Chapter

Introductory Chapter: Rotating Machinery

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1. Introduction

Rotating machinery or turbomachinery is a machine with a rotating component that transfers energy to a fluid or vice versa. Consequently, in a turbomachine there is energy transfer between the fluid and the rotor through dynamic interaction. Generally, if the energy transfer is from the rotor to the fluid, it is either a pump or fan. If the energy transfer is from the fluid to the rotor, then the machine is called turbine.

We come across a turbomachine in everyday life. In fact, we come to use a turbomachine at least once in a day. When we dry our hair with a hair dryer, we are using a turbomachine. A hair dryer blows room temperature air over nichrome (alloy of nickel, chromium, and often iron) hot coils speeding up water evaporation. The important component of the hair dryer is the one that blows air (aka fan). This component is a turbomachine. Another commonly used household machine is the clothes washer. The washing machines need to drain the used dirty water and replace it with fresh water. To do so an important component of a washing machine is a pump that is used to remove the dirty water and supply fresh water. This pump is a turbomachine.

If you own a car, you know how important it is to maintain an optimum operating temperature of your car. A water pump (hydrodynamic pump) is essential to your car's operation. The pump ensures that the coolant keeps circulating through the engine block, hoses, and radiator and maintains an optimum operating temperature.

Another everyday example is a kitchen vent. Fans inside the kitchen vent that pull the fumes in and push them via ductwork to the outside or through filters (that remove odors) and vent them back into the room are turbomachines.

Besides a washing machine, a dishwasher, or a kitchen vent, when we are writing on our laptop/desktop, when we turn on the bathroom vent, and when we turn on a desktop fan or a ceiling fan, we are using turbomachines.

All these components, the little fan in our computer which helps maintain the temperature of our computer or the ceiling fan which provides the thermal comfort needed in summer times, have certain types of geometry and shapes. You have probably noticed the difference in shapes and the number of blades between a windmill and modern wind turbine. These shapes and numbers are a result of careful analysis of fluid flow or air flow through these machines.

2. Advances in rotating machinery research

As turbomachines are key machines used in power generation and energy conversion, recent research focus has been on improving the aero-thermal performance of these machines and their efficiencies. In the aviation industry, research has focused on reducing environmental impact and fuel consumption. Most of the current research in rotating machinery is concentrated mainly in the following areas [1–7]:

- Fluid dynamics of turbomachinery (numerical simulation, theoretical model, and experimental measurement)
- Noise reduction methods and noise testing technologies in fans, compressors, pumps, and wind turbines
- Optimization methods
- Turbomachinery materials performance enhancement

Although turbomachines are one of the most widely used machines, the two main areas of applications are power generation and propulsion. Current high-level research topics related to power generation turbines include numerical modeling of two-phase flow fields, and research efforts are aimed at reducing erosion (cavitation erosion and liquid drop erosion) in these machines [8, 9, 10]. Computational fluid dynamics (CFD) is being increasingly used to assess blade design with respect to aero-elastic instability for improving component life span and efficiency [11]. CFD analysis is used to minimize cavitation effects in hydraulic turbines, thus leading to better performance, efficiency, and cost savings. Identification of alternative fuels emission reduction is another area of research as environmental regulations get stricter. Research focus includes studying the combustion characteristics of alternative fuels (ethanol, palm methyl ester (PME), dimethyl ester (DME), hydrogen/syngas, and biofuels [12–17]).

3. Concluding remarks

Turbomachines are essential for they have key applications including power generation. Consequently, research and development is driven by the relevant industry. Research focus thus is on increased efficiency (geared toward cost savings), reliability (increasing life span of a component), and sustainability (driven by stricter regulations). CFD has emerged to be important in designing and analyzing turbomachinery components.

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