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Professor Bins

L330- Energy

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An in Depth Look at Oil

Petroleum is one of the world's most important natural resources, and the foundation of our modern civilization.

I don't know what the real "foundation of modern civilization" was, but coal is generally credited with being responsible for the start of the industrial revolution, which was about 50 years before oil in the U.S. (see handout).

With oil being the driving force of industrialization, it seems strange than that so little is known about the processes that create, remove and utilize it. Geologically speaking, petroleum is a renewable resource, in that it is created through a natural process which will repeat in millions of years. Unfortunately this will not help the people of the 21st century, whose the main concern is how to economically remove the most oil from the earth and until recently control as much of the oil industry as possible. Not only does petroleum provide the world with the majority of its energy supply, many oil based petrochemical products have become so much a part of society that it is difficult to imagine life without them.

Petroleum can be found on the earth's surface, but those resources have long since been used up, and now it must be drilled out. The process which creates oil began over a million years ago, when underwater remains of mostly aquatic plant and animal life became buried under layers of sand, silt and rock minerals. Overtime, pressure builds up in the bottom layers and the temperature increases causing the sand and silt particles to become porous sedimentary rocks like sandstone and limestone (Encarta 2004). While this is happening, the decomposed organic

matter recombines to form the system of complex hydrocarbons known today as petroleum, or crude oil The crude oil is less dense that the stone around it and will seep upwards through the pours in the surrounding rocks. If nothing solid blocks its upward movement, it will eventually break the surface, but often the petroleum encounters an impermeable stone, like shale that will prevent its upward flow (Doe.gov 2004). The crude oil becomes trapped between solid rocks and becomes a reservoir.

Locating these reservoirs is the first step to the retrieval and eventual use of petroleum. Traditionally, the only way of finding petroleum was to geologically survey the area and take a core sample of the surrounding rock, but today seismic testing is employed. Shockwaves are sent through the ground and are bounced back at different frequencies depending on the material that they hit (Doe.gov 2004). In this way, drillers can better estimate a place to make an initial well. If the well is discovered to connect to an economically profitable amount of oil, the process can continue. Most oil wells are drilled by using the rotary method. The drill is connected to pipes and a combination of mud, water and air is used to remove debris from the hole while it is being dug. The crude oil in reservoir is trapped within the earth under extreme pressure, so when the drill hole breaks though the cap rock, oil is forced up the well pipe without pumping (see Figure 1). This primary production will continue until the pressure of the reservoir equals the pressure on the surface. The crude oil helps maintain the high pressure in the reservoir for a longer period of time by releasing the natural gas that had been held in liquid form by the super high pressures, but with the gradual release of the liquid petroleum, this gas separates and increases pressure on the liquid (Encarta 2004). Despite this natural boost, the pressure within the reservoir will eventually equalize and then methods of enhanced oil recovery must be implemented.

While the oil is under pressure, it does not take any energy to remove it from the ground, but enhanced oil recovery requires extra energy input so the process quickly becomes energetically and economically unfeasible. The two most popular methods of enhanced recovery involve the displacement of the petroleum by increasing the pressure in the reservoir. This is done using either water or steam. In the water injection method, water can be pumped directly into the reservoir if there is little clay content (see Figure 2), but usually it is pumped into an alternative chamber or emptier reservoir to increase the pressure. Steam injection is used when the reservoir contains viscous oils: oils that are thick and flow very slowly. The increased temperature caused by the steam helps the petroleum flow faster. Primary production will remove about 25% of the crude oil from the reservoir, and enhanced methods can bring this number up to 60% using the direct water injection method. However, even using enhanced methods of recovery, the average yield of an oil reservoir is only 33% of the total oil it contains (Encarta 2004). The reason why 67% the world's most importance resource can be abandoned can be found within the business world and the historical developments of the international economy.

It remains to be seen whether the remaining 67% will be economically and environmentally competitive with renewables when the world's cheap oil suppies run out.

Historically, the increasing levels of oil production and control that businesses had over the production and distribution of oil allowed them to stop production when reservoirs become unprofitable. Oil has long been under the dominion of the developed nations of the world, "from the inception of the industry in the previous century, until about 30 years ago all aspects were firmly under the control for the international oil companies" (Omorogbe, 3). This system of control was called the concessionary system and was lead by the "Seven Sisters" of big oil: the

Dutch company Shell, BP or British Petroleum, and the American companies Exxon, Mobil, Chevron, Texaco and Gulf.[1] These companies in confederation had enough control over the oil industry to set the world price of oil. This control was gained by covert or overt backing of foreign governments and in negations with comparatively ignorant nations. In 1979, political economist Asante wrote,

> "a government which is anxious to attract an investor is compelled by its weak bargaining position to conclude long-term fiscal arrangements without the benefit of all the facts[…] the result is that transitions are invariable lop sided and highly advantageous to the investor" (26).

