DLPSTAFFS

Go green

ENERGY AND THE ENVIRONMENT

I. INTRODUCTION

- Energy is an essential part of our daily lives.
- Need of energy:-

  a) to provide heating, cooling and processing of fluids.

  b) to provide electricity to drive machines, or power lights.
- All living things need energy too. Plants use the light from the sun to grow. Animals and people eat the plants and use the energy that was stored.
- Food is fuel for our bodies energy needs like muscle power.

- The very first energy source was the sun providing heat and light during the day.
- Later fire was discovered by a lightning strike, producing another source of heat and light.
- In the next section will discuss the various forms of energy, and how it converts from one form to another form.

II. FORMS OF ENERGY

- We associate energy with devices whose inputs are fuel based such as electrical current, coal, oil or natural gas; resulting in outputs such as a movement, heat or light.
- Unit of energy is the Joule (J). The rate of producing energy is POWER which has the unit of Joule per second or the watt(W).
- There are five forms of energy:-
  a) Mechanical Energy
  b) Electrical Energy
  c) Chemical energy
  d) Nuclear Energy
  e) Thermal Energy

a) Mechanical Energy:-

- This type of energy is associated with the ability to perform physical work.
- Two forms of mechanical energy:-
  I. potential energy
  II. Kinetic energy

Potential energy:

As the name implies is contained in a body due to its height above its surroundings, examples such as the gravitational energy of the water behind a dam, and the energy stored in batteries.

Potential Energy = Mass X Acceleration due to gravity (9.81) X height above datum

$$E_p = m \times g \times h$$

The energy produced by one kilogram of water falling from a height of 100m above ground is a potential energy, which can be calculated as follows.

$$Ep = 1 \times 9.81 \times 100 = 981 \text{ J/kg}$$

Kinetic energy:

kinetic energy is related to the movement of the body in question. Examples of KE such as the flywheel effect and the energy of water flowing in a stream.

Kinetic energy = ½ mass x velocity squared

$$Ek = \frac{1}{2} \times m \times v2$$

The water stream in a river flowing at a velocity of 2m/s has a kinetic energy of:

Kinetic Energy = ½ mass x velocity squared = ½ x 1 x (2)2 = 2J/kg

b) Electrical energy:-

This type of energy as the name implies is associated with the electrons of materials. Electrical energy exists in two forms:

Electrostatic electricity:-

- Electrical energy is produced by the accumulation of charge on the plates of a capacitor. Charles Coulomb first described electric field strengths in the 1780s.

- The electrical force varies directly with the product of the charges. The greater the charges, the stronger the field.

- The field varies inversely with the square of the distance between the charges. This means that the greater the distance, the weaker the force becomes.

$$F = k (q1 \times q2) / d2$$

- Where q1 and q2 are the charges, d is the distance between the charges. And k is the proportionality constant which depends on the material separating the charges.

Electromagnetic energy:-

- This type is produced with a combination of magnetic and electric forces. It exists as a continuous spectrum of radiation.
- The most useful type of electromagnetic energy comes in the form of solar radiation transmitted by the sun that forms the basis of all terrestrial life.

c) Chemical energy:-

- This type is associated with the release of thermal energy due to a chemical reaction of certain substances with oxygen.
- Burning wood, coal or gas is the main source of energy we commonly use in heating and cooking.
- The energy liberated from the combustion of a given mass of fuel, with a known calorific value in a combustion chamber of known efficiency is given by:

chemical energy = Mass of fuel x Calorific value x Efficiency of combustion

d) Nuclear energy:-

This energy is stored in the nucleus of matter, and is released as a result of interactions with the atomic nucleus. There are three types of nuclear reactions:-

Radioactive decay:

In which one unstable nucleus (radioisotope) decays into a more stable configuration resulting in the release of matter and energy.

Fission:

A heavy nucleus absorbs a neutron splitting it into two or more nuclei accompanied by a release of energy. Uranium U235 has the ability to produce 70x109 J/kg.

$$E= mC2$$

Where m is conversion of matter into energy, C is speed of light.

