to port 'T' & port 'B' is connected to port 'P' due to this service seal is in closed position.

Position of Valve (Device no. MIV): In this position, Port 'A' is connect to port 'T' & port 'B' is connected to port 'P' due to this main inlet valve is in closed position.

Position of Valve (Device no. ROV-1): As the maintenance seal is closed , this valve is not operated therefore , Port 'A' is connect to port 'T' & port 'B' is connected to port 'P'.

Position of Valve (Device no. ROV-2): As the MIV is closed, this valve is not operated therefore, and Port 'A is connect to port T' & port 'P' is blocked.

Position of Valve (Device no. ROV-3): As the MIV is closed, this valve is operated therefore, Port 'A' is connect to port 'P & port 'B' is connected to port 'T'.

Position of Valve (Device no. ROV-4): As the service seal is closed, this valve is not operated therefore, Port 'A' is connect to port 'T & port 'B' is connected to port 'P'.

Position of Valve (Device no. ROV-5): As the service seal is closed, this valve is not operated therefore, Port 'A' is connect to port 'T & port 'P' is blocked.

IV. VALIDATING THE AUTO OPENING SEQUENCE OF MIV THROUGH THE NEW HYDRAULIC SCHEME BY ELECTRICALLY

BYPASS VALVE OPENING (FIRST STEP)

Opening command (220 VDC supply for 15 seconds) received from the auto sequencer. Refer the figure-2 which shows that when opening command received from the auto sequencer, the solenoid (SOV-Ø) of valve (SOV) will operate. When solenoid (SOV-Ø) of valve (SOV) is operated, the port 'P' will connect to port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to opening hydraulic port of the BPV through valve (SOV) as shown in the above scheme. The pressurized line will shift the spool of the valve (BPV) due to which port 'P' will connect to port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to the opening chamber of bypass valve through valve (BPV) and open the bypass valve and simultaneously closing port will be connect to drain. Now the water will start filling in downstream of MIV

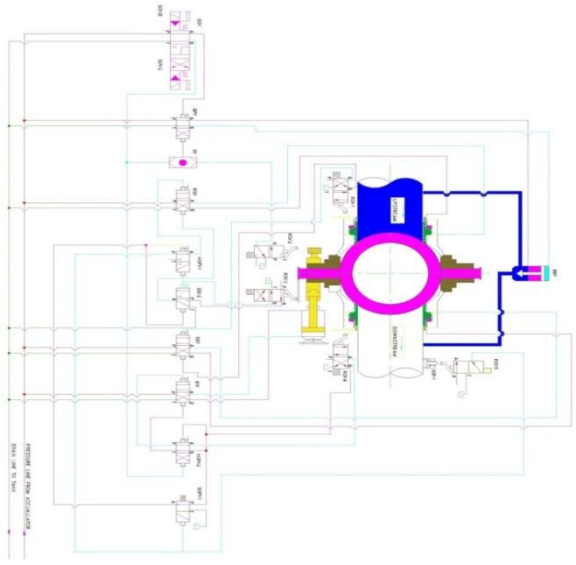


FIGURE 2: BYPASS VALVE OPENING

(i.e. in spiral casing of Francis turbine or in distributor of Pelton turbine) as shown in the scheme by dark blue color. After 15 sec of receiving the command , spool of valve (SOV) will shift in to the center due to which port 'A' & 'B' will connect to port 'T' and port 'P' will be blocked

MAINTENANCE SEAL OPENING (SECOND STEP)

Refer the figure-3 in which when the downstream pressure become almost equal to upstream pressure, the spring operated plunger will move in the upward direction & operate the roller operated spring return valve (Device no. ROV-5) due which the port 'P' will connect to the port 'A' & port 'T' will be blocked. Now the pressure line will connect to opening hydraulic port of the maintenance seal valve (MSV) through valve (ROV-5) & valve (HOPV-1) as shown in the above scheme. The pressurized line will shift the spool of the valve (MSV) due to which port 'P' will connect to port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to the opening chamber of maintenance seal through valve (MSV) & simultaneously closing chamber will be connect to drain due to which maintenance seal will open.

