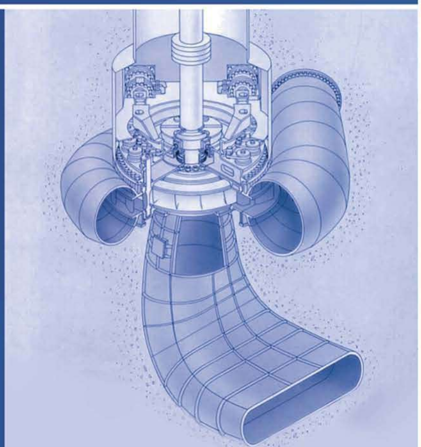
透平机械：水轮机与水泵专业英语

Professional English for Turbomachines: Hydraulic Turbines and Pumps

主编 ● 王辉艳 刘小兵



TOSHIBA Hydraulic Turbine

西南交通大学出版社

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前　言

本书可作为高等学校能源与动力工程专业水力机械及工程、水利水电动力工程方向本科生，以及动力机械及工程、流体机械及工程专业研究生的专业英语教材，还可以作为透平机械设计、制造、管理人员，水利水电工程设计、建设和管理人员专业英语参考书。

本书所选英文文献针对性较强，大多摘自原版英文技术资料、教材和相关网站，难度适中。本书共分为两大部分，第一部分主要讲述的是各种常用水轮机（切击式、斜击式、双击式、混流式、轴流定桨式、轴流转桨式、斜流式和灯泡贯流式）的结构、组成部分、各部分的功能、运行原理，以及水轮机的调速和选型；第二部分主要讲述的是离心泵的基本结构、基本参数、基本理论、能量损失、特性曲线、运行原理、空化空蚀，以及轴流泵和容积式泵。考虑到课堂教学的时间以及学生的知识结构等因素，本书共分为 18 章，每一章都是一个专题，每个章节的字数都在 2 000 英文单词左右，适合在两个学时内进行讲解。

为了方便学习，章节后附有本章中出现的重点词汇表，在书后还附有全部的英—中、中—英词汇对照表。每章后提出了总结性的问题，附有相关参考文献或参考网址，有助于教师、学生和专业人员查找相关的资料，并了解最新的动态。书后还附有每章内容的完整译文，供参考。

本书由流体及动力机械教育部重点实验室，四川省研究生教育教学改革项目，西华大学研究生教育教学改革项目资助出版，编者在此表示感谢。

鉴于编者水平有限，教材中难免存在不足与疏漏之处，敬请使用本书的师生和其他读者批评指正。

编　者

2016 年 5 月

CONTENTS

0 Exordium

0.1 Definition of a Turbomachine

Turbomachines are defined as all those devices in which energy is transferred to or from a continuously flowing fluid by the dynamic action of one or more moving blade rows. The word “turbo” or “turbinis” is of Latin origin and implies that which spins or whirls around. Essentially, a rotating blade row, a rotor or an impeller changes the stagnation enthalpy of the fluid moving through it by doing either positive or negative work, depending upon the requirement of the machine. These enthalpy changes are intimately linked with the pressure changes occuring simultaneously in the fluid.

0.2 Classification of Turbomachines

0.2.1 According to Power Conversion Directions

Two main categories of turbomachines are identified: firstly, those absorb power to increase the fluid pressure or head (fans, compressors, and pumps); secondly, those produce power by expanding fluid to a lower pressure or head (wind, hydraulic, steam, and gas turbines). Fig.0.1 shows a variety of turbomachines commonly used in practice. The reason why so many different types of either pump (compressor) or turbine are in use lies in the almost infinite range of service requirements. Generally speaking, for a given set of operating requirements, one type of pump or turbine is best suited to provide optimum conditions of operation. Only hydraulic turbines and pumps are studied in this book.