Fusion:

Two light nuclei combine to produce a more stable configuration accompanied by the release of energy. Heavy water (Deuterium) fusion reaction may produce energy at the rate of 0.35x1012 J/kg

e) Thermal energy:-

Thermal energy is associated with intermolecular vibration resulting in heat and a temperature rise a if it is in bove that of the surroundings. Thermal energy is calculated for two different regimes:

When the substance in a pure phase, say if it is in a liquid, gas or solid, then
Thermal energy = mass x specific heat capacity x temperature difference

During a change of phase, such as evaporation or condensation, it can be calculated by:
Thermal energy = mass x latent heat

However, if there is a change of phase, say during the condensation of water vapour into liquid, there is an additional amount of heat released while the temperature remains constant during the change of phase.

For 1 kg of water to be heated at ambient pressure from 20 to 120 0C, the requirement is

Thermal energy = heating water (20-100) 0C + evaporation at 100 0C +super-heating vapour (100-120) 0C

Thermal energy = 1x 4.219 x (100-20) + 1x2253.7 + 1x2.01 x (120-100)

= 337.52 +2256.7 +40.2

= 2634.42 kJ

III. ENERGY CONVERSION

It is important to understand that losses are encountered during the transformation of energy during the different conversions into the final form for a given application, for example consider a wind turbine, the following conversions take place:

Kinetic energy of the oncoming air strikes the rotor blades, turning them, and hence the axial kinetic energy is turned into mechanical energy of the rotating blades.

Some of this mechanical energy is lost in the control mechanism, consisting of the gear box and brake to regulate the speed and match it with that of the generator. Some energy losses are encountered due to friction.

The shaft turning with the remaining energy will rotate in turn the generator; hence converting it’s the output into electrical energy (mechanical to electrical).

Some losses are dissipated through the mechanical connections between the turbine and the electrical generator.

Electricity is used by customers for lighting/heating or to operate electric devices such as radio, television, etc. electrical devices are designed to operate on an optimum condition; efficiency of the operation will vary depending on its use, age and maintenance.

100 units of energy are stored in the incoming air as kinetic energy.
40 units are converted into rotational / mechanical energy by the blades.
35 units are transferred by the shaft; some units are absorbed by the brake and gear.
33 units are converted from mechanical into electrical energy in the electrical generator.
30 units is the net output, as 3 units are lost in voltage conversion, storage and distribution.

The final figure depends on many factors, including the type of turbine, efficiency of the control system, efficiency of the generator, and the quality of the transformer and the distribution system.

From/ To	Mechanical	Electrical	Thermal	Chemical	Nuclear
Mechanical	Gear Nutcracker Push mover	Electric Generator	Friction	X	X
Electrical	Electric motor	Light bulb	Electric fire	Electrolysis	Particle accelerator
Thermal	Steam turbine	Thermo-couple	Heat exchanger	X	Fusion reactor
Chemical	Jet engine Rocket	Battery Fuel cell	Car engine Boiler	Intermediat e reaction	X
Nuclear	X	X	Nuclear reactor	X	X

IV. ENVIRONMENTAL IMPACT OF FOSSIL FUELS

Coal, Oil and natural gas have their relative merits in terms of availability, price and thermal performance. The below table is constructed for comparison of the heat capacity, CO2 and SO2 production by the three fossil fuels. the 4th column is of particular importance in comparing all three fuels; it represents the quantity of carbon dioxide emitted for every unit of energy produced.

Coal produces the highest amount of carbon dioxide for a given output of energy; then oil, then natural gas which produces nearly half the emission of coal and a third less than that of oil.

The results displayed in the table below for the production of CO2 mass per unit energy compares well with data published by the UK government, Action on Energy, the values found in this chapter are lower than those quoted in the reference, the difference is that the calculations shown in this chapter…

Were only concerned with the combustion process itself; there other knock on effect in the calculations when the life cycle of the fuel is considered, hence the addition of energy used to transport, process the fuel, and to include distribution losses.

Fuel	Calorific value MJ/kg	CO_2 Kg/kg fuel	CO_2/ Energy Kg/MJ	SO_2 Kg / kg fuel
Coal	26	2.361	0.091	0.018
Oil	42	3.153	0.075	0.040
Natural gas	55	2.750	0.050	0

Environmental impacts of fossil fuels