Brief History of Fluid Mechanics

Fluid mechanics has a history of erratically occurring early achievements, then an intermediate era of steady fundamental discoveries in the eighteenth and nineteenth centuries.

Ancient civilizations had enough knowledge to solve certain flow problems. Sailing ships with oars and irrigation systems were both known in prehistoric times. The Greeks produced quantitative information. Archimedes and Hero of Alexandria both postulated the parallelogram law for vector addition in the third century B.C.. Archmedes (285-212 B.C.) formulated the laws of buoyancy and applied them to floating and submerged bodies, actually deriving a form of the differential calculus as part of the analysis.

Up to the Renaissance, there was a steady improvement in the design of such flow systems as ships, canals, and water conduits, but no recorded evidence of fundamental improvements in flow analysis. Then Leonardo da Vinci (1452-1519) derived the equation of conservation of mass in one-dimensional steady flow. Leonardo was an excellent experimentalist, and his notes contain accurate descriptions of waves, jets, hydraulic jumps, eddy formation, and both low-drag (streamlined) and high-drag (parachute) designs. A Frenchman, Edme Mariotte (1620-1684), built the first wind tunnel and tested models in it.

In 1687, Isaac Newton (1642-1727) postulated his laws of motion and the law of viscosity of the linear fluids now called newtonian. The theory first yielded to the assumption of a "perfect" or frictionless fluid, and eighteenth-century mathematicians (Daniel Bernoulli, Leonhard Euler, Jean d'Alembert, Joseph-Louis Lagrange, and Pierre-Simon Laplace) produced many beautiful solutions of frictionless-flow problems. Euler developed both the differential equations of motion and their integrated form, now called the Bernoulli equation. D'Alembert used them to show his famous paradox: that a body immersed in a frictionless fluid has zero drag. These beautiful results amounted to overkill, since perfect-fluid assumptions have very limited applications in practice and most engineering flows are dominated by the effects of viscosity. Engineers began to reject what they regarded as a totally unrealistic theory and developed the science of hydraulics, relying almost entirely on experiment. Such experimentalists as Chézy, Pitot, Borda, Weber, Francis, Hagen, Poiseuille, Darcy, Manning, Bazin, and Weisbach produced data on a variety of flows such as open channels, ship resistance, pipe flows, waves, and turbines.

At the end of the nineteenth century, unification between experimental hydraulics and theoretical hydrodynamics finally began. William Froude (1810-1879) and his son Robert (1846-1924) developed laws of model testing, Lord Rayleigh (1842-1919) proposed the technique of dimensional analysis, and Osborne Reynolds (1842-1912) published the classic pipe experiment in 1883 which showed the importance of the dimensionless Reynolds number named after him. Meanwhile, viscous-flow theory was available but unexploited since Navier (1785-1836) and Stokes (1819-1903) had successfully added the newtonian viscous terms to the governing equations of motion. Unfortunately, the resulting Navier-Stokes equations were too difficult to analyze for arbitrary flows.

In 1904, a German engineer, Ludwig Prandtl (1875-1953), published perhaps the most important paper ever written on fluid mechanics. Prandtl pointed out that fluid flows with small viscosity (water and air flows) can be divided into a thin viscous layer, or boundary layer, near solid surfaces and interfaces, patched onto a nearly inviscid outer layer, where the Euler and Bernoulli equations apply. Boundary-layer theory has proven to be the single most important tool in modern flow analysis. The twentieth-century foundations for the present state of the art in fluid mechanics were laid in a series of broad-based experiments by Prandtl and his two chief friendly competitors, Theodore von Kármán (1881-1963) and Sir Geoffrey I. Taylor (1886-1975).