Samenvatting

Technische Bedrijfskunde

Energy Technology

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Energy Technology

Energy, Work, and Power

Work is causing an object to move into, or out of, some position, especially when it moves against the resistance

Energy is the capacity for doing work

Power is the rate of doing the work

Power = Work / Time

Work = Force x distance

Human energy

Early observation

Fuel + O_2 → CO_2 + H_2O + ENERGY

Food+ O_2 → CO_2 + H_2O + ENERGY

1 nutritional calorie (Calorie) = 1000 calories = 1 kilocalories = 4.184 kJ

A calorimeter can be used to measure the energy released form foods

There is no difference between ENERGY being released from food or from fuel

The energy balance

Food energy in – Food energy used = Food energy stored

A *system* is whatever portion of the universe ins under specific observation or study.

For any system: $E_{in} - E_{used} = E_{stored}$

If no energy is stored or 'hidden' in a system, a process that produces more energy than was originally in is impossible

Energy → Work + Waste (heat)

Whenever energy is converted into work, a portion is wasted (usually as heat)

Energy cannot be converted completely to work. Some energy is inevitably wasted.

Fire

Fire was the first energy source used by humans, other than the muscles of human or animals

Fire was first used for safety against animals
Then it was used for warmth and light
Then for cooking

Fire was very abundant, easy to handle and store, easy to ignite and was a low tech fuel.

It was the dominant fuel until 19th century

Heat is a form of energy

Nothing is truly destroyed in a fire

In a system (for an example of a system, check figure 5.5) of a fire with the use of methane is this the formula

CH_4 + O_2 → CO_2 + $2H_2O$ (+ heat)

State is the condition in which a system happens to exist

When a system undergoes a spontaneous change from one state to another, energy is released

Getting the energy to do work means that we need to figure out how to take advantage of spontaneous changes in systems.

The energy released during combustion comes from energy stored in the chemicals bonds of the fuel and the oxygen

Gaseous fuel have small molecules that mix easily with air

With firewood, the heat comes from the stored energy in the bonding molecules.

Wood energy is a form of stored solar energy

An energy crisis is not a result from running out of energy supply. It is a result from real or contrived difficulties in distribution and matching it with demand.

The problem with the fire and houses is that there was too much smoke. This led to the invention of the chimney.

Franklin invented the Franklin stove for use of firewood in home.

Waterwheels

The energy associated with moving bodies is called kinetic energy.

Kinetic energy can be used to do work

When water stands still we talk about potential energy. It isn't kinetic energy because it doesn't move yet. More complete will be gravitational potential energy.

When a system undergoes a spontaneous change from high potential to low potential, we can extract energy.

2 types of waterwheels. Undershot and overshot.

Undershot: Kinetic energy, velocity of water, simple construction, low costs to build.
Overshot: Superior if scanty flow, potential energy, buffering.

Overshot was fully developed in 400 AD. It was used to cut timber and stone or for flower and oil.

The waterwheel had not been used for mechanical purposes until the middle ages.

Water was as vital an energy resource to medieval Europe as oil is to us today

The model describing the transport and fate of water around the world is called hydrologic cycle

Water power is an indirect form of solar energy

Water is very reliable form of energy but it has a lot of limitations. They can only be located near streams. They won't work if the word freezes or dries up and during war, the enemy would cut off the water supply.

Wind energy

Winds are a manifestation of solar energy

Wind differs in one crucial aspect compared to water. The wind can and does change at the most places in the world daily.

Post mills are windmills that turn with the direction of the wind by manpower.

The windmills were a cheaper investment because there was no need for a dam, sluices, and other water-control equipment. Also the windmill could be placed everywhere. It will also still work during winter.

Windmills were not really important in areas where there was enough streaming water.

The post mills became unwieldy as they got bigger. Turning the windmills was getting harder as the windmills got bigger. Most of the times they would get wrecked by heavy storms.

A turret mill was a windmill that would have a solid base instead of wood.

The fantail was a windmill that had the right angle to change direction when the wind would do that too.

The limitation of the windmill and waterwheels is that the power or work has to be done on location.

Both wind and water have a limitation when used as energy. Not all the kinetic energy is processed to work.

It is impossible to convert energy completely into work

Energy cannot be converted completely into work. Some energy is inevitably wasted.

Steam Engine

The medieval world was based on three energy sources: Draft animals, watermills and waterwheels. The first major invention was the steam engine.

Leonardo Da Vinci made a steam operated gun

Denis Papin made a pressure cooker

Otto von Guericke

- Used air to make two spheres strongly against each other. Two groups of eight horses were not strong enough to separate them. He showed the world there was a lot of power with air pressure
- First implosion was also from an experiment from Otto von Guericke

Papin started with gun powder and noticed that steam was better. His engine would push a piston down and that made it possible to lift something heavy.

Saverin started with a boiler that created steam rather than boiling the water right in the cylinder. This engine was inefficient, expesive to buy and operate and it was dangerous. It was called the miners friend.

Newcomen made the first successful steam engine that used steam to do work. He used counter weight to the piston. The engine had a lot of flaws. It was very slow, real effort was atmospherically. It was wasteful because it had to swing between warm and cold. It was also very enormous in size. It was a commercial success because it was better than the available technology. Only 1 or 2 percent of the potential energy of coal was actually set into work.

James Watt made a second chamber that was always cool. So by using two chambers, the machine became more efficient than because it didn’t have to change from hot to cold. One chamber was always warm and the other was always cold (the condenser). The second crucial improvement was the invention of a system called the sun-and-planet gear. It made a up-and-down motion of the piston possible. His engine made 6 or 7 percent of the potential energy of coal. He put a patent on his invention and sold a lot of engines. He defined how much work a horse could do and made a new name of unit for power called horsepower.

Richard Trevithick tried to go around the patent of James Watt. He was thinking that with a high-pressure, it was possible that the engine could move itself. Our even more. Steam was the energy of the industrial revolution. It made everything geographical close because of the easy way of transporting goods.

Charles Parsons & Carl Gustav Laval

Heat and Thermal Efficiency

Efficiency = output / input
This was important because if you had a negative efficiency, it will cost you more work to get the output than to get the input.

Heat spontaneously flows from an object at high temperature to one at low temperature.

With the waterfall and the burning methane cases, the systems are from a high energy potential to a low energy potential. In the case of potential energy from heat, we refer to thermal potential energy.

The three systems that are used as example (waterfall, methane and terminal) all have the same in common. There is a high potential energy, a low energy potential and a way to get energy from this potential.

Gay-Lussac found out that, when a gas gets heated, it expands by about 1/300 in volume for each degree Celsius. It didn't matter what gas it was. There were two restrictions: The pressure of the gas must remain constant and the amount of the gas being studied must also remain the same.

The exact number of this observation was 1/273 for each degree that increased or decreased. When the volume was 273/273 the gas would vanish. This isn't possible so that is how they know -273°C is the maximum lowest temperature.

Temperature	Volume	Volume remaining
0°C	0/273	273/273
-1°C	1/273	272/273
-100°C	100/273	173/273
-273°C	273/273	0/273

Kelvins = °C + 273

In 1851 William Thomson saw that when the temperature becomes 0K, there would be no potential energy left. On the basis of this analogy, available energy can be expressed as Th – Tl. h = high and l = low.

$\boldsymbol{n} = \frac{\boldsymbol{Th-Tl}}{\boldsymbol{Th}}$ **$\boldsymbol{n}$ = efficiency**

$\%\boldsymbol{n} = 100\left(\frac{Th-Tl}{Th}\right)$ $\%\boldsymbol{n}$ = efficiency in %

In this equations the T must always be in K

This efficiency value is called Carnot efficiency.

100 % efficiency is impossible because Tl of 0 K is impossible

It is impossible to convert thermal energy to work completely. This is a fact that is for a forms of energy

Example:
$\%\boldsymbol{n} = 100\ \left(\frac{Th - Tl}{Th}\right)$

$\%\boldsymbol{n} = 100\ \left(\frac{100 - 0}{100}\right)$ =1 or 100%

Tl = 0 is impossible so to get a Th – Tl = Th is impossible

Heat is a form of motion

The total amount of energy in the universe is always the same. It can be converted in other forms but it can't be created nor destroyed.

Heat can move in a system by three mechanisms:
- *Conduction*
It occurs when heat is transferred directly through the body of an object. Atoms from a warm object move rapidly because they have the most kinetic energy. The atoms from an cooler object, will be affected by the kinetic energy until they move just as fast.
- *Convection*
This is the process where heat transfer occur in gases or liquids. An example is the steam from boiled water.
- *Radiation*
We can sense heat from an object without being in direct contact with it for conduction or feeling it through convection.

It doesn't matter which mechanism there is for heat, the heat will always move from a warm to a cooler object.

Electricity

First observation of electricity was rubbing pieces of amber against each other that made it possible to abstract small objects. This was discovered by Thales of Miletus

The first significant contributors was William Gilbert in 1570. He called objects with feeble attractive forces 'electrics'. This was later called static electricity.

Otto von Guericke built a machine that consisted of a large ball of sulfur that could rotate at high speeds in 1660. He didn't realise the potential that it had.

Franklin proposed the concept that electricity is a fluid in mid=eighteenth century. (not true)

Stephen Gray started experimenting with electricity. He found out that electricity doesn't stay in one object. Some objects could rapidly pass electric fluid, now called conductors. Some object retained the electric fluid, now called insulators. One day he connected a metal rod on both ends in a dark room. He saw sparks and it looked like thunder. He realized that lighting was somehow similar to electricity.

