

Power Hydraulics*

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ALTHOUGH POWER hydraulic power (control) goes back to ancient times, it was the theoretical work on hydraulics of the Frenchman Pascal, published in 1646, that opened new perspectives in power hydraulics. The first practical application of Pascal's Law was derived more than a century later by Boswell, who demonstrated the working of a simple hydraulic press. From that moment on, fluid power applications were growing constantly, with a temporarily diminishing growth rate at the end of the nineteenth century due to the rise of electrical power transmission.

However, only after World War II, with the introduction of servomechanisms, hydraulics have modern developments in hydraulic power evolved expanded enormously. Starting from early applications as engines, lifters, and mixers, it spread over almost the whole field of mechanical engineering and mechanical power using, shipbuilding and the steel industry to automotive engineering, robotics, aeronautics, ... This expansion can mainly be explained by the unique features of hydraulic power, such as the high safety and simple maintenance of the hydraulic systems; good dynamic characteristics with fast starts, stops and speed reversals; high stiffness properties of hydraulic actuators which give little drop in speed with increased loads; and the versatility of its usage, e.g. in compact and light devices that can develop hydraulic power varying from a few kilowatts to several megawatts. Hydraulic power, which acts as lubricants and very easy maintenance, generated during action, for a heat exchange (lack) of these properties resulting in a few series of components.

In many industrial applications, the positive features of hydraulic power, or greatly surpass their disadvantages, which include: low efficiency, the high cost of hydraulic parts and their high sensitivity to dirt and contamination in the fluid which gives rise to damage or stalling of expensive components.

During the last three decades, fluid power hydraulics evolved from a more empirical science, with emphasis on fluid mechanics, to a highly technological and interdisciplinary subject in applied science. It acts from the computer, besides an influence brought into component design and component interaction, a good working knowledge of engineering mechanics, hydraulics, electricity and electronics, control and modern control theory, instrumentation and computer science.

It is clear that a "one-volume book" about all aspects of hydraulic power systems would result in an work of thousands of pages. Therefore authors have to make a logical selection between some topics of these disciplines and put them together in a coherent and possible way. The choice lies between two extremes, and depends on the target group.

The first extreme includes all topics which keep mathematics and calculations as simple as possible, but try to give a clear physical insight into the operation and interaction of all components in hydraulic circuits (pumps, valves, cylinders, filters, etc.), and the use of hydraulic power. To be complete in their content, they should also describe rules and practical hints for hydraulic systems design and maintenance. Consequently, it should make them not only useful as an introductory course for junior engineers, but also of help to practicing engineers and even to engineers.

In the second extreme, all recent and advanced topics in hydraulic power systems design should get their share. This recently starts with a mathematical representation of the dynamic characteristics of different pumped and controlled system components such as valves, pumps, motors, actuators, and transmission lines. Since most of these show a highly nonlinear behavior, a nonlinear analysis seems inevitable rather a linearized description. These models are not only useful for accurate simulation purposes, which can be employed a design studies, but also to predict and detect the undesirable behavior of some devices under certain working conditions.

The most important topic concerns the use of modern system theory in power hydraulics. Due to their excellent dynamic hydraulic devices are utilized more and more in complex mechanical control systems, e.g. in vibration control on elastic structures, extremely precise position, speed, and force control of flexible robots, active and semi-active suspensions in automobiles; these act for advanced control algorithms. For this reason, state-space and multivariable frequency domain techniques, nonlinear, digital and robust control, adaptive and self-tuning control, model reference control and (on-line) system identification, are becoming indispensable methods in hydraulic power control.

It is evident that the ability to apply these techniques together with their advantages, restrictions, and shortcomings should be described respectively in close relation with hydraulic system characteristics. As a consequence this kind of book would be of interest to (under)graduate students, interested researchers and practicing engineers, who need a profound knowledge of the subject.

Turning to the existing literature in this field, one notices that there exists no single category of books. In the first, the material is handled in a descriptive way (Boswell and Banks, 1966; Ransoh, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 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