0.2.2 According to Flow Paths

Turbomachines are further categorized according to the nature of the flow paths through the passages of the rotor. When the path of the through-flow is wholly or mainly parallel to the axis of rotation, the device is termed an axial flow turbomachine [e.g., Fig.0.1(a) and (e)].When the path of the through-flow is in a plane wholly or mainly perpendicular to the rotation axis, the device is termed a radial flow turbomachine [e.g., Fig.0.1(c)]. Mixed flow turbomachines are widely used. The term mixed flow in this context refers to the direction of the through-flow at the rotor outlet when both radial and axial velocity components are present in significant amounts. Fig.0.1(b) shows a mixed flow pump and Fig.0.1(d) shows a mixed flow hydraulic turbine.

0.2.3 According to Pressure Changes

All turbomachines can be classified as either impulse or reaction machines according to whether pressure changes are absent or present in the flow through the rotor. In an impulse machine all the pressure changes take place in one or more nozzles, the fluid being directed onto the rotor. The Pelton wheel, Fig.0.1(f), is an example of an impulse turbine. In a reaction machine, both the kinetic energy and pressure energy change when the fluid flows through the rotor. Fig.0.1(a-e) are all reaction machines.

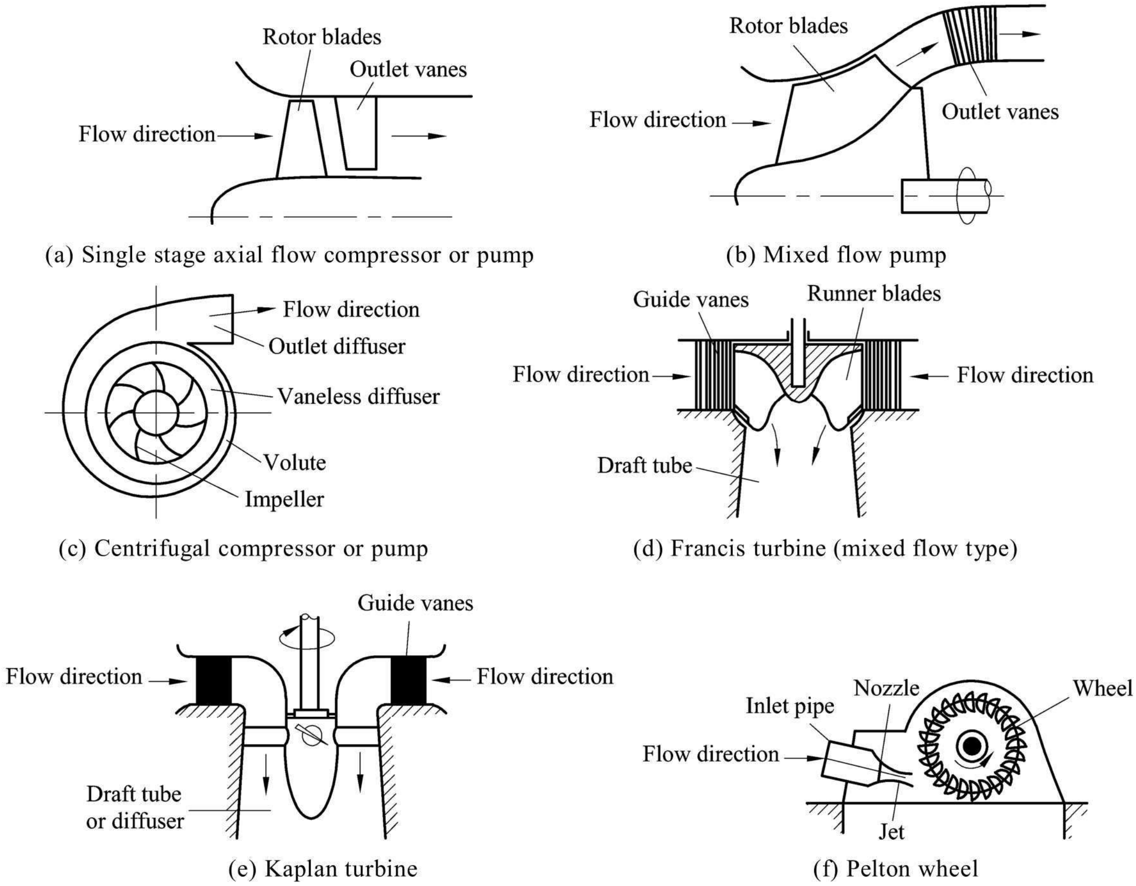

Fig.0.1 Examples of turbomachines

Questions

1. Define turbomachines.
2. Classify turbomachines according to power, flow path and pressure changes.

Reference

[1] S. L. Dixon and C. A. Hall. Fluid Mechanics and Thermodynamics of Turbomachinery [M]. 6th ed. Oxford: Butterworth-Heinemann, 2010.

Important Words and Phrases

absent　缺少的
axial flow　轴流；轴向流动
axis of rotation　旋转轴；转动轴
blade row　叶栅；叶片排
category　种类；分类
centrifugal compressor　离心式压缩机
compressor　压缩机
diffuser　扩散器；导轮
draft tube　尾水管
dynamic action　动力作用；动态作用
enthalpy　焓
exordium　绪论
expand　扩张；扩大
fan　风机
flow path　流动路径
fluid　液体；流体
Francis turbine　混流式水轮机
gas turbine　燃气轮机
guide vane　导叶
head　水头
hydraulic turbine　水轮机
identify　辨认；识别
impeller　叶轮
impulse turbine　冲击式水轮机
impulse　冲击式
infinite　无限的；无数的
jet　射流
Kaplan turbine　转桨式水轮机
