Hydraulic Systems Volume 1

Introduction to Hydraulics for Industry Professionals

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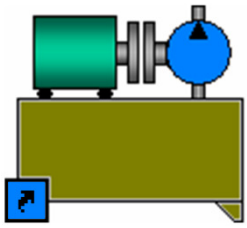

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Introduction to Hydraulics for Industry Professionals

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PREFACE

An unfair question being asked that is: "Which of the Mechanical, Electrical and Fluid Power systems is the best for power transmission and control?" The fact is none of these systems is the best from all points of view. If one of these systems is best from all points of view, why would the other systems still being used? What we can agree about is that there is a specific system that is the best choice for a specific application.

This book is intended for industry professionals who would like to achieve a deeper understanding of the principles of hydraulic control, and who would like to improve their practical skills in building a hydraulic-driven machine. Unlike similar books, the contents of this book are presented in a unique way. It fills the gap between the very academic style of fluid power books and the very commercial style of books that are produced by fluid power manufacturers.

The book contains two software packages to download. The first package is the *Hydraulic Components Sizing Calculator*. The second package is the *Animated Circuits Files*, which is produced by Automation Studio Software. Both packages are extremely helpful in understanding the subject and interactive designing of a hydraulic system.

Hydraulic system builders and users will find this book beneficial in understanding the operating principles of the hydraulic components, using the right terminologies, determining the proper specifications of a hydraulic component, performing the required calculations to size a hydraulic component, reading the hydraulic schematics, and much more.

With more than twenty-five years of experience in teaching fluid power for industry professionals, the author had effectively applied his solid understanding to the subject and his post-doctoral level of academic education in the preparation of this book. Half of this book has been written while I am flying from one state to other to conduct a seminar. The book features in brief are easy language, brand non-biased, practical oriented, associated with a workbook, colored, and demonstrative.

The author wants to continue on his goal of supporting fluid power and motion control professional education by developing the following series of volumes:

- Hydraulic Systems Volume 1: Introduction to Hydraulics for Industry Professionals.
- Hydraulic Systems Volume 2: Electro-Hydraulic Components and Systems.
- Hydraulic Systems Volume 3: Best Practices for Safe and Reliable Hydraulic Systems.
- Hydraulic Systems Volume 4: Hydraulic Systems Modeling and Simulation for Application Engineers.
- Hydraulic Systems Volume 5: Design Strategies of Hydraulic Systems.
- Hydraulic Systems Volume 6: Design Strategies of Electro-Hydraulic Systems.
- Hydraulic Systems Volume 7: Hydraulic Components Modeling and Simulation.

Dr. Medhat Kamel Bahr Khalil

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To my head's crown, my wife, Nahla Mohamed

To my sons, Karim, Sharif, Moataz and Yasser

To the soul of my parents who taught me the values of ISLAM

To my best teachers and supervisors: Dr. Saad Kassem, Dr. Rama Bhat, Dr. Ibrahim Saleh, Dr. Galal Rabie, and Dr. Abed Kattab

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Lastly, the author particularly wishes to thank the administration at Milwaukee School of Engineering and his supervisors who made his job easy to develop this book.

ABOUT THE BOOK

Book Description:

Introduction to Hydraulics for Industry Professionals is a learning package for students and professionals who are looking to build their fluid power careers. The package includes a ***colored textbook***, an ***interactive software-based tool to size hydraulic components***, ***electronic files for the animated hydraulic circuits***, and a ***colored workbook*** (separate price) that contains printed power point slides, chapter reviews and assignments. The book is the first in a series that the author plans to publish to offer complete and comprehensive teaching and design tools for the fluid power industry. This book is an attempt to fill the gap between the very academic style of fluid power books and the very commercial style of books that are produced by fluid power manufacturers. The book presents the equations in both the Metric and English systems of units. The book considers presenting real-life examples for Mobile and Industrial applications. The book goes above and beyond the fundamental level of fluid power. This book covers the construction and operating principles of the hydraulic components, using the right terminologies. Topics covered include: determination of proper specifications of hydraulic components, how to perform the required calculations to size a hydraulic component, how to read hydraulic schematic diagrams, how to predict pump efficiency under specific operating conditions, how to draw the power distribution for the duty cycle of a machine, how to investigate the losses in a hydraulic system, a presentation of different concepts for building hydraulic circuits, and much more.

The textbook is produced in letter size (8.5 x 11) inches, and weighs 3.5 lb. The textbook contains a total of eight chapters distributed on 337 pages. The workbook is produced in the same size and weighs 1 lb. The associated software is online downloadable.

Book Objectives:

Chapter 1: Hydraulic Systems Overview

This chapter presents a comparative study of different power transmission and control systems; namely: Mechanical, Electrical, Hydraulic and Pneumatic. This chapter explains the main features of hydraulic systems and concludes by exploring the structure of a generic hydraulic system.