For example, in 1938 Nigeria was coerced into ceding their entire mainland to the Shell Corporation (4). Even as recently as 1997 more than 70% of the total refinery capacity in the world was wither either operated directly or indirectly by the "Seven sisters"(33).

This connects nicely with Brian's papers on human rights. I think he cited Nigeria as a worst case.

The growing importance of oil in world economics and the peculiarities of petroleum have recently shifted the importance of oil production back to the source countries. In 1960, the Organization of the Petroleum Exporting Countries (OPEC) was formed as a direct reaction against the power of international oil companies (Omorogbe, 4). The economic power shift was so tremendous that soon it was the OPEC nations that were setting the price of oil. Then in 1997, Venezuela reacted to the intense pressure from foreign investors by nationalizing all the assets of oil production and ejecting the foreign companies (20). Today the distribution of oil producers is much more widespread and more and more countries are in control of their national

[1] In more modern times Cheveron has merged with Gulf and the French company Compaigne Francaise des Petroles (CFP), has become so important that it has been labeled the eighth sister (Omorogbe 33).

production and exportation (see Graph 1). This power shift was able to progress because of the nature of petroleum and many of the problems that arise from its transportation. Petroleum is naturally found in the liquid state, and as such is difficult to store and move from place to place; the only ways used today, are pipelines for short distances and ocean tankers for long distances. Also, stockpiling oil is a difficult and cost inefficient, so oil is only bought and shipped in the amounts needed. This means that the best place to keep oil that is not going to direct use is to keep it in the ground. This places a new ball of power firmly in the court of the oil producing nations, and since the 1980's, the price of oil has been subject to free market prices due to the increasing number of internationally independent oil manufacturers (5).

Most oil leaves its native country in the crude form and is taken to other countries where it has to be refined before it can be used to fulfill energy, transportation or petrochemical needs. The basic refinement process, called fractional distillation involves heating the petroleum which separates specific hydrocarbons at different temperatures (see Figure 3). The first material to be distilled from crude oil is gasoline, followed by naphtha used in cleaners and kerosene used in old fashioned oil lamps from the turn of the century. The rest of the mixture is very thick and has to be treated with strong acids to create paraffin waxes and asphalt. To meet increased gasoline demands (see Graph 2) the process of thermal cracking was developed which increases the heat and pressure on the mixture usually allowed to form paraffin and asphalt. Instead of producing these heavier hydrocarbons, the molecules are split into smaller ones that create more gasoline. To create jet fuel and high quality gasoline, a process known as alkylation cracking recombines the smaller hydrocarbons produced by thermal cracking with the use of a catalyst. The catalyst cracking process uses a finely divided catalyst that can produce more diverse hydro

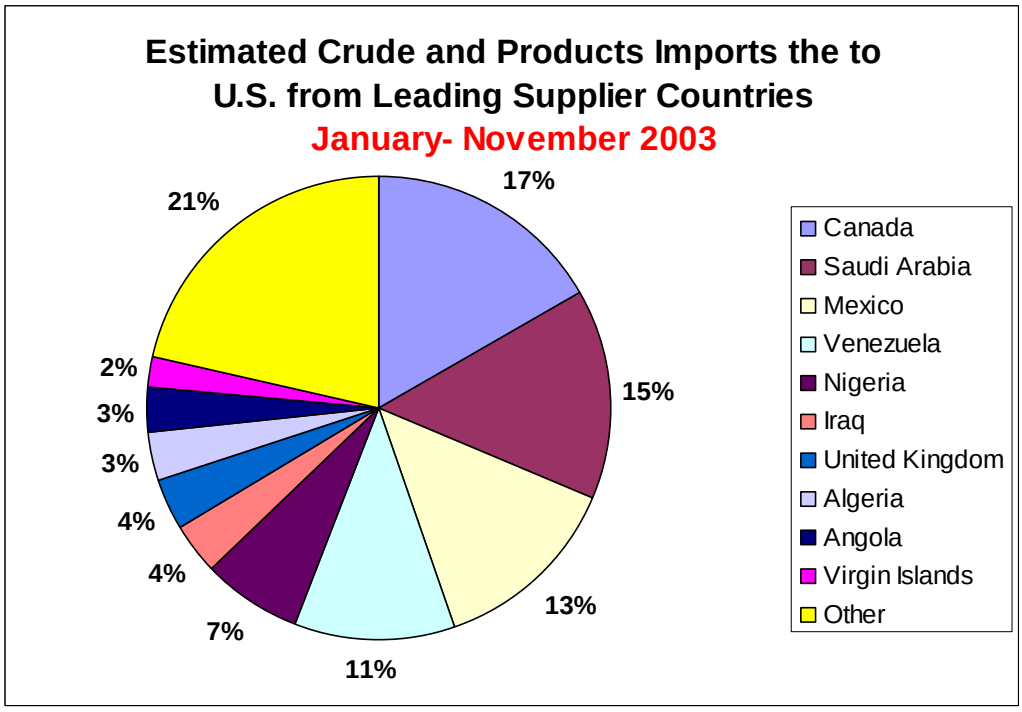
carbons that can be recombined to be used in the vast petrochemical industry (Encarta, oil refinement).