kinetic energy　动能
mixed flow hydraulic turbine　混流式水轮机
mixed flow pump　混流泵
mixed flow　混流
negative work　负功
nozzle　喷嘴
optimum　最适宜的
outlet　出口
parallel　平行的
passage　通道
Pelton wheel　切击式水轮机
perpendicular　垂直的；正交的
plane　平面
positive work　正功
power conversion　能量转化
power　能量；动力
pressure energy　压能
pump　泵
radial flow　径向流；辐流
reaction　反击式
rotating　旋转；转动
rotation axis　旋转轴；转动轴
rotor　转子；转轮
simultaneously　同时地
spin　快速旋转
stagnation enthalpy　滞止焓
steam turbine　蒸汽轮机
through-flow　过流
turbo　涡轮
turbomachine　透平机械；透平机械；涡轮机
vane　叶片
vaneless　无叶片的
velocity component　速度分量
volute　蜗壳
wheel　转轮
whirl　旋转；回旋
wind turbine　风轮机

1 Hydraulic Turbines

1.1 Introduction

Hydraulic machine is a device in which mechanical energy is transferred from the liquid flowing through the machine to its operating member (runner, piston and others) or from the operating member of the machine to the liquid flowing through it. Hydraulic machines in which, the operating members receive energy from the liquid flowing through it and the inlet energy of the liquid is greater than the outlet energy of the liquid, are referred as hydraulic turbines. Hydraulic machines in which energy is transmitted from the working member to the flowing liquid and the energy of the liquid at the inlet of the hydraulic machine is less than the outlet energy are referred to as pumps.

It is well known from Newton's Law that to change the momentum of fluid, a force is required. Similarly, when the momentum of fluid is changed, a force is generated. This principle is also used in hydraulic turbine. In a turbine, blades or buckets are provided on a wheel and directed against water to alter the momentum of water. As the momentum is changed with the water passing through the wheel, the resulting force turns the shaft of the wheel performing work and generating power.

Hydraulic turbine uses potential energy and kinetic energy of water and converts it into usable mechanical energy. The mechanical energy available at the turbine shaft is used to run an electric power generator which is directly coupled to the turbine shaft. The electric power which is obtained from the hydraulic energy is known as hydroelectric energy.

