FLUID POWER TRANSMISSION AND CONTROL
[APPLIED HYDRAULICS AND PNEUMATICS]

By
A. Alavudeen, K. H. Syed, N. Shanmugam

ABOUT THE BOOK
This text-book provides an in-depth background in the field of Fluid Power. It covers Design, Analysis, Operation and Maintenance. The reader will find this book useful for a clear understanding of the subject and also to assist in the selection and troubleshooting of fluid power components and systems used in manufacturing operations, providing a systematic summary of the fundamentals of hydraulic power transmission.

This book discusses the main characteristics of hydraulic drives and their most important types in a manner comprehensible even to newcomers of the subject.

This book covers a broad range of topics in the field, including: physical properties of hydraulic fluids; energy and power in hydraulic systems; frictional losses in hydraulic pipelines; hydraulic pumps, cylinders, cushioning devices, motors, valves, circuit design, conductors and fittings; hydraulic system maintenance; pneumatic air preparation and its components; and electrical controls for fluid power systems. It provides everything you need to understand the fundamental operating principles as well as the latest maintenance, repair and reconditioning techniques for industrial oil hydraulic systems.

Better understanding of the material is promoted by the sample solutions to various mathematical problems given in each chapter. A number of photographs and illustration have been attached to reflect current “Fluid Power system.”

The book in its 15 Chapters and 3 Appendices contain:
* 431 Neatly drawn self-explanatory diagrams
* 54 Useful Tables
* 52 Worked examples
* 285 Questions are given for preparation of examinations

It is hoped that this book will satisfy the need of the Mechanical Engineering students preparing for the B.Tech/B.E. examinations of almost all the Indian Universities, Diploma examinations conducted by various Boards of Technical Education, Certificate courses as well as for the A.M.I.E., U.P.S.C., G.A.T.E. and other similar competitive and professional Examinations. It should also be of an immense help to the practising Engineers.

CONTENT
1: INTRODUCTION – HISTORY
2: HYDRAULIC BASICS
3: HYDRAULIC PRINCIPLES
4: HYDRAULIC DEVICES
5: HYDRAULIC ACCESSORIES
6: HYDRAULIC CIRCUIT DIAGRAMS
7: TROUBLESHOOTING IN HYDRAULIC
8: HYDRAULIC ELECTRICAL DEVICES: TROUBLESHOOTING AND SAFETY
9: PNEUMATICS
10: COMPONENT OF PNEUMATICS
11: BASIC PNEUMATIC CIRCUITS
12: APPLICATION FOR PNEUMATICS
13: SERVO SYSTEMS, PROPORTIONAL VALVES AND PNEUMATIC SAFETY
14: FLUIDICS
15: DESIGN OF PNEUMATIC CIRCUITS

APPENDIX A: BASIC SYMBOLS OF MECHANICAL COMPONENT, VALVE
APPENDIX B: GLOSSARY
APPENDIX C: MODEL QUESTION PAPERS
INDEX
**Chapter 1: INTRODUCTION – HISTORY**

1-1. Hydraulics  
1-2. Development of hydraulics  
1-3. Advantages of fluid power  

**Questions 1**

**Chapter 2: HYDRAULIC BASICS**

2-1. Pressure and force  
2-2. Pascal’s law  
2-3. Flow  
2-4. Energy, work, and power  
2-5. Liquids at rest  
2-6. Transmission of forces through liquids  
2-7. Density and specific gravity  
2-8. Pressure of a liquid is independent of direction  
2-9. Pressure and force in fluid power systems  
2-10. Multiplication of forces  
2-11. Law of conservation of energy  
2-12. Streamline and turbulent flow  
2-13. Factors involved in flow  
2-14. Kinetic energy  
2-15. Relationship of force, pressure, and head  
2-16. Static and dynamic factors  
2-17. Bernoulli’s principle  
2-18. Operation of hydraulic components  
2-19. Hydraulic jack  
2-20. Hydraulic brakes  
2-21. Typical examples  

**Questions 2**

**Chapter 3: HYDRAULIC PRINCIPLES**

3-1. Introduction  
3-2. Properties  
3-2-1. Viscosity  
3-2-2. Lubricating power  
3-2-3. Chemical stability  
3-2-4. Freedom from acidity  
3-2-5. Flash point  
3-2-6. Fire point  
3-2-7. Minimum toxicity  
3-2-8. Density and compressibility  
3-2-9. Foaming tendencies  
3-2-10. Cleanliness  
3-3. Types of hydraulic fluids  
3-3-1. Petroleum based fluids  
3-3-2. Synthetic fire resistant fluids  
3-3-3. Water based fire resistant fluids  
3-4. Fluid contamination  
3-4-1. Particulate contamination  
3-4-2. Fluid contamination  
3-5. Origin of contamination  
3-6. Contamination control  
3-7. Hydraulic fluid sampling  
3-8. Measurement and pressure control devices  
3-8-1. Pressure gauges  
3-8-2. Bourdon tube gauges  
3-8-3. Spiral and helical bourdon tubes  
3-8-4. Bellows elastic elements  
3-9. Pressure switches  
3-10. Temperature measuring instruments  
3-10-1. Bimetallic expansion thermometer  
3-10-2. Distant reading thermometer  
3-11. Temperature switches  
3-12. Sealing devices and materials  
3-12-1. Seals  
3-12-2. Seal materials  
3-12-3. Types of seals  
3-13. Fluid lines and fittings  