Petroleum is usually discussed and debated on in terms of its energy uses, but the petrochemical industry uses about 5% of the total supply of oil in the United States (see Graph 3). So aside from powering plants that produce electricity and providing fuel for cars, oil is used in the creation of alcohol, detergents, synthetic rubber, fertilizer, solvents, the raw materials for medicines, nylon, plastics, paints, polyesters, food additives, and supplements, explosives, dyes, and insulating materials. (Encarta) The world's dependence on petroleum runs deeper than just energy. Alternative forms of energy conversion, like wind or solar power cannot supply the hydrocarbons needed for petrochemicals. For these products, nothing but chemicals will work. Fortunately, this problem is not being entirely over looked and a solution is being researched. In September of 2001, the Department of Energy began funding a project to investigate vegetable oils as a possible source of hydrocarbons for the future (OIT). Specifically, soybean oil is proposed as the alternative substance because the US is already the world leader in its production. They purpose a process called hydroformylation which is similar to catalyst cracking distillation used in fossil fuels. The problem they are encountering is recovering the catalyst from the reaction so it doesn't contaminate the reformation process. While this solution will not solve the energy problem and the world's dependence of fossil fuels, it will allow the petrochemicals products that are so important to modern health and safety to continue even when petroleum supplies have completely dissipated.

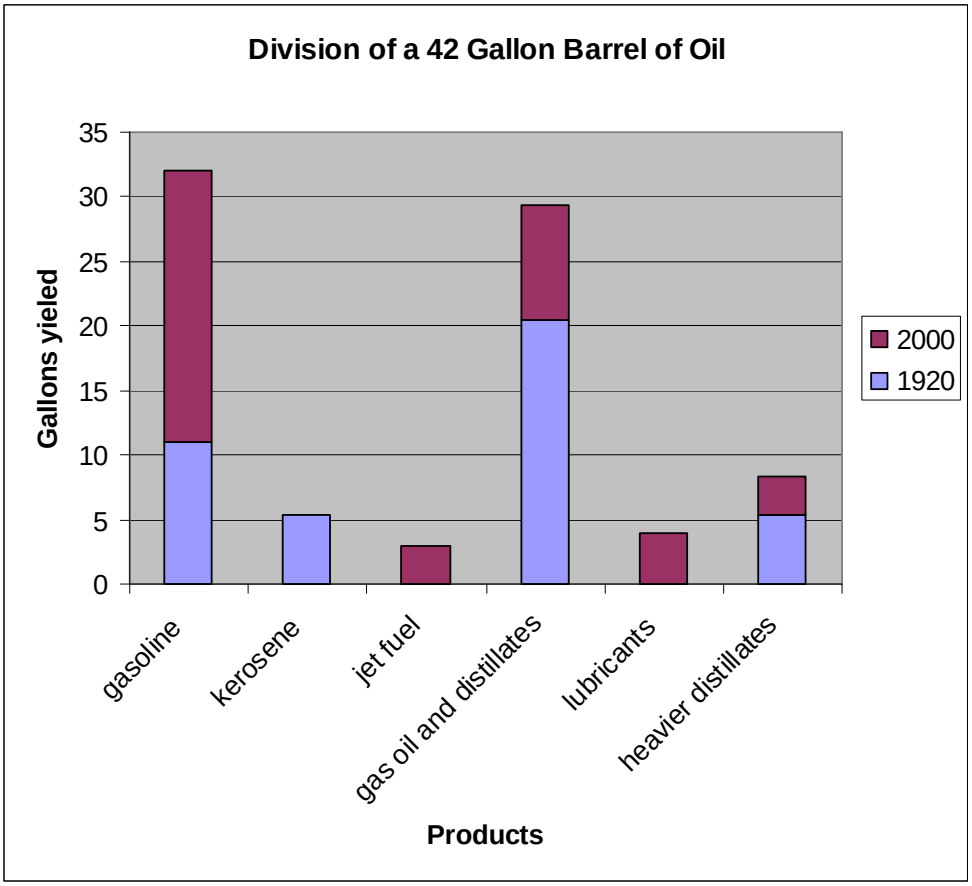
Some think future generations will condemn ours for burning up the world's non-renewable supply of "liquid gold" instead of conserving it for other uses for which there are no substitutes.