SERVICE SEAL OPENING (THIRD STEP)

Refer the figure-4 in which when the maintenance seal is fully opened , the plunger coming out with the maintenance seal will operate the roller operated spring return valve (ROV-1) due which the port 'P' will connect to the port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to opening hydraulic port of the service seal valve (SSV) through valve (ROV-1) as shown in the above scheme. The pressurized line will shift the spool of the valve (SSV) due to which port 'P' will connect to port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to the opening chamber of service seal through valve (SSV) & simultaneously closing chamber will be connect to drain due to which service seal will open

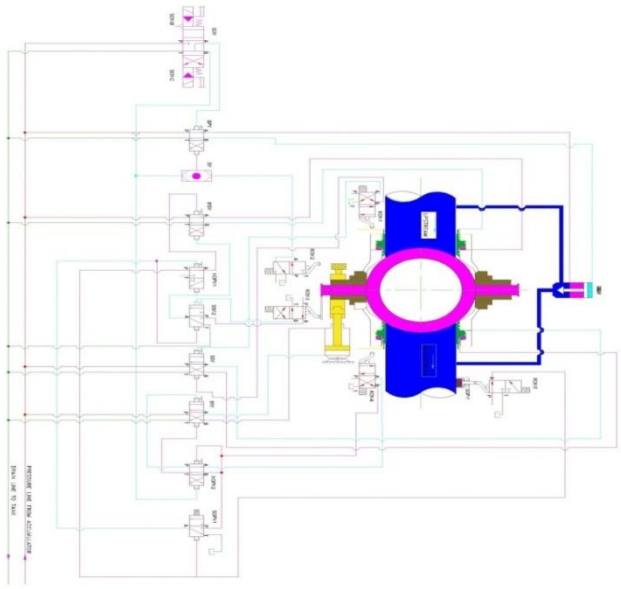


FIGURE 3: MAINTENANCE SEAL OPENING

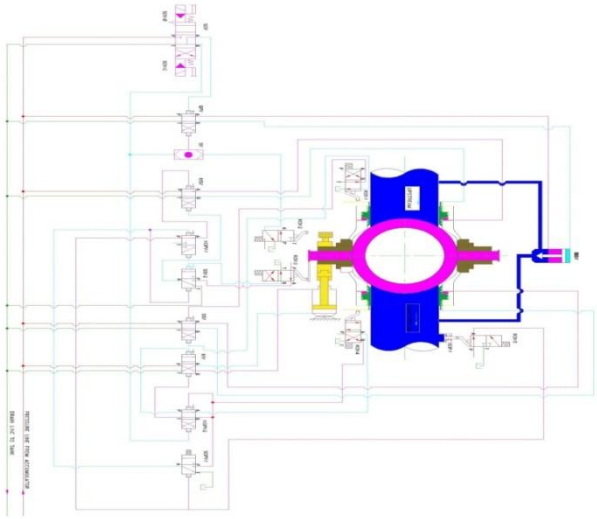


FIGURE 4: SERVICE SEAL OPENING

MIV OPENING (FORTH STEP)

Refer the figure-5 in which when the service seal is fully opened , the plunger coming out with the service seal will operate the roller operated spring return valve (ROV-4) due which the port 'P' will Connect to the port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to opening hydraulic port of the main inlet valve (MIV) through valve (ROV-4) & valve (HOPV-) as shown in the above scheme. The pressurized line will shift the spool of the valve (MIV) due to which port 'P' will connect to port 'A' & port 'B'

