Troubleshooting Hydraulic Systems Part 1

Thomas S. Wanke, CFPE
Director Fluid Power Institute
Outline

- Component troubleshooting
- Diagnostic tools
- Seven steps to hydraulic system troubleshooting
- Example hydraulic system troubleshooting
- Questions and answers
Component Troubleshooting
If the pump is not delivering any fluid, it could be caused by:

- An air lock in the pump
- The pump may not be primed
- Severe cavitation
- Rotating in the wrong direction
- No rotation (sheared shaft key or spline)
- Volume control set to zero flow on variable pump
- Excessive internal leakage caused by wear
If the pump is delivering some flow, but less than normal, it could be caused by:

- Cavitation
- Aeration
- Lower than normal speed
- Volume control on variable pump not set to proper flow or volume control not operating properly
- Excessive internal leakage caused by wear
- Pump pressure compensator set too low or not operating properly
- System relief set too low for required load pressure
If the motor is running at less than the normal speed, it could be caused by:

- Insufficient flow from pump for desired speed
- Excessive internal leakage due to wear
- Insufficient pressure to overcome the torque required to drive the load
- Mechanical binding or dragging in the external load (brake dragging)
Motor Troubleshooting

If the motor stalls or runs erratically, it could be caused by:

- Insufficient pressure to overcome the torque required to drive the load
- Excessive internal leakage
- Mechanical binding or dragging in the load
- Brake not completely released
- Aeration
Cylinder Troubleshooting

- Erratic motion of the cylinder could be caused by:
  - Directional control valves sticking or binding
  - Cylinder sticking or binding
  - Aeration or air lock in cylinder

- If there is leakage around the piston rod:
  - Usually indicates misalignment of rod with load
  - Worn rod or wiper seal
Cylinder Troubleshooting

- If there is a scored piston rod, it could be caused by:
  - Airborne dirt that has collected on the piston rod
  - Can also result from run away load conditions
- If there is a scored cylinder barrel and or piston, it could be caused by:
  - Contamination that is stuck inside the cylinder
  - Misalignment
Cylinder Troubleshooting

- Broken piston rods
  - Indicate a need for mechanical stops or cylinder cushions
- Bent or jack knifed piston rod can result from:
  - Excessive bending moment caused by a large compressive load on a long stroke cylinder
If the valve makes noise or chatters, it could be due to:

- Adjustment too close to system operating pressure
  - Set at least 150 psi higher than the prescribed working pressure
- Pilot section cone or seat worn
- Control section spring fatigued
- Vent line too long or restricted
- Valve may be under-sized
  - Check flow rating of valve against flow rate in system.
- Tank line restricted
Pressure Control Valve Trouble shooting

- Insufficient pressure could be caused by:
  - Valve setting too low
  - Pilot cone not properly seating
  - Improper assembly for the required pressure function
  - Orifice in main poppet plugged

- Erratic pressure could be caused by:
  - Poppet sticking in body
    - Clean contaminants and check for wear or scoring and freedom of movement
  - Cone sticking in seat
    - Replace cone and seat if worn or scored.
  - Contamination particles causing inadvertent sticking
If the valve spool fails to move, it could be a result of:

- Contamination particles locking valve in a given position
- Blocked pilot drain
- Pilot pressure or supply pressure is too low
- Solenoids inoperative
  - Check electrical source and solenoid coils.
- Distortion
  - Align valve body and piping to avoid strain.
- Improper assembly after repair or overhaul. Use parts drawing to check for proper assembly.
Directional Control Valve
Troubleshooting

- If the valve spool has a sluggish response, it could be due to:
  - Contamination particles restricting spool motion
  - Restricted pilot drain
  - Pilot pressure tool low
    - Usually 65 psi is the minimum required
  - Malfunction of solenoids
    - Check for proper source of voltage and frequency.
Directional Control Valve Troubleshooting

• If the valve produces undesired response in the machine, it could be due to:
  • Improper installation connections
    • Check piping connections.
  • Improper assembly of valve
    • Check parts drawing.
  • Spool installed backwards
    • Reverse spool end for end

• If the detented valve spool does not stay in position, it could be due to:
  • Detent piston, ball, or spring worn or broke
Directional Control Valve Troubleshooting

- If the spool is not returning to the center position with a three position valve or not returning to “start” position with a two position valve, it could be because of:
  - A broken spring
    - Remove broken spring parts, flush out completely, and replace spring
  - Excessive flow forces
- If the solenoids are burned out in several valves, it could be because of:
  - Dirty or severely oxidized fluid
Directional Control Valve Troubleshooting

- If the solenoid for a valve infrequently burns out, it could be because of:
  - Silting: an accumulation of fine contaminants between the spool and body
    - This problem usually occurs more frequently above 2,500 psi
    - Improve filtration level of the system.

