Chapter 3

Oil,Transportation, and World War

The Race is On!

The story of technology is a story of change. For thousands of years, people used wood and animal dung for cooking and heating and artificial lighting was a rare luxury. The use of coal to power factories and to generate electricity for lighting revolutionized life for the countries that had access to coal. Coal was used to power factories that mass produced consumer goods and weapons that enabled those countries to dominate world trade and to establish empires. The British, French, German, Italian, Russian, U.S., and Japanese empires competed for dominance.

New transportation technologies that used oil allowed the leaders of these empires to seriously consider world domination. The race was on between the empires to see who would take advantage of this new technology to control the world.

Why Do I Need to Know This?

In this unit, we explore the technologies of the internal combustion engine and the manufacture of explosives and how their use was influenced by intolerance and prejudice during two world wars. In this chapter, you gain a perspective on how quickly a new technology can change the world and specifically how oil became such a dominant factor it today's politics and conflicts. These are big topics and we are limited to an overview. You will also learn how to interpret the ratings of biofuels, gasoline octane ratings, and diesel fuel CN ratings to buy the right fuel for your vehicle without paying for more than you need.

1 Pace of Invention Accelerates

Learning Objectives

1. Identify the millennia in which technological inventions related to energy, transportation and warfare were the greatest and how it compared to previous millennia. [3.1.1]
2. Identify the centuries of the second millennia in which technological innovation accelerated. [3.1.2]

The story of technology is a story of change. For thousands of years, people used solid fuels for cooking and heating. Artificial lighting was a rare luxury. That changed dramatically in recent history. If we look at the history of the technologies used for energy, transportation, and war in thousand-year intervals, we see the big jump in such activity in the last millennia, as shown in Figure 3.1.

Millennia (thousand years)	Inventions	Number of Inventions
Before 10th BCE	Knife, cooking, ships, bow, mining	5
10th BCE	agriculture	1
9th BCE	metalworking, village walls	2
8th BCE		0
7th BCE	Bow drill	1
6th BCE		0
5th BCE	wheel and axle	1
4th BCE	canal, stone paved street, sailing	3
3rd BCE	chariot, shipyard, sickle-sword, candles	4
2nd BCE	spoked-wheel chariot	1
1st BCE	catapult, blowgun, iron tools and weapons, trebuchet, water wheel, watermill, compass	7
1st CE (0-999)	chimney, horseshoes, Greek fire, distillation, hang glider, kerosene, windmill, gunpowder, street lamp	9
2nd CE (1000-1999)	Watertight hull, steel, fire arrow, rocket, cannon, piston engine, torpedo, steam turbines, (see next table for 1700-1900)	101

Figure 3.1.Pace of invention accelerates.

Things really began to change in the late 1700s when the energy in coal was used in steam engines which dramatically increased the power available for transportation and manufacturing. People in the countries that developed this resource could travel cheaply on railroads and afford manufactured products. The next dramatic change occurred about 75 years later in 1859 when the technologies of drilling and refining petroleum into kerosene made artificial lighting affordable to most people. Then, only 23 years later, Edison started delivering electricity for lighting. In a little over 100 years introduction of new technologies dramatically changed the way people lived but this was only the beginning. At the end of the 19th century (1800s) petroleum was used for lighting and coal was used for power and transportation. In the early 1900s (20th century) new technologies would change the world again—this time it would only take 15 years, as shown in Figure 3.2.

Quarter-Centuries	**Energy, Transportation, and War**	**Number**
1700-1724	iron smelting with coke, Newcomen steam engine	2

1725-1749	marine chronometer, Franklin stove,	2
1750-1774	steam car	1
1775-1799	submarine, steamboat, Watt steam engine, parachute, hot air balloon, shