Electro-Mechanical Energy-Conversion Machines

❖ Principle of Operation and justification for Rotary Machine to work as Motor as well as generator

A large amount of electrical power is used to provide heat during winters, either for heating a room or for heating water in a geyser. During summers, we use electrical power to provide cooling, as in air-conditioners or refrigerators. Some heat conversion is used to provide light as in the common light bulb. But a lot of electrical power is used to drive machines in industry and homes. Useful gadgets like fans, tape-recorders, mixies, etc., all run with the help of a ***motor*** fixed inside them. Basically, these motors take energy from electrical power mains and ***convert*** it into mechanical energy which is used to turn the blades of the fan or mixie. Reverse conversion takes place in a machine called ***generator***. You have a generator (also, called *dynamo*) in your car. While the car is running, the dynamo converts mechanical energy (drawn from the engine) into electrical energy which keeps on charging the battery.

Motors and generators are electro-mechanical energy-conversion (EMEC) devices or machines*. The process of electro-mechanical energy conversion is essentially *reversible* (except for a small amount which is lost as heat energy). In both the motor and the generator, it is the *magnetic field* that ***couples*** the electrical system and the mechanical system, as illustrated in Fig. 14.1. The magnetic field provides the mutual link between the two systems. The energy to be transferred from one system to the other is temporarily stored in the magnetic field and then released in the other system.

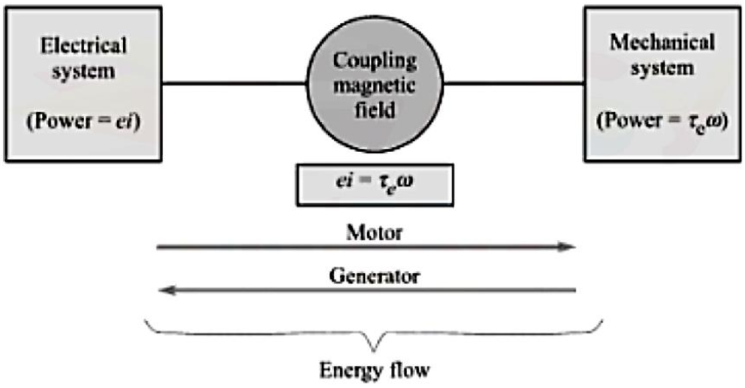

Fig. 14.1 *Representation of electro-mechanical energy-conversion (EMEC) machines.*

The interchange of energy between the electrical system and mechanical system takes place through the conductors placed in a magnetic field. The primary quantities in the electrical system are *induced emf* (e) and *current* (i). The analogous quantities in the mechanical system are *electromagnetic torque* (τ_e) and *angular speed* (ω), respectively.

When the electrical system is characterized by direct current, the machines are called *dc motors* and *dc generators*. Similarly, if the electrical system is characterized by alternating current, the machines are called *ac motors* and *ac generators*. Basically, the ac machines are not different from the dc machines. They differ merely in the constructional details. Only for our convenience, we discuss different type of machines in different Chapters.

Essentially, an electrical rotary machine has two parts—the fixed part, called the ***stator***, and the moving part, called the ***rotor.*** Following are the two phenomena associated with the operation of a machine:

1. Whenever the conductors of a coil cut across the magnetic flux (or are cut by it), an emf e is induced in it. This emf can supply a current i to an electrical load. Thus, an electrical power ei is generated. This is the *generator action.*
2. Whenever a current-carrying conductors of a coil are placed (perpendicularly) in a magnetic flux, a force is experienced by each conductor giving rise to an electromagnetic torque τ_e. This torque can rotate a mechanical load at an angular speed ω. Thus, a mechanical power $\tau_e\omega$ is generated. This is the *motor action.*

Both the generator action and motor action go hand in hand in an electro-mechanical energy-conversion machine. Only the direction of power flow decides whether the machine is a generator or a motor, as illustrated in Fig. 14.1. In a generator, the magnetic field converts the mechanical power $\tau_e\omega$ into electrical power ei. Reverse is the conversion in a motor. Conservation of energy dictates that we must have

$$\boxed{ei = \tau_e\,\omega} \qquad (14.1)$$