Typical FLOW CHART tracing crude oil from well to finished product

OIL WELL

FIELD STORAGE PIPE LINE PUMPING STATION

PIPE LINE TO REFINERY

REFINERY STORAGE PIPE STILL BUBBLE TOWER

CONDENSER (COOLER)

OIL WELL MANY THOUSAND FEET DOWN IN THE EARTH

GAS OIL WATER

RAW GASOLINE RAW KEROSENE

GAS OIL

CONTINUOUS PURIFYING (WASHING) SYSTEM

ACID WATER CAUSTIC DOCTOR WATER

AGITATOR

FINISHED KEROSENE

CRACKING UNIT

CRACKED GASOLINE

HEAVY FUEL OILS

GAS OIL PIPE HEATER REACTION CHAMBER EVAPORATOR

COOLER

UNCONVERTED GAS OIL

LUBE DISTILLATE

ACID CAUSTIC WATER SUCCESSIVELY

AGITATOR

BRINE OIL AT -30°F

DEWAXED LUBE OIL

CLAY PERCOLATOR

FINISHED LUBRICATING OILS

RAW GASOLINE

GAS OIL PARAFFIN OILS

ASPHALT

HEAVY BOTTOMS

COKE STILL

CONDENSER

COKE

AIR

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Crude petroleum — a heavy, black, foul-smelling liquid that you would never recognize as the parent of the refined products that enter your everyday life — is found far beneath the earth's surface. From the well, it comes up by pipe lines to the producing plant and thence by pipe line, tank car, tank trucks and so on. The efficiency of the modern petroleum industry is illustrated by the fact that one barrel of crude oil, from its extraction to the refinery, is not more than 48 hours old. The transportation and refining of crude oil is only about twenty-five percent of the final cost of the final product which you buy at your gas pump. The rest is divided about equally between taxes and the cost of the complex distribution system which brings the refined products to your doorstep.

A modern refinery is an enormous affair. You can get an idea of its size from the fact that the total building area is 10 square miles, or 1600 acres, 750 feet high. An inch in this model equals a foot in the actual refinery plant. One gallon of crude oil is carried by some 16,000 miles of various pipes and ducts to the refinery. Here it passes through a series of operations, both physical and chemical, through which it is changed into the useful substances which man has learned to make from it. The most important and the most common refinement of the products. The principle on which this is done is, boiling the oil and separating and collecting its various vapors.

The crude oil is pumped from a storage tank 1 through coils in a heater 2 similar in principle to an ordinary hot-water heater except that the coils are thousands of feet long. These coils are heated to more than 700° Fahrenheit, a temperature high enough to boil away all but the heaviest parts of the oil. The gas oil rises to the top of the tank, and the heavier portions of the oil fall to the bottom.

The mixture of vapors from the coils is discharged into the bottom of a high bubble tower 3 and the vapors rise through it while the oil falls down the inside of pipes, is separated into heavy fuel, gas oil, and light fuel, and is finally cooled and collected in trays which are placed at various heights in the tower. The process illustrated by the small diagram on the table before you. The circles represent the oil molecules of the different products. The heavy fuel oil rises to the top of the tower while the lighter molecules – the heavier oil – remain at the bottom of the tower. The heavy vapors do not rise far before they are cooled and condensed by dripping into the condensers. The lubricating oils are contained in this fraction. In the trays higher up the light fuel oil is condensed and separated from the main body of the oil that is drawn off. The lightest vapor, the gas oil, passes out of the very top of the tower and is condensed in a cooler.

After the crude oil has been fractionally distilled through the bubble tower the five separated fractions are stored. For the time being we will put the fuel oil or asphalt in tank 35, the lubricating oil in tank 25, the gas oil in tank 10, the kerosene in tank 20, and gasoline in tank 4. This fractional distillation was a purely physical separation that involved no chemical changes of any sort. That is why it is put away for further handling. Each of these parts, however, contains raw materials which must be processed into important finished products of commerce. This is done largely by chemical processes.

Let us now see what further treatment the five products we have just met go through. First, the raw gasoline must go through the same high-temperature fuel that you fill up with your filling station pump into the tank of your car.

From tank 4 the gasoline is run into a continuous gasoline treating plant, through towers to 10 to 11 to 12. The process is called continuous because it is an automatic operation by which the gasoline is run through all the towers in succession without stopping. The object of this process is to remove those gum-forming substances and corrosive substances including sulfur compounds from the gasoline before it is stored.

From tank 3 the stoves, tractors or any of the numberless uses of this oil. The raw kerosene is taken from storage tank 15, but instead of being pumped into a series of towers it is pumped into the cone-bottomed tank or agitator 14. It too goes through a series of strange baths. Here active chemical compounds are added and mixed with the kerosene by blowing air inside the tank. After this, the oil is allowed to settle in tower 15, the treating agent is drawn off at the bottom. In this manner the kerosene is successfully treated with solid, while the treated stock of acid is washed and washed again, after which it is separated and for use and stored in tank 15.

And now we come to the well-known cracking process. This is one of the most important developments in the oil industry. It doubled the amount of gasoline that could be recovered out of every barrel of crude oil produced would not yield enough gasoline to satisfy the present demand.