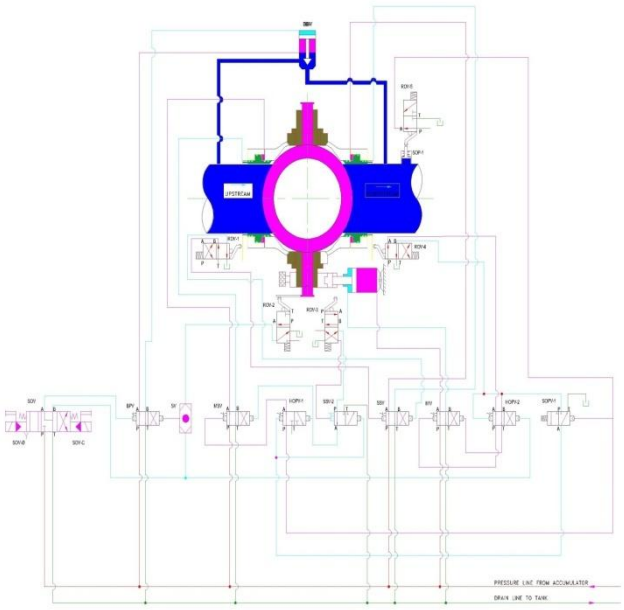


FIGURE 5: MIV OPENING

will connect to port 'T'. Now the pressure line will connect to the opening chamber of MIV double acting cylinder & simultaneously closing chamber will be connect to drain due to this which MIV will open.

BYPASS VALVE CLOSED (FIFTH STEP)

Refer the figure-6 in which when the MIV starts opening, the roller operated spring return valve (ROV-3) will become free & return to its original position because of spring. Now due to this the port 'P'

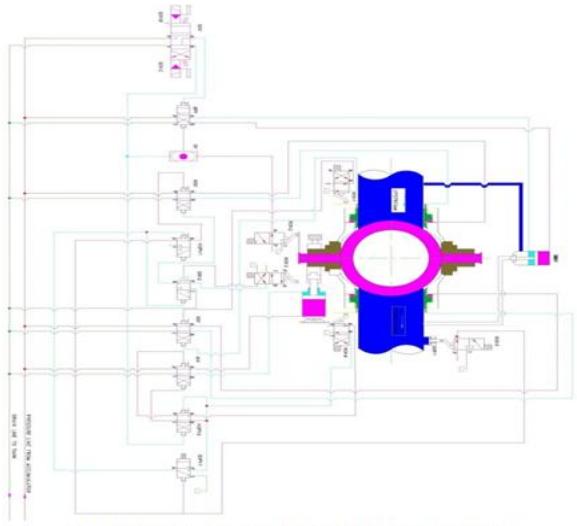


FIGURE 6: BYPASS VALVE CLOSED

will connect to the port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to the hydraulic opening port of valve (SSV-2) due to which port 'P' will connect to port 'A' & port 'B' and 'T' will be blocked. After fully opening of MIV, cam connected to MIV will operate the roller operated spring return valve (ROV-2) due which the port 'P' will connect to the port 'A' & port 'T' will be blocked. Now the pressure line will connect closing hydraulic port of the bypass valve (BPV) through shuttle valve. The pressurized line will shift the spool of the valve (BPV) due to which port 'P' will connect to port 'B' & port 'A' will connect to port 'T'. Now the pressure line will connect to the closing chamber of by-pass valve & simultaneously closing chamber will be connect to drain due to which bypass valve will closed.

VALIDATING THE AUTO CLOSING SEQUENCE OF MIV THROUGH THE NEW HYDRAULIC SCHEME BY ELECTRICALLY

MIV CLOSING (FIRST STEP)

Closing command (220 VDC supply for 15 seconds) received from the auto sequencer. Refer figure-7 which shows that when closing command received from the auto sequencer, the solenoid (SOV-C) of valve (SOV) will operate.