Nice graphs and figures.

Graph 1: *(from the American Petroleum Institute- 2004)*



Graph 2: *(Encarta.com- 2004)*



Graph 3: *(polymerplace.com & Encarta.com)*

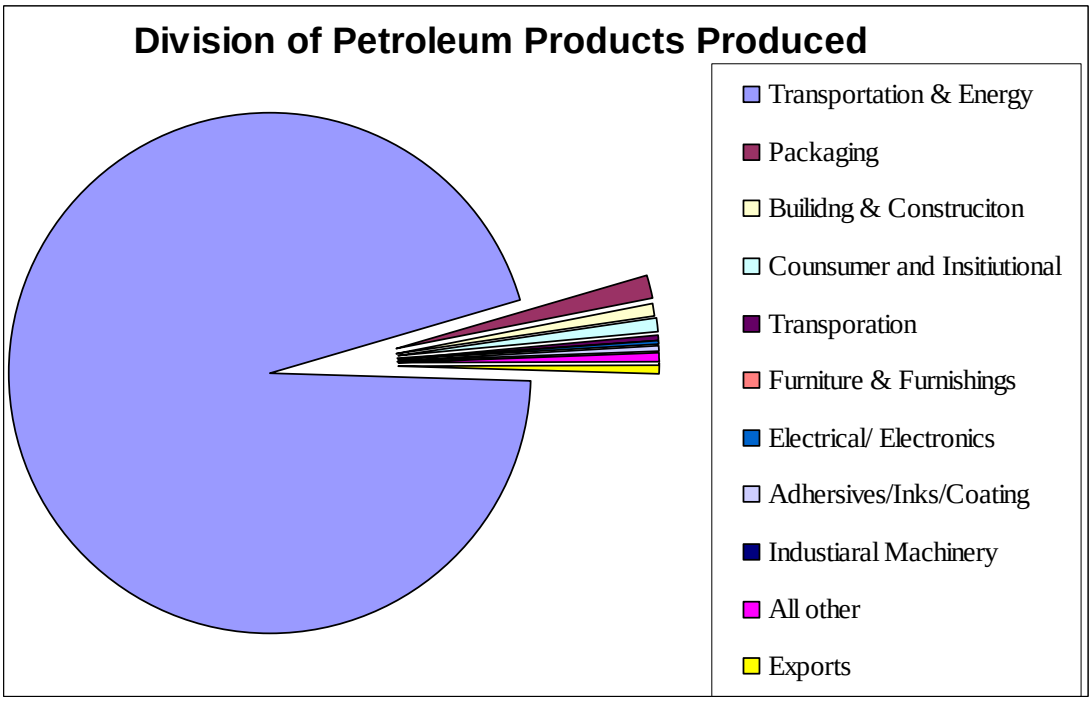


Figure 1: *psu.edu- 1999*

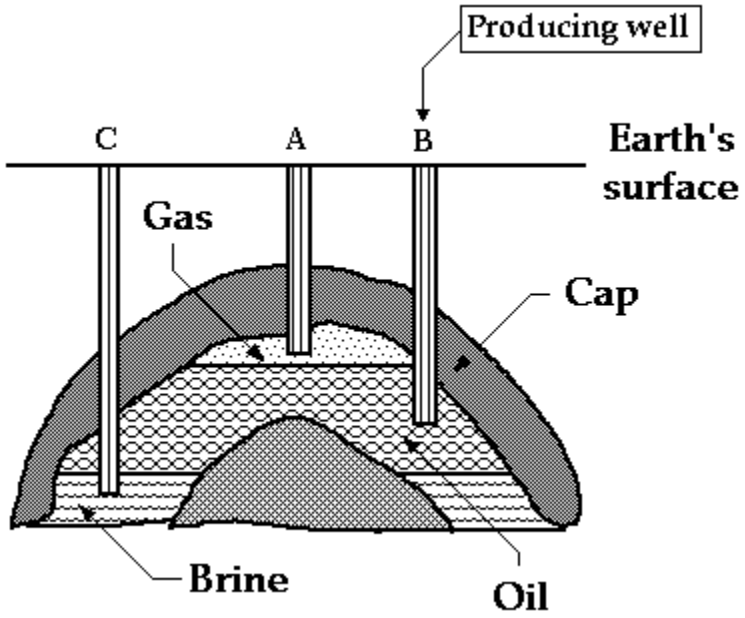


Figure 2: *psu.edu-1999*

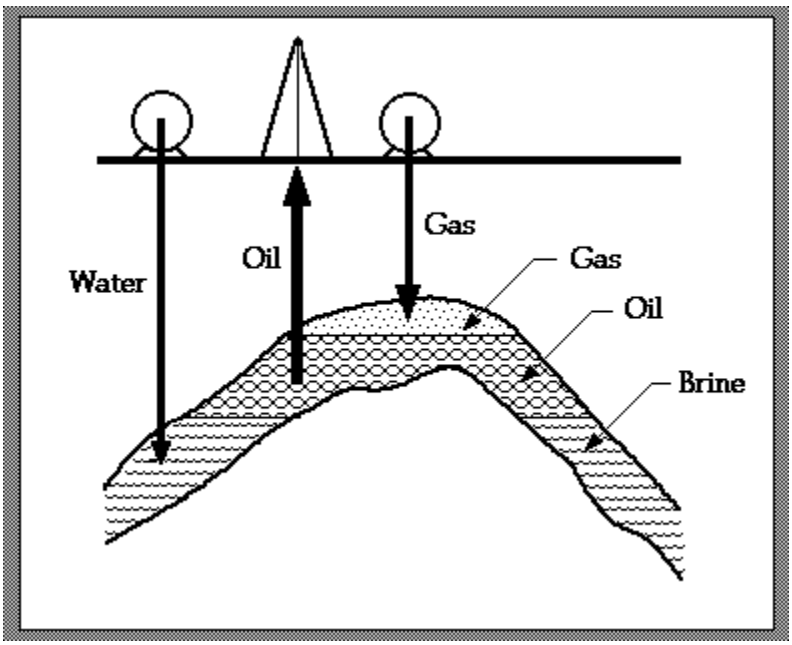
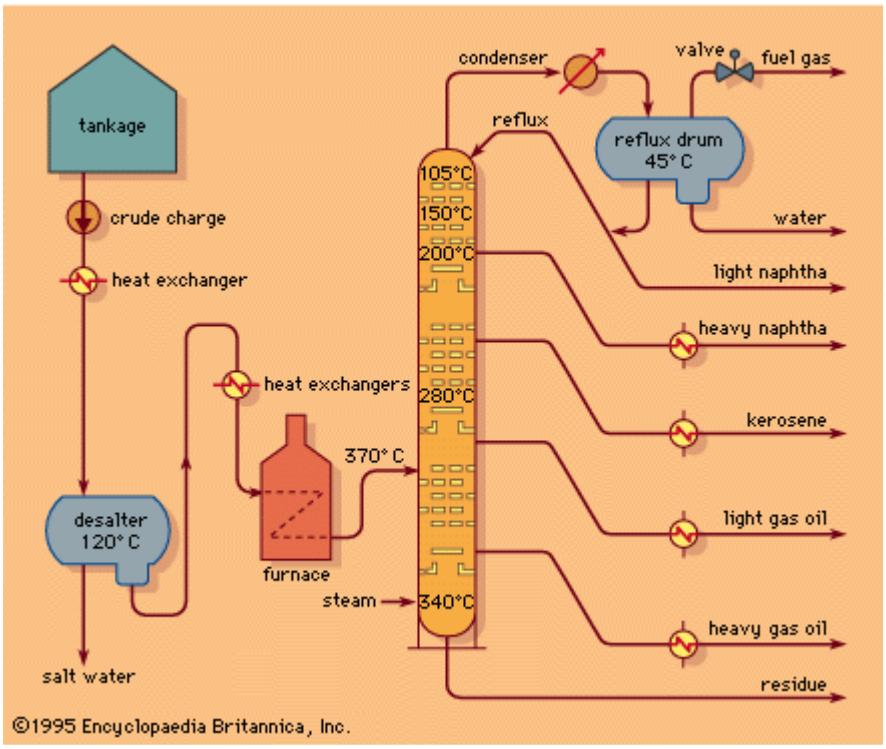


Figure 3: *plantech.or.kr*


tankage
crude charge
heat exchanger
heat exchangers
desalter
120° C
salt water
furnace
370° C
steam
condenser
valve
fuel gas
reflux
reflux drum
45° C
water
105°C
150°C
200°C
280°C
340°C
light naphtha
heavy naphtha
kerosene
light gas oil
heavy gas oil
residue
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