1.2 Development History

The hydraulic turbine has a long period of development. Its oldest and simplest form is the water wheel, which was firstly used in ancient Greece and subsequently adopted throughout medieval Europe for the grinding of grain, etc. It was a French engineer, Benoit Fourneyron, who developed the first commercially successful hydraulic turbine (circa 1830). Later Fourneyron built turbines for industrial purposes that achieved a speed of 2300 r/min, developing about 50 kW at an efficiency of over 80 percent.

The American engineer James B. Francis designed the first radial-in-flow hydraulic turbine which became widely used, gave excellent results and was highly regarded. In its original form it was used for heads of between 10 m and 100 m. A simplified form of this turbine is shown in Fig.1.1. It can be observed that the flow path followed is essential from a radial direction to an axial direction.

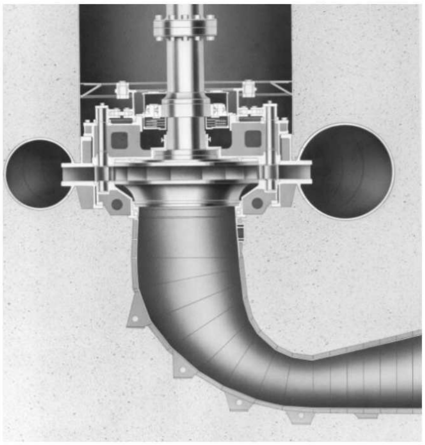

Fig.1.1 A simplified Francis turbine

The Pelton wheel turbine, named after its American inventor Lester A. Pelton, was brought into use in the late nineteenth century. This is an impulse turbine in which water is piped at high pressure to a nozzle where it expands completely to atmospheric pressure. The emerging jet makes impacts onto the blades (buckets) of the turbine, producing the required torque and power output. A simplified diagram of a Pelton wheel turbine is shown in Fig.1.2. The head of water used originally was between about 90 m and 900 m (modern versions operate up to heads of 2,000 m).

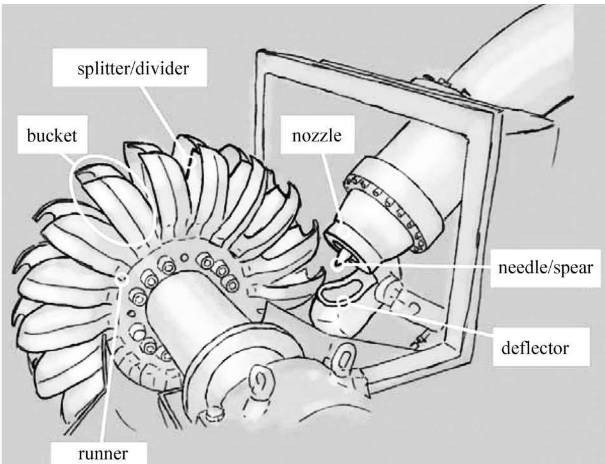

Fig.1.2 A simplified Pelton turbine

The increasing need for more power during the early twentieth century also led to the invention of a turbine suitable for small heads of water, i.e. 3 m to 9 m, in river locations where a dam could be built. It was in 1913 that Viktor Kaplan revealed his idea of the propeller (or Kaplan) turbine (see Fig.1.3), which acts like a ship's propeller in reverse rotation. Then Kaplan improved his turbine by means of swivelable blades, which improved the efficiency of the turbine in accordance with the prevailing conditions (i.e. the available flow rate and head).

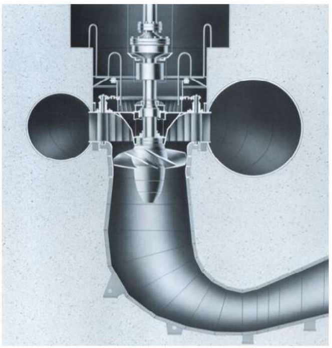

Fig.1.3　A simplified Kaplan turbine

1.3　Turbine Classification

The turbine has vanes, blades, or buckets that rotate around the axis by the action of the water. The rotating part of the turbine or water wheel is often referred to as the runner. The rotary action of the turbine in turn drives an electrical generator to produce electricity or drives other rotating machineries. Hydraulic turbines are machines that develop a torque from the dynamic and pressure action of water.