**Questions 3**

**Chapter 4: HYDRAULIC DEVICES**

4-1. Pumps  
4-2. Hydraulic pumps  
4-3. Pump classifications  
4-3-1. Non positive displacement pumps  
4-3-2. Positive displacement pumps  
4-3-3. Characteristics  
4-3-4. Centrifugal pump  
4-4. Rotary pump  
4-4-1. Gear pumps  
4-4-2. Lobe pump  
4-4-3. Vane pumps  
4-4-4. Screw pump  
4-4-5. Performance of screw pump  
4-5. Reciprocating pumps  
4-5-1. Hand pumps  
4-5-2. Piston pumps  
4-6. Pump operational problems  
4-7. Pump symbols  
4-8. Typical examples  
4-9. Hydraulic valves  
4-10. Directional control valves  
4-10-1. Poppet valve  
4-10-2. Sliding spool valve  
4-10-3. Check valves  
4-10-4. Shuttle valve  
4-10-5. Two way valve  
4-10-6. Four way valves  
4-10-7. Solenoid operated, two and four way valves  
4-10-8. Rotary spool  
4-11. Flow control valve  
4-11-1. Gate valve  
4-11-2. Globe valve  
4-11-3. Needle valve  
4-11-4. Restrictor  
4-11-5. Orifice check valve  
4-11-6. Flow equalizer  
4-12. Cartridge valves  
4-13. Valve installation  
4-14. Valve failures and remedies  
4-14-1. Servicing valves  
4-14-2. Disassembling valves  
4-14-3. Repairing valves  
4-15. Valve assembly  
4-15-1. Trouble shooting valves  
4-15-2. Pressure control valves  
4-15-3. Directional control valves  
4-15-4. Volume control valves  
4-16. Control methods  
4-17. Actuators  
4-17-1. Cylinders  
4-17-2. Ram type cylinders  
4-18. Piston type cylinders  
4-19. Construction and application  
4-20. Maintenance  
4-21. Motors  
4-22. Piston type motors  
4-23. Reaction turbine  

**Questions 4**
Chapter 5 HYDRAULIC ACCESSORIES
Reservoirs, strainers, filters
5-1. Reservoirs
5-2. Filtration
5-2-1. Filter elements
5-2-2. Filter size and efficiency
5-2-3. Location
5-3. Accumulators
5-3-1. Types of accumulators
5-3-2. Operation of accumulator
5-3-3. Applications
5-3-4. Maintaining pressure
5-3-5. Developing flow
5-3-6. Absorbing shock
5-4. Selection of accumulator
5-4-1. Failure modes
5-4-2. Output volume
5-4-3. Flow rate
5-4-4. Fluid type
5-4-5. Response time
5-4-6. Shock suppression
5-4-7. High frequency cycling
5-4-8. Mounting position
5-4-9. External forces
5-4-10. Sizing information
5-4-11. Certification
5-4-12. Safety
5-5. Sizing of accumulator
5-5-1. Auxiliary power source
5-5-2. Hydraulic line shock suppression
5-5-3. Thermal expansion
5-5-4. Piston pump pulsation dampening
5-5-5. Existing accumulator output used in an auxiliary power source application
5-5-6. Hydraulic power packs
Questions 5

Chapter 6 HYDRAULIC CIRCUIT DIAGRAMS
6-1. Hydraulic-circuit diagrams
6-2. United States of American Standards Institute (USASI) graphical symbols
6-3. Typical mobile circuits
6-4. Different hydraulic circuit diagrams
6-4-1. Control of double acting hydraulic cylinder
6-4-2. Regenerative circuit
6-4-3. Control of single hydraulic cylinder
6-4-4. Pump unloading circuit
6-4-5. Intensifier circuit
6-4-6. Intensifier press circuit
6-4-7. Counter balance valve application
6-4-8. Hydraulic cylinder sequence circuit
6-4-9. Automatic cylinder reciprocation circuit
6-4-10. Synchronising circuits
6-4-11. Locked cylinder using pilot check valve
6-4-12. Cylinder hooked in series—synchronization
6-4-13. Safety circuits
6-4-14. Two-hand safety control circuit
6-5. Typical examples — Design of hydraulic circuits
Questions 6