Charles François Du Fay discovered to kinds of electricity. One that was generated from rubbing glass, the other from rubbing a piece of resin. He found out that the same kind of electricity repelled against each other but the opposite kinds attracted.

Franklin realized that the concept of two kinds of electricity wasn’t necessary. He found out that when two conductors were rubbed against each other, it will either lose electric fluid (become negative) or gain electric fluid (become positive). When a positive object gets in contact with an negative object, the electricity would move from the positive object to the negative object. One of the most famous experiments was the thunder-kite-experiment. Franklin flew a kite with a key on it during thunder. It didn’t kill him even though it was a very dangerous experiment.

In the systems water, thermal and electricity, the potential energy goes from high to low. To measure the amount of energy from electricity, we used current

Current = Change / Time

The unit of Current was Ampere or amp

Conductors and isolators don’t have the same equal as conductors or isolators. It is determined by the resistance.

It was now a custom to think in resistance instead of conductivity.

Current = I	Amps = Coulomb (C) / second (s)
Potential =V	Volts = Joule (J) / Coulomb (C)
Resistance =R	Ohm
Power = P	Watts
Energy = E	Kilowatts-hour

Current = Potential / Resistance	I = V / R
Resistance = (Length . Resistivity) / Area	
Power = (Charge / Time) . Potential	
Power = Current . Potential	P = I . V
Power = Resistance . (Current)^2	$P = R . I^2$

There are two molecules in a battery. A “+” and a “-“

Primary cells have a one-way chemical reaction. After fully consumption it is completely useless. Secondary cells can be recharged when going out of potential.

There is always a little electricity in the air. Faraday’s law showed it to us.
Faraday’s law is the way electricity is produced through magnetism.

AC vs DC
There were two competing systems. Edison had a lot of patents and was a good businessman. He

sold electricity only the big problem was the power of the electricity. The electricity would lose its use after a few kilometres. This was when DC was used. Westinghouse was a huge fan of AC. The biggest scientist of Westinghouse was Tesla. Edison started a hate campaign against AC. Even though the hate campaign, AC is now the most used way of electricity.

Petroleum

Long time petroleum was used for light. Later petroleum was used to make asphalt for roads. This happened a long time ago in Babylon and Bagdad.

Petroleum = all carbon byproduct that are liquid.
Started with photosynthesis.
It changes from inorganic to organic to kerogen.

Kerogen is a mixture of large, complex organic compounds.

Small molecules are gas
Large molecules are liquid

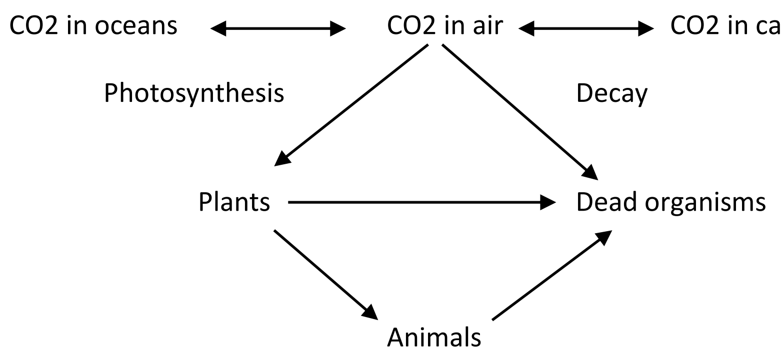
Old oil has different molecules than newer oil.

Carbon cycle is when the carbon dioxide warms up the earth and that increases the carbondioxede in the air.

Respiration gets O2 and C from food and gives CO2. Trees do it the other way around. The C that they get out of the air, is put in the ground. If a bacteria gets to this C, it makes it CO2. This can't happen when there is no air supply.

Using trees and oil by burning to get energy, is called combustion. It will give more CO2 in the air.

Cold water takes in more CO2 than warm water.

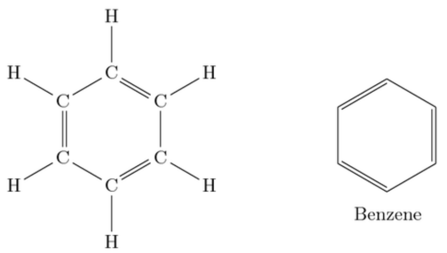


Oil is made by natural gas, and oil that are trapped under gray shale. It is formed by pressure and a high temperature.