The hydraulic turbines are classified according to the flowing direction of water through vanes, the head at the inlet of the turbines, the specific speed of the turbines, and the pressure change of liquid through the runner.

1.3.1　According to the Direction of Flow through Runner

Tangential flow turbines: In this type of turbines, the water strikes the runner in the tangential direction to the wheel. Example: Pelton wheel turbine (Fig.1.2).

Radial flow turbines: In this type of turbines, the water flows in radial direction. The water may flow radially from outwards to inwards or vice versa. If the water flows from outwards to inwards through the runner, the turbine is known as inward radial flow turbine. Example: old Francis turbine. If the water flows from inwards to outwards, the turbine is known as outward radial flow turbine. Example: Fourneyron turbine (Fig.1.4).

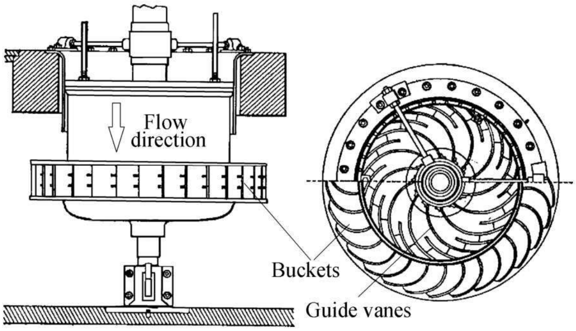

Fig.1.4　Fourneyron turbine

Axial flow turbines: The flow of water is in the direction parallel to the axis of the shaft. Example: Kaplan turbine and propeller turbine (Fig.1.3).

Mixed flow turbines: The water enters the runner in the radial direction and leaves in axial direction. Example: Modern Francis turbine (Fig.1.1).

1.3.2 According to the Head at the Inlet of Turbine

High head turbine: In this type of turbines, the net head varies from 150 m to 2000 m or even more, and these turbines require a small quantity of water. Example: Pelton wheel turbine.

Medium head turbine: The net head varies from 30 m to 150 m, and these turbines require moderate quantity of water. Example: Francis turbine.

Low head turbine: The net head is less than 30 m and these turbines require large quantity of water. Example: Kaplan turbine.

1.3.3 According to the Disposition of the Turbine Shaft

Turbine shaft can be either vertical or horizontal. In modern practice, Pelton turbines usually have horizontal shafts whereas the rest, especially the large units, have vertical shafts.

1.3.4 According to the Specific Speed of the Turbine

The specific speed of a turbine is defined as the rotating speed of a geometrically similar turbine that will develop unit power when it works under a unit head (1m head). It is prescribed by the relation $n_s = \frac{n\sqrt{P}}{H^{5/4}}$.

Low specific speed turbine: The specific speed is less than 50 (varying from 10 to 35 for single jet and up to 50 for double jet). Example: Pelton wheel turbine.

Medium specific turbine: The specific speed varies from 50 to 250. Example: Francis turbine.

High specific turbine: the specific speed is more than 250. Example: Kaplan turbine.

1.3.5 According to the Pressure Change of Liquid through the Runner

Based on the pressure change of liquid when it flows through the runner, turbines can be grouped into two types. One type is the impulse turbine, which utilizes the kinetic energy of a high-velocity jet of water to transform the water energy into mechanical energy. The second type is a reaction turbine, which develops power from the combined action of pressure energy and kinetic energy of the water.

1.3.5.1 Impulse Turbines

An impulse turbine is driven by high velocity jets of water from a nozzle directed on to buckets fixed on the periphery of the runner. The resulting impulse spins the turbine and leaves the fluid with diminished kinetic energy. There is no pressure change of the fluid on the