Chapter 7 TROUBLESHOOTING IN HYDRAULIC
7-1. Troubleshooting
7-2. 10 Ways to increase hydraulic circuit cycle speed
Questions 7

Chapter 8 HYDRAULIC ELECTRICAL DEVICES: TROUBLESHOOTING AND SAFETY
8-1. Hydraulics and electricity
8-2. Troubleshooting electrical devices
8-3. Ground
8-4. Safety
Questions 8

Chapter 9 PNEUMATICS
9-1. Development of pneumatics
9-2. Characteristics of gases
9-2-1. Density
9-2-2. Temperature
9-2-3. Pressure
9-3. Compressibility and expansion of gases
9-4. Kinetic theory of gases
9-5. Boyle’s law
9-6. Charles’s law
9-7. General gas law
9-8. Pneumatic gases
9-8-1. Qualities
9-8-2. Compressed air
9-8-3. High-pressure air systems
9-8-4. Medium-pressure air
9-8-5. Low-pressure air
9-9. Contamination control
9-10. Potential hazards
9-11. Safety precautions
Questions 9

Chapter 10 COMPONENT OF PNEUMATICS
10-1. Compressors
10-1-1. Vane compressors
10-1-2. Screw compressor
10-1-3. Lobe compressor
10-2. Selection of compressor
10-3. Air capacity rating of compressors
10-4. Sizing of air compressor
10-5. Power required to drive a compressors
10-6. Air conditioners
10-6-1. Removal of solids
10-6-2. Removal of moisture
10-6-3. Air pressure regulator
10-6-4. Air lubricator
10-6-5. Air service unit
10-6-6. Pneumatic silencer
10-6-7. Pneumatic actuators
10-6-8. Pneumatic semi rotary actuators
10-6-9. Directional control valves
10-7. Air pressure losses in the pipe line
10-8. FRL unit
10-9. Installation of FRL unit
10-10. Quick exhaust valve
10-11. Speed control
10-12. Air control valves
10-13. Pneumatic circuit design considerations
10-14. Hydro pneumatic
10-14-1. Air-oil reservoir
10-14-2. Air-oil cylinder
10-14-3. Air-oil intensifier
Questions 10
FLUID POWER TRANSMISSION AND CONTROL
DETAILED CONTENTS

Chapter 11 BASIC PNEUMATIC CIRCUITS
11-1. Air pilot control of double acting cylinder
11-2. Two step speed control system
11-3. Control of air motor
11-4. Deceleration air cushion cylinder
11-5. Movement diagram
11-6. Cascade system of pneumatic circuit design
11-6-1. Principle and procedure
11-6-2. Advantages of cascade system
11-7. Use of Karnaugh-Veitch map for pneumatic circuit design
11-8. K-V diagram
11-9. Design of pneumatic circuit with K-V diagram
11-10. Ladder diagrams
11-11. Sequence charts
11-12. Cascade method
11-13. Ladder diagram design : cascade method
11-14. Introduction to industrial automation
11-14-1. Huffman method
11-14-2. Sequential systems
11-14-3. Ladder logic program
11-15. Programmable logic control
11-16. PLC history
11-17. PLC construction
11-18. Programming the PLC

Chapter 12 APPLICATION FOR PNEUMATICS
12-1. The advantages of compressed air
12-2. Pressure ranges
12-3. Possible applications for compressed air
12-3-1. Tensioning and clamping with compressed air
12-3-2. Conveyance by compressed air
12-3-3. Pneumatic drive systems
12-3-4. Spraying with compressed air
12-3-5. Blowing and flushing with compressed air
12-3-6. Testing and inspection with compressed air
12-3-7. Using compressed air for process control
12-4. Examples of specialized applications
12-5. Fluid power technical specification

Chapter 13 SERVO SYSTEMS, PROPORTIONAL VALVES AND PNEUMATIC SAFETY
13-1. Introduction
13-2. Safety considerations
13-3. Servo valve
13-4. Proportional valves
13-5. Electro hydraulic servo valve

Chapter 14 FLUIDICS
14-1. Introduction
14-2. Principles of fluidic logic control
14-3. The coanda effect

Chapter 15 DESIGN OF PNEUMATIC CIRCUITS
15-1. Introduction
15-2. Choice of components
15-3. Choice of signal source and transmitting systems
15-4. Fluid power advantages
15-5. Performance, precision and price make fluid power the right choice
15-6. Model design
15-6-1. Design of Hoist
15-6-2. Design of ram type hydraulic press
15-6-3. Hydraulic tilting for electric arc furnace
15-6-4. Design of hydro pneumatic spring
15-6-5. Pneumatic sequencer

Appendix A BASIC SYMBOLS OF MECHANICAL COMPONENT, VALVE
Appendix B GLOSSARY
Appendix C MODEL QUESTION PAPERS
Index