Natural gasses are gasses like
Methane = CH_4
Ethane = C_2H_6

The formula for natural gasses are C_nH_{2n+2}

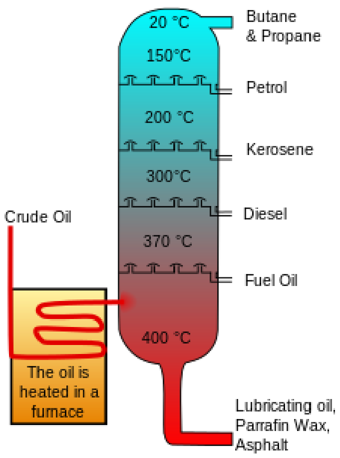
Benzene is C_6H_6. It has three double bindings. It looks like this



Distillation is the most important step in petroleum refining.

The gasoil molecule gets a bigger speed and breaks into other molecules and changes into benzene and other molecules.

Distillation:



Gasoline

The four-stroke Otto cycle has four strokes:

The intake stroke
The piston moves down, an intake valve opens and a gasoline-air mixture enters the cylinder.
The compression stroke
The piston moves up and the valve closes
The power stroke
There is a spark and the heat raises the pressure. The high pressure pushes the piston down. *This stroke converts the chemical potential energy in the gasoline molecules into the mechanical work.*
The Exhaust stroke
The piston moves up and the exhaust valve opens.

Breaking Uranium in two parts results in the release of 40-50 times the energy.
When Uranium is thrown in neutrons, the Uranium will absorb one of the neutrons.
This will make the uranium unstable and break it in two equal parts.
This is nuclear fission.
The uranium is split in barium and krypton. They release 3 neutrons plus a high amount of energy.
The 3 neutrons can be combined with more uranium and will make a high amount of energy.

The nuclear reactor has three components.

Fuel elements
Moderator
Control rods

The fuel elements come in thin rods and contain uranium. All the fuel elements together is called the reactor core. The reactor core is in water inside of the moderator. The moderator slows down the neutrons in the reactor. The neutrons are produced by the fuel elements. The main function of the control rods is to absorb any spare neutron in the moderator to prevent any further reaction. These rods are mostly made of boran of cadmium.

The nuclear reactor has a thick wall, the reactor core, heat exchanger and a pump. The energy of the reactor core heats up the water in the heat exchanger. The heat is then used to rotate the turbine. The water is constantly pumped into the nuclear reactor.

There are two types of generating energy from nuclear fission. The boiling water reactor and the pressurized water reactor.
The difference is that the in the PWR the water is kept under pressure to prevent it from boiling. The non nuclear steam is pushed to the turbine that moves the generator.
The BWR uses boiling water to directly move the turbines and rotate the electoral generator.

Nuclear fusion is the fusion or combination of nuclei.
Nuclear fusion can be defined as a nuclear reaction, in which lighter nuclei are combined together to form heavier product nuclei with the release of enormous amount of energy.

When two hydrogen nuclei (example) come together to merge. It gives deuterium, a positron and an neutron. When a deuterium is combined with another hydrogen, it will form helium isotope. If two helium isotopes are fused together, there will be a heavier helium. These 3 steps, where four protons come together, is called a nuclear fusion.

Biomass

Carbon neutrality. Is when the carbon dioxide increase is just as high as the carbon dioxide decrease.

Biomass is using organic material as an energy source. Biomass can be:

Natural, without human intervention.
Residual, remains from other natural used product.
Energy crops

Wood is the most used biomass material. Biomass can be used for heat.

Industrial biomass, at times it is used to generate energy. It is burned in the furnace and heats the water. The steam from the water rotates the turbine and generator.

Advantage of biomass.

100% renewable
Reduces the use of fossil fuels (less CO2)
Creates employment in rural areas
It is recyclable

Process of pyrolysis
For a successful process of pyolysis you need dry biomass. The biomass is grinded and moved in the pyrolysis reactor. There is an airlock to maintain the oxide supply. The combustor preheats the reactor. The reactor produces raw gases. The raw gases go to the char collection. The raw gases and char are send to a cyclone and that filters out the char. The raw gases continue to the quench system. The raw gases are quenched with cold water. The raw gases cool down and the bio-oil is saved. The spare gasses are reused. The bio-oil is stored.

Production of bio-methanol steps

1. Solids to gas. Non-food biomass is applied with heat pressure and steam to convert it into synthesis gas, which is cleaned. The biomass feedstock is fed into a hopper and is conveyed into a devolatilization unit. The heat and pressure are applied to convert the biomass into gas. The produced gas is reformed with steam into CO and h2 which is called synthesis gas (syngas). The syngas is cleaned and is fed into the next step.
2. Gas to liquids. The cleaned syngas is passed over a proprietary catalyst and transformed into cellulosic biofuels. These fuels can be separated and processed to yield a variety of low carbon biofuels, including cellulosic methane.

Wind
https://www.youtube.com/watch?v=qSWm_nprfqE

Sun
https://www.youtube.com/watch?v=qIJx2PRGKqw