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Fossil Fuel Power Stations

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Fossil power stations utilize the thermal cycle described by the laws of thermodynamics to convert heat energy into mechanical energy. This conversion, however, is highly inefficient as described the second law of thermodynamics, where a large amount of the heat energy must be wasted in order to convert the rest into mechanical energy. The description of the conversion process is depicted in formula.

Since heat flows only from high temperature to low temperature, a heat sink temperature $T2 < T1$ is needed to facilitate the flow of heat. The second law states that the ideal efficiency η ideal of a heat engine (turbine, internal combustion engine).

$$\eta_{ideal} = (T1 - T2)/T1 * 100\%$$

Keep in mind that this efficiency does not include the friction and other mechanical losses, heat leakages, etc. Therefore, the real efficiency less than η ideal. In modern thermal power stations, the temperature of the source T1 is about 500- 600 ºC, while the temperature of the heat sink T2 about 30-70 ºC.

The turbine of the power station is installed between the heat source and the heat sink. The turbine is a thermo-mechanical device (heat engine) that converts the heat energy into mechanical energy. It extracts some of the thermal energy of Q1 and converts it into mechanical energy W. The rest is dissipated in the heat sink, without which no heat travels through the turbine.

The mechanical energy W is the difference between the source energy Q1 and the energy dissipated in the heat sink Q2.

$$W = Q1 – Q2$$

The ideal efficiency of the turbine η ideal can be written in terms of heat energy as

$$\eta \text{ ideal} = (Q1 – Q2)/ Q1*100\%$$

Note that if T2=T1, the heat sink does not dissipate any heat energy, that is, Q2=Q1. In this case, no mechanical energy is produced by the turbine, and the turbine efficiency is zero [1].

Fossil Fuel

Since the start of the industrial revolution in Europe in the 19th century, the world became dependent on energy produced by fossil fuel, which was realized as an effective and reliable source for energy. Fossil fuel is formed from fossil buried for millions of years. It is composed of high carbon and hydrogen elements. Because the information of fossil fuel takes millions of years, it is considered non-renewable.

Most of the fossil fuel is used in transportation and industrial processes, and a relatively small percentage is used to generate electricity. Almost 70% of the world’s oil is consumed by the transportation sector, and only 2 % is used to generate electricity [2].

Description of a Thermal Power Station

Generally, most fossil fuel power stations have similar designs. The main differences among them are the designs of their burners, fuel feeders, and stack filters. Nevertheless, these differences are not essential for the description of the operation of any thermal station, and therefore, we shall discuss the coal-fired type only.

Typical views of the powerhouse of a thermal power station consist mainly of a turbine and a generator. The turbine consists of blades mounted on a shaft. Blades of turbine are designed to capture the maximum thermal energy from the steam.

The process of work starts when coal is delivered to the station by trucks and railroad trains. The coal is then crushed and delivered to the burnt via conveyor belts. The coal is then burnt to generate heat that is absorbed by water pipes inside the boiler. The water turns into high-pressure steam at high temperature. The steam leaves the boiler at a temperature higher than 500ºC and enters the turbine at a velocity greater than 1600km/h. The high-speed steam hits the blades of the turbine and causes the turbine to rotate. The rotating turbines shaft is connected to the shaft of the generator, thus causing the generator to rotate, and electricity is generated. Because of the presence of the condenser (heat sink), the thermal cycle is completed as described by the second law of the thermodynamics. The condenser cools the steam to about 50ºC, turns it to a liquid form and goes back to the boiler to complete the thermal cycle. Inside the cooling tower, the condenser uses water from the nearly lake to cool down the steam.

Conclusion

Although coal-fired power stations are wide-spread and simple in design and easy to maintain, they have some considerable disadvantages:

1. The first and the most important disadvantage is the pollution of the environment. Fossil fuel power stations are major producers of pollution (carbon dioxide CO_2, carbon monoxide CO, sulfur dioxide SO_2, nitrous oxide NO_x, and others products of coal combustions). In fact, burning of coal from the power plants and industrial sector is responsible for 30-40% of the total carbon dioxide CO_2 in the air. It is main cause of breach delicate balance in the atmosphere.

2. The conversion of heat energy into mechanical energy is highly inefficient, because heat leakages and other mechanical losses are big.

3. Fossil fuel is non-renewable resource and world’s stores of oil and natural gas are exhausted [2].

References:

1. Mode of access: https://en.wikipedia.org/wiki/Fossil_fuel_power_ station/. – Date of access: 15.03.2017.

2. Mode of access: https://books.google.by/books?isbn=1498760031/. – Date of access: 17.03.2017.