Remember the gas oil that was stored in tank 10? Gas oil is mainly used for making more gasoline. Now you will see what is meant by cracking the process. In the process, as its expressive name indicates, the fundamental chemical structure of the oil is completely changed. The oil is taken in the tank and when it is put together again it is no longer gas oil, but two other products, mainly gasoline and some heavy petroleum.

The cracking process, however, involves a chemical change, and is being evaluated by heating the oil at high temperatures under pressure. Let us follow this operation.

The entire cracking process is illustrated by the animated diagram which you see at the edge of the table before you. The various size circles represent molecules of gasoline, gas oil and heavy fuel oil. See how the molecules in the heater and reaction chamber are breaking up, dividing and recombining into new products.

In the cracking process the gas oil cannot be converted completely to gasoline by one passage through the system. It must be circulated several times through the system before it is completely converted into gasoline. For this reason the gas oil is not pumped directly to the heater but is pumped into the bottom of the tank. In this way the cost of the final product which has already been through the cracking process before. The mixture then is pumped out of the bottom of the tower into the heater 17, and the light fuel oil and the heavy fuel oil up to the top of the heater where it is heated to the temperature necessary for cracking.

The heater looks like the heater in the distillation unit, but is much hotter, and in it the oil is heated to such a degree as 1000 degrees Fahrenheit, while under pressures of as much as 1500 Ibs. per square inch. To give more time for the changes to take place the oil vapors are passed without coming from the heater into an empty drum or reaction chamber 18, in which the reaction continually from this reaction drum outer oil is sent to a fractionating tower 24. The gas oil go into an evaporator or separating tower 19 where the heavy tar separates out and is removed. The tar is stored in a tank 20 and the gas oil passes through the bubble tower 21 where the gas oil which has been formed is separated from gas oil by cooling oil oils inside the tower near the top. The gas oil follows through the tower. The gas oil vapors pass out the top of the tower and down to the cooler 7.

From the gas oil we have thus produced a quantity of raw gasoline in addition to the gas oil which we secured from the distillation of the crude oil. This raw cracked gas oil goes to the storage tank 4 where it is mixed with the converted gas oil by distillation and as we have previously seen, is now ready for refining.

Next we come to the refining of lubricating oils. The raw lubricating oil is sent to the top of a tower 20 where it is distilled in an agitator 24 (not quite like the agitator found in a washing machine, but it mixes things up about the same way) where, like kerosene, it is treated with acid and other chemical reagents. One of these is dibutyl phthalate, or a solution of dibutyl phthalate in a solvent. This is drawn off from sludge and asphalt and is drawn off for storage in tank No. 26.

This treated oil, however, still contains something that wouldn't do for your car. Its temperature is not low enough. It didn't come directly from the asphalt. Remember that asphalt is the simple fact that asphalt becomes solid at a low temperature which decrudes it and reduces the liquid. The oil is pumped into tank 35 entering the tank and forth, leaving the cooler at the bottom. The inner oil pipes are surrounded by outer pipes through which binacaine flows and keeps the oil cooled. The oil is cooled up below freezing temperature and practically all the asphalt and pitch in the oil are drawn off. The temperature is raised by the flow of oil in the inner pipes are provided with some very sensitive thermometer which shows the wax is crystallizing and it is moving.

The cold mixture of wax and oil is then pumped into filter presses to the right 27 to separate the oil from the wax. The oil passes through the filter while the wax is held back on the cloth in the press. When the pressure is run off, the wax is removed by the pressure being taken off and the wax is removed. The partly open press shows the internal construction and how wax accumulates inside. The oil passes out to tank 26 and the wax is stored separately in tank 29. This wax is the source of the paraffin the house- owners use in the waxes and the dyes.

The oil is now free from wax and is finished except that its color is not satisfactory and it is not clear. To clarify the oil and improve its color, it is pumped into the top of a condenser 30 where it trickles slowly down through a large bed of fine clay. The oil comes out clear, of bright color and ready to use.

And now to turn to our fifth basic product. What happens to the fuel oil that comes from the bottom of the tower 20? The fuel oil, although it is too heavy for use as household heat, may be used for industry, or for lighting purposes such as natural gas oil. It may be used by the asphalt still 26. This still is first used to crack the fuel oil into light oil, which is run into the tower and prescin a crack, oil, oxidizing it and changing its properties so that it becomes asphalt. Besides, asphalt some lighter oils that come from this process.

Some of this heavy oil that is not recovered for fuel oil or asphalt is inverted into the petroleum coke you use in your furnace. It is run into a cracking still 33 which is similar to the asphalt still except that it has no air pipes and is heated to a much higher temperature so that the heavy ends are finally boiled off or converted into petroleum coke. Lighter and of asphalt still 30 are pumped into the condenser box 34 after they are usually used for industry.

After the process in coke still 33 is complete and the still is partly cooled, it is opened and workmen go in with bare and shoes and remove the coke in lumps. After the coke is crushed and it is ready for use as household or industrial fuel.

We have now shown you how the major products of petroleum are separated and are used. And entirely different use is made of these products today. As we have seen, the refinery produces many grades of these products and also different uses that are made of them. Refineries are finding new uses for their products and is special refining problems. To solve them is work of petroleum chemists, and the chemists today have come one of the most complex branches of applied chemistry.