- If the spool is not shifting full stroke, it could be because:
  - Push rod between armature and spool peened over or corroded
    - Will cause burn out if solenoid is energized by AC current when armature does not shift full stroke
Diagnostic Tools
Diagnostic Equipment

- Pressure gauges
- Pressure transducers with appropriate readouts for measuring pressure spikes
  - Digital peak hold meter
  - Oscilloscope or chart recorder
- Flowmeter
- Surface Temperature Indicator
- Flashlight
- Speed indicator
- Multimeter or voltage indicator
- Amp clamp
- Stop watch
Diagnostic Test Coupler

Uncoupled

Pin
Viton O-Ring
Secondary Seal
1620 Thread
Poppet
Anti-vibration O-ring
Viton O-Ring
Primary Seal
Pressure Spring
Sealing O-ring
Threaded Test Point Body
Coupled
Inline Test Points

In-Line male / female test points

1. [Diagram of in-line male/female test points]
2. [Diagram of in-line SAE flange test points]

3. [Diagram showing connection points]
Microflex Connector Hoses
Pressure Gauge Kit
Pressure Gauge Kit
Digital Pressure Gages
Pressure Transducers
Portable Hydraulic Testers

- **Flow** (GPM or LPM)
  - 0-20 GPM up to 0-200 GPM
- **Pressure** (PSI or BARS)
  - As high as 10,000 PSI (3,000 or 6,000 PSI are common)
- **Temperature** (°F or °C)
  - As high as 350°F
- **Speed** (RPM) - Optional on some design models
  - Up to 10,000 RPM
Portable Hydraulic Testers
Portable Hydraulic Testers
Portable Hydraulic Testers
Portable Hydraulic Testers
Portable Hydraulic Testers
Portable Hydraulic Testers
Hand Held Readout
Portable Hydraulic Testers
System Troubleshooting
Seven Basic Steps of Troubleshooting

1. Know the system
2. Ask the operator how the machine is malfunctioning
3. Operate the machine yourself
4. Inspect the machine carefully
5. List probable causes for failure
   - Process of elimination
   - Proof of function via each part
6. Reach a conclusion
7. Test the conclusion on the machine itself
Know the System

- The hydraulic circuit diagram
- The hydraulic circuit function
- The machine’s capability/ability
- The hydraulic circuit sequence
- The hydraulic circuit/component relationships
- The electrical control circuit diagram
Know the Symptoms

- Have the operator give you a history of the machine.
  - What is the machine application?
  - Was the development of the malfunction gradual or sudden?
  - Does the malfunction change as the oil temperature changes?
  - Did the malfunction first appear after a change of machine application or a repair/adjustment was made?
  - Has this problem occurred before?
Hydraulic System Testing

- Know what the system is supposed to do
  (Do not jump the gun)

Determine

A. Flow
B. Speed
C. Pressure ratings

Check

1. Nameplates
2. Service manuals
3. Equipment files
Hydraulic System Testing

- Know and check relief valve setting
- **Never** start a test under pressure, bring pressure up slowly
- Cycle the machine to bring the oil up to normal operating temperature
- If a gas or diesel prime mover is used - bring prime mover up to proper speed
- Test individual components or the entire system
## Interpreting Pump Test Results

If the GPM reading at no load was:  

| 20 | 19 | OK |
| 20 | 10 | 50% efficient. Working part of the system will take twice as long to complete cycle |
| 20 | 0  | Completely bad. Working part of the system will not function. |
| 15 | 14 | Okay, but there is a problem in suction line. |
Determine the following information about the circuit:

- Relief valve setting
- Pump output
- Pump’s volumetric efficiency @ 1,500 psi
Circuit Analysis Example 1

- Point A  Pump test
Circuit Analysis Example 1

- Point A: Pump test: Flow should be 33gpm.