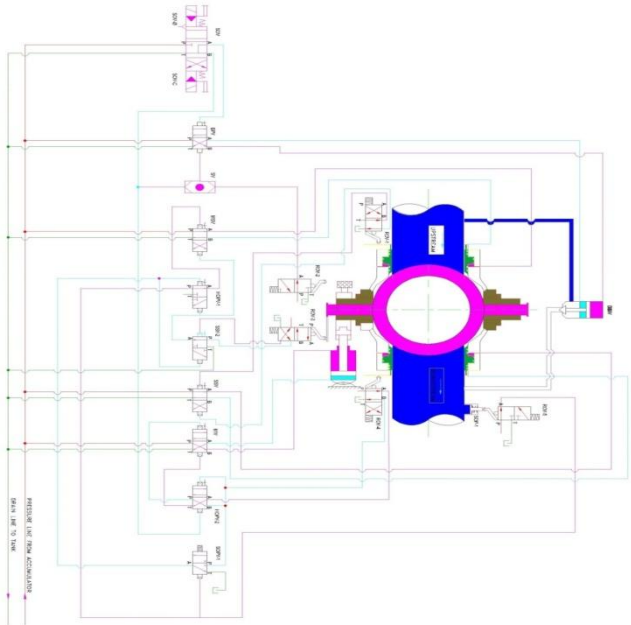


FIGURE 7: MIV CLOSED

When solenoid (SOV-C) of valve (SOV) is operated, the port 'P' will connect to port 'B' & port 'A' will connect to port 'T'. Now the pressure line will connect to closing hydraulic port of the valve (HOPV-2) due to which port 'P' will connect to port 'B' & port 'A' will connect to port 'T'. Now the pressure line coming from the valve (ROV-4) will connect to closing hydraulic port of the valve (MIV) which will shift the spool due to which port 'P' will connect to port 'B' & port 'A' will connect to port 'T'. Now the pressure line will be connected to the closing chamber of MIV double acting cylinder & simultaneously opening chamber will connect to drain which causes the closing of MIV.

MAINTENACE SEAL CLOSING (SECOND STEP)
Refer the figure-8 in which when the MIV is fully closed , the cam attached with MIV will operate the roller operated spring return valve (ROV-3) due to which port 'P' will connect to port 'A' & port 'B' will connect to port 'T'. Now the pressure line will connect to the closing hydraulic port of maintenance seal valve (MSV) through valve (SSV-2) & simultaneously blocking the pressure line coming from valve (ROV-5) by operating the valve (HOPV-1). The pressurized line will shift the spool of valve (MSV) due to which port 'P' will connect to port 'B' & port 'A' will connect to port 'T'. Now the pressure line will connect to closing chamber of maintenance seal &

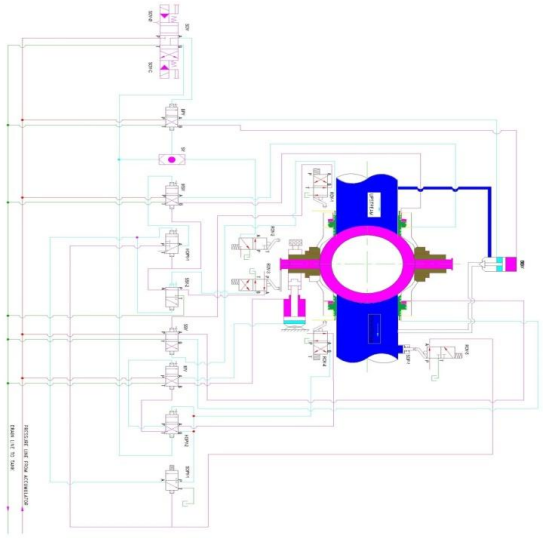


FIGURE 8: MAINTENANCE SEAL CLOSED

simultaneously opening chamber will connect to drain, due to which maintenance seal will be closed.
SERVICE SEAL CLOSING (THIRD STEP)
Refer the figure-9 in which when the maintenance seal is fully CLOSED , the plunger attached to maintenance seal is also goes away from the valve (ROV-1) because of this valve (ROV-1) will return to Its original position due which the port

