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

Yatendra Singh¹, Arun Patel²
¹PG Student, ²Asst. Professor
Department of Mechanical Engineering, NRI Institute of Science & Technology, Bhopal, Madhya Pradesh, India

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, the 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

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description of Items</th>
<th>Capacity</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Solenoid operated valve for MIV</td>
<td>Size NG32, coil voltage: 220 VDC, Solenoid rating: 26 W, Leakage: 2 CM³/Min</td>
<td>1 No. 2 Nos. solenoid</td>
</tr>
<tr>
<td>2.</td>
<td>Solenoid operated valve for Bypass valve</td>
<td>Size NG6, coil voltage: 220 VDC, Solenoid rating: 26 W, Leakage: 0.5 CM³/Min</td>
<td>1 No. 2 Nos. solenoid</td>
</tr>
<tr>
<td>3.</td>
<td>Solenoid operated valve for maintenance seal</td>
<td>Size NG6, coil voltage: 220 VDC, Solenoid rating: 26 W, Leakage: 0.5 CM³/Min</td>
<td>1 No. 2 Nos. solenoid</td>
</tr>
<tr>
<td>4.</td>
<td>Solenoid operated valve for service seal</td>
<td>Size NG6, coil voltage: 220 VDC, Solenoid rating: 26 W, Leakage: 0.5 CM³/Min</td>
<td>1 No. 2 Nos. solenoid</td>
</tr>
<tr>
<td>5.</td>
<td>Duplex filter</td>
<td>200 LPM at 0.5 Bar</td>
<td>1 No.</td>
</tr>
<tr>
<td>6.</td>
<td>LED Light</td>
<td>10 W</td>
<td>2 Nos.</td>
</tr>
</tbody>
</table>

EXISTING MIV ELECTRICAL CONTROL PANEL DETAIL

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

STATUS OF AUXILLARY RELAY OF MIV ECP.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description of Items</th>
<th>Active during open position of MIV</th>
<th>Active during open position of MIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Auxiliary contractor BV-1</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>2.</td>
<td>Auxiliary contractor SS-2</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>3.</td>
<td>Auxiliary contractor SS-1</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>4.</td>
<td>Auxiliary contractor MIV2</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>5.</td>
<td>Auxiliary contractor MIV1</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>6.</td>
<td>Auxiliary contractor</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>
### MACHINE AVAILABILITY DETAIL FOR ONE YEAR

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Machine run continuously</td>
<td>3 months (Rainy season)</td>
</tr>
<tr>
<td>2.</td>
<td>Machine run 12-15 Hour per day</td>
<td>4 months (winter season)</td>
</tr>
<tr>
<td>3.</td>
<td>Machine run max 6 Hour per day</td>
<td>4 months (Summer season)</td>
</tr>
<tr>
<td>4.</td>
<td>Machine under maintenance</td>
<td>One month</td>
</tr>
</tbody>
</table>

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, 2 way 2 position 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-1 consists 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)

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 its 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.

FIGURE 3: MAINTENANCE SEAL OPENING

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 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 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 which port ‘P’ will connect to port ‘A’ & port ‘B’ & port ‘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.
MAINTENANCE 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 & ‘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

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Item Description</th>
<th>Power Consumption</th>
<th>Quantity (Nos.)</th>
<th>Active during open position of MIV</th>
<th>Active during close position of MIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Supply monitoring relay</td>
<td>Power consumption =10W</td>
<td>01</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>2.</td>
<td>DC-DC converter</td>
<td>Power consumption= 5 W</td>
<td>01</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>3.</td>
<td>Space Heater</td>
<td>Power consumption= 60W</td>
<td>1</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>4.</td>
<td>Auxiliary contactor BV-1</td>
<td>Power consumption=10W</td>
<td>1</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>5.</td>
<td>Auxiliary contactor SS-2</td>
<td>Power consumption=10W</td>
<td>1</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>6.</td>
<td>Auxiliary contactor SS-1</td>
<td>Power consumption=10W</td>
<td>1</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>
### FOR NEW HYDRAULIC SCHEME

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

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 CM³/MIN = 0.00375 LPM

**POWER CONSUMPTION COMAPRISON 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 175W per 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/cm²
Motor capacity of power pack is 12 KW at 60 Kg/cm²
Minimum normal working pressure of power pack (P₁) = 57+1 Kg/cm²
Maximum normal working pressure of power pack (P₂) = 60+1 Kg/cm²
Pressure receiver capacity (V₁) = 3500 liter
Adiabatic constant (γ) = 1.3
Oil volume at 60Kg/cm² = 1170 liter
Air volume at 60Kg/cm² (V₂) = 2330 liter

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

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

\[
P_1 \times (V_1) = P_2 \times (V_2)^\gamma\]
\[
V_2 = (P_2/P_1)^\gamma \times V_1
\]
\[
V_2 = (61/58)^{(1/1.3)} \times 2330 = 2422 L
\]

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

Time for dropping the pressure from 60 to 57 Kg/cm² 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.

**REFERENCES**

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