Chapter 2: Basic Concepts Review

This chapter presents reviews of fundamental concepts of multidisciplinary systems; namely: Mechanics, Physics, Fluid Mechanics and Hydraulics. The fundamental concepts reviewed are the ones that are useful in understanding some properties of hydraulic systems. In reviewing the concepts of fluid mechanics, this chapter explains how to quantify the frictional and local pressure losses in a hydraulic line based on laminar or turbulent flow patterns in the line.

Chapter 3: Hydraulic Component Sizing Calculations

This chapter presents a case study to demonstrate the method to size a hydraulic system to achieve desired operating conditions. The chapter presents the step-by-step procedure to perform the calculations required to size the components in the system.

Chapter 4: Hydraulic Pumps and Motors Overview

This chapter has three main parts. The first part presents an overview of: positive displacement machines versus hydrodynamic machines, pumps versus motor mechanisms, fixed versus variable displacement machines, and symbols. The second part focuses on investigating the power losses in pumps and motors. This investigation is used to evaluate the efficiency of a pump and a motor under certain operating conditions using data published by the manufacturers. The third part of the chapter presents the construction and operating principles of gear, vane, and piston type positive displacement machines. The chapter concludes by the selection criteria for pumps and motors.

Chapter 5: Hydraulic Valves Overview

This chapter presents the construction and operating principles of the three families of control valves: namely pressure, directional, and flow control valves. The chapter presents the reasons why one of these valves should be selected over the other from a practical point of view. Valve symbols and comparison tables are presented.

Chapter 6: Hydraulic Reciprocating Actuators

This chapter covers two types of hydraulic reciprocating actuators; namely cylinders and rotary actuators. The chapter presents the various types of hydraulic cylinders, the effect of using a differential cylinder on the pressure and flow distribution in the system, and the calculations for sizing a hydraulic cylinder. The chapter also presents the various types of rotary actuators and the reasons for using them. Symbols for reciprocating actuators are presented.

Chapter 7: Hydraulic Accumulators

This chapter covers the construction, operating principles and symbols of the three types of accumulators: piston, bladder and diaphragm type. The chapter discusses the applications of energy storage and shock absorption using accumulators.

Chapter 8: Hydraulic Circuits for Basic Applications

This chapter covers the basic safety and energy saving requirements of a hydraulic system. The chapter also presents ideas for motion control of a single hydraulic actuator against resistive and overrunning loads, multiple hydraulic actuators in parallel and series, speed control of a hydraulic actuator, boosting speed of a hydraulic actuator, sequence of operation, and hydrostatic transmission.

Book Statistics:

The table shown below contains interesting statistical date about the textbook:

Chapter #	*Pages*	*Figures*	*Animated Circuits*	*Equations*	*Tables*	*Lines*	*Words*	*Characters*
Chapter 1	26	22	2	0	10	820	5323	28392
Chapter2	50	50	3	37	4	1450	9359	46113
Chapter 3	9	10	0	0	0	277	1836	9305
Chapter 4	72	86	4	20	2	1697	14197	71407
Chapter 5	108	125	23	0	5	2205	15918	79222
Chapter 6	29	26	1	8	1	604	3869	19573
Chapter 7	13	8	0	4	1	435	2048	9869
Chapter 8	80	89	46	7	4	1492	9985	51416
Other	**99**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Total	**436**	**416**	**79**	**76**	**27**	**8980**	**62535**	**315297**

ABOUT THE AUTHOR

Medhat Khalil, Ph.D. is Director of Professional Education & Research Development at the Applied Technology Center, Milwaukee School of Engineering, Milwaukee, WI, USA. Medhat has consistently been working on his academic development through the years, starting from Bachelor's and Master's Degrees in Mechanical Engineering in Cairo Egypt and proceeding with his Ph.D. in Mechanical Engineering and Post-Doctoral Industrial Research Fellowship at Concordia University in Montreal, Quebec, Canada. He has been certified and is a member of many institutions such as: Certified Fluid Power Hydraulic Specialist (CFPHS) by the International Fluid Power Society (IFPS); Certified Fluid Power Accredited Instructor (CFPAI) by the International Fluid Power Society (IFPS); Member of Center for Compact and Efficient Fluid Power (CCEFP); Listed Fluid Power Consultant by the National Fluid Power Association (NFPA); and Listed Professional Instructor by the American Society of Mechanical Engineers (ASME). Medhat has balanced academic and industrial experience. Medhat has a vast working experience in the field of Mechanical Engineering and more specifically hydraulics, having developed and taught fluid power system training courses for industry professionals, being quite aware of the technological developments in the field of fluid power and motion control and the production program of leading fluid power companies. In addition, Medhat has worked for several world-wide recognized industrial organizations such as Rexroth in Egypt and CAE in Canada. Medhat had designed several hydraulic systems and developed several analytical and educational software. Medhat also has considerable experience in modeling and simulation of dynamic systems using Matlab-Simulink.