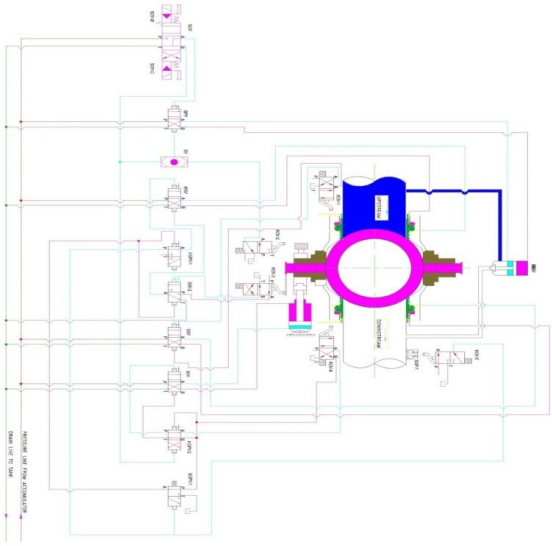


FIGURE 9: SERVICE SEAL CLOSED

'P' will connect to the port 'B' & port 'A' will connect to port 'T'. Now the pressure line will connect to closing hydraulic port of the service seal valve (SSV) through valve (ROV-1) as shown in the above scheme. The pressurized line will shift the spool of the valve (SSV) due to which port 'P' will connect to port 'B' & port 'A' will connect to port 'T'. Now the pressure line will connect to the closing chamber of service seal through valve (SSV) & simultaneously opening chamber will be connect to drain due to which service seal will fully closed. After the closing of service seal & maintenance seal pressure in the downstream side become very low or almost zero due to which the plunger of valve (SOP-1) moves in down ward direction.

VALIDATING THE AUTO OPENING SEQUENCE OF MIV THROUGH THE NEW HYDRAULIC SCHEME BY MANUALLY.
For opening the MIV in auto by manually, press the opening side plunger by hand of the valve (SOV) for 5 seconds and then same sequence & operation of valve will be followed as described above for the opening sequence by electrically.

VALIDATING THE AUTO CLOSING SEQUENCE OF MIV THROUGH THE NEW HYDRAULIC SCHEME BY MANUALLY.
For closing the MIV in auto by manually, press the closing side plunger by hand of the valve (SOV) for 5 seconds and then same sequence & operation of valve will be followed as described above for the closing sequence by electrically.

ITEMS WHICH ARE NOT SAME FOR AUTO OPERATION OF MIV IN BOTH THE HYDRAULIC SCHEME.
For old hydraulic scheme

S. No.	Item Description	Power consumption	Quantity (Nos.)	Active during open position of MIV	Active during close position of MIV
1.	Supply monitoring relay	Power consumption =10W	01	YES	YES
2.	DC-DC converter	Power consumption= 5 W	01	YES	YES
3.	Space Heater	Power consumption= 60W	1	YES	YES
4.	Auxiliary contractor BV-1	Power consumption=10W	1	NO	YES
5.	Auxiliary contractor SS-2	Power consumption=10W	1	NO	YES
6.	Auxiliary contractor SS-1	Power consumption=10W	1	NO	YES

7.	Auxiliary contractor MIV2	Power consumption=10W	1	NO	YES
8.	Auxiliary contractor MIV1	Power consumption=10W	1	YES	NO
9.	Auxiliary contractor PNS-1X	Power consumption=10W	1	NO	YES
10.	Auxiliary contractor LSSSC-1X	Power consumption=10W	1	NO	YES
11.	Auxiliary contractor LSSSC-2X	Power consumption=10W	1	NO	YES
12.	Auxiliary contractor LSSS0-1X	Power consumption=10W	1	YES	NO
13.	Auxiliary contractor LSMSC-X	Power consumption=10W	1	NO	YES
14.	Auxiliary contractor GVCX	Power consumption=10W	1	NO	YES
15.	Auxiliary contractor PS1-1X	Power consumption=10W	1	YES	YES
16.	Auxiliary contractor EC1	Power consumption=10W	1	NO	NO
17.	Auxiliary contractor EC2	Power consumption=10W	1	NO	NO
18.	Auxiliary contractor MIV-2X	Power consumption=10W	1	NO	NO
19.	Auxiliary contractor MIV-1X	Power consumption=10W	1	NO	NO
20.	Auxiliary contractor LSBPC-1X	Power consumption=10W	1	YES	YES
21.	Auxiliary contractor LSBPO-1X	Power consumption=10W	1	NO	NO
22.	Auxiliary contractor LSMIVC-1X	Power consumption=10W	1	NO	YES
23.	Auxiliary contractor LSMIVC-2X	Power consumption=10W	1	NO	YES
24.	Auxiliary contractor LSMIVO-1X	Power consumption=10W	1	YES	NO
25.	Auxiliary contractor LSMSO-X	Power consumption=10W	1	YES	NO
26.	Auxiliary contractor PS2-2X	Power consumption=10W	1	YES	NO
27.	Auxiliary contractor MIVSO UPS-1X	Power consumption=10W	1	YES	YES
28.	Auxiliary contractor MIVOP US-1AX	Power consumption=10W	1	YES	YES
29.	Auxiliary contractor MIVOP US-1AX	Power consumption=10W	1	YES	YES