<table>
<thead>
<tr>
<th>Test Station</th>
<th>Test Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td>B1</td>
<td>L</td>
</tr>
<tr>
<td>B2</td>
<td>O</td>
</tr>
<tr>
<td>C</td>
<td>W</td>
</tr>
<tr>
<td>D</td>
<td>G</td>
</tr>
<tr>
<td>E</td>
<td>P</td>
</tr>
</tbody>
</table>
Example 1 Conclusions

- Pump volumetric efficiency is:
  - 91% at 500 psi (30/33)
  - 85% at 1000 psi (28/33)
  - 79% at 1500 psi (26/33)
  - 73% at 2000 psi (24/33)
Circuit Analysis Example 2

- Point B: Circuit test
**Circuit Analysis Example 2**

- **Point B: Circuit flow after relief valve**
  - B1 circuit disconnected at DCV
  - B2 circuit connected, DCV shifted to retract

<table>
<thead>
<tr>
<th>Test Station</th>
<th>Test Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>32</td>
</tr>
<tr>
<td>L</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>32</td>
</tr>
<tr>
<td>L</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0</td>
</tr>
<tr>
<td>L</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

* @ 1,850
Example 2 Conclusions

- **B1:** Relief valve full flow setting is 1850 psi
- **B1:** Relief valve is leaking
  - 1 gpm at 1000 psi (0.6 hp)
  - 1.5 gpm at 1500 psi (1.3 hp)
- **B2:** DCV and/or cylinder leaking in retract direction
  - 1.5 gpm at 1000 psi (0.9 hp)
  - 2.5 gpm at 1500 psi (2.2 hp)
  - 3.5 gpm at 1850 psi (3.8 hp)
Points C and D: Cylinder test
Circuit Analysis Example 3

- Point C: Circuit flow after directional valve on cylinder retract side

<table>
<thead>
<tr>
<th>Test Station</th>
<th>Test Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td>32</td>
</tr>
<tr>
<td>B1</td>
<td>32</td>
</tr>
<tr>
<td>B2</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

* @ 1,850
Example 3 Conclusions

- DCV is leaking on the retract side
  - 0.25 gpm at 1000 psi (0.2 hp)
  - 0.5 gpm at 1500 psi (0.4 hp)
  - 1 gpm at 1850 psi (1.1 hp)
- Cylinder is leaking on the retract side
  - 1.25 gpm at 1000 psi (0.7 hp)
  - 2 gpm at 1500 psi (1.8 hp)
  - 2.5 gpm at 1850 psi (2.7 hp)
**Circuit Analysis Example 4**

- Point D: Circuit flow after directional valve on cylinder extend side

<table>
<thead>
<tr>
<th>Test Station</th>
<th>Test Pressure (psi)</th>
<th>100</th>
<th>500</th>
<th>1,000</th>
<th>1,500</th>
<th>2,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>F</td>
<td>32</td>
<td>30</td>
<td>28</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td>B1</td>
<td>L</td>
<td>0</td>
<td>0</td>
<td>1.5</td>
<td>2.5</td>
<td>3.5*</td>
</tr>
<tr>
<td>B2</td>
<td>O</td>
<td>0</td>
<td>0</td>
<td>1.5</td>
<td>2.5</td>
<td>3.5*</td>
</tr>
<tr>
<td>C</td>
<td>W</td>
<td>0</td>
<td>0</td>
<td>1.25</td>
<td>2</td>
<td>2.5*</td>
</tr>
<tr>
<td>D</td>
<td>G</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>P</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* @ 1,850
Example 4 Conclusions

- Cylinder is not leaking on the extend side
- DCV is leaking on the extend side
  - 1.5 gpm at 1000 psi (0.9 hp)
  - 2.5 gpm at 1500 psi (2.2 hp)
  - 3.5 gpm at 1850 psi (3.8 hp)
Circuit Analysis Conclusions

- Pump has 79% volumetric efficiency at 1500 psi (6.1 hp)
- Relief valve is leaking 1.5 gpm at 1500 psi (1.3 hp)
- DCV is leaking 0.5 gpm at 1500 psi on retract (0.4 hp)
- DCV is leaking 2.5 gpm at 1500 psi on extend (2.2 hp)
- Cylinder is leaking 2 gpm at 1500 psi on retract (1.8 hp)
- Cylinder is not leaking on extend
- Total leakage on retract at 1500 psi is 11 gpm (9.6 hp)
- Total leakage on extend at 1500 psi is 11 gpm (9.6 hp)
- Circuit efficiency at 1500 psi is 22/33, 67%. The 33% loss is heat
Any Questions?
Thank you