FOR NEW HYDRAULIC SCHEME

S.No.	Item Description	Internal Leakage	Quantity (Nos.)
1.	Solenoid operated spring centred valve (SOV)	Leakage: 0.5 CM3/MIN	1
2.	Roller operated spring return valve(ROV-1,2,3,4&5)	Leakage: 0.25 CM3/MIN	5
3.	Valve (HOPV-1, HOPV-2, SSV-2, SOPV-1)	Leakage : 0.5 CM3/MIN	4

All valves remain in active condition during open & close position of MIV, except when machine is under maintenance.

Total leakage from the valves = 3.75 CM^3/MIN =0.00375 LPM

POWER CONSUMPTION COMAPRISION BETWEEN BOTH HYDRAULIC SCHEMES FOR AUTO OPERATION OF MIV

For power consumption, only items which are not common shall be considered.

Power consumption for old hydraulic scheme

From the tables given above, Power consumption during open position of MIV is 175Wper Hour. Therefore power consumption in one year = 175(W/Hour) x 4320(hour)

= 756000 W = 756KW

Power consumption during close position of MIV is 235 W per hr.

Therefore power consumption in one year = 235(W/Hour) x 3600(Hour) = 846000 W = 846KW

Total power consumption in a year is 1602 KW.

Power consumption for New hydraulic scheme.

Data taken from the P.P.set data & different item table and then following procedure will be followed for calculating the power consumption.

Pump capacity of power pack is 95 LPM at 60 Kg/cm^2

Motor capacity of power pack is 12 KW at 60 Kg/cm^2

Minimum normal working pressure of power pack (P_2) = 57+1 Kg/cm^2

Maximum normal working pressure of power pack (P_1) = 60+1 Kg/cm^2

Pressure receiver capacity (V_1)= 3500 liter

Adiabatic constant (γ)=1.3

Oil volume at 60Kg/cm^2= 1170 liter

Air volume at 60Kg/cm^2 (V_1) = 2330 liter

Total leakage from the above valve-1&2 is 2 +3 = 0.00375 LPM

Amount of oil available from pressure 60Kg/cm^2 to 57 Kg/cm2 will be calculated as per ideal gas equation for the adiabatic compression & expansion.

$$P1 \text{ X } (V1)^{\gamma} = P2 \text{ X } (V2)^{\gamma}$$

$$V2 = (P1/P2) \text{ ^ } (1/\gamma) \text{ X } V1$$

$$V2 = (61/58)\text{^}(1/1.3) \text{ x } 2330$$

$$= 2422 \text{ L}$$

Oil volume = V2-V1 =2422-2330 = 92litre

Time for dropping the pressure from 60 to 57 Kg/cm^2 due to internal leakage from the valve will be =92/0.00375

= 24560 Minute (Approx)

= 409 Hr.(Approx).

To build the pressure from the 57 Kg/cm2 to 60 Kg/cm2 = Oil volume /pump capacity = 92 / 95 = 1 Minute (approx)

It means power pack will run for 1 minute only after every 24560 minute to full fill the leakage requirement.

In one minute power consumption will be 200W.

As per the table no. 6&8, valves are active for 7920 Hr. (approx.) in a year.

No. of times power pack operate will be = 7920/ 409 = 21 times (approx.)

Therefore power consumption in a year is 21 x 200 W = 4200W = 4KW.

Power consumed by new hydraulic scheme is only 4KW while power consumption by old hydraulic scheme is 1602KW in a year.

From the above calculation, it is clear power consumption is very less & auto operation is also very simple through electrically as well as manually.

V. CONCLUSION

In the present work the old hydraulic scheme used for the operation of MIV has been modified and from the analysis it is revealed that

A) Auto operation (Opening & closing) of MIV is possible by giving the one single electrical pulse command for opening & one single pulse command for closing.

B) Auto operation (Opening & closing) of MIV is possible by pressing the plunger one time only for opening & onetime only for closing.

C) In manual & electrical operation, auto operation of MIV is reliable.

D) Energy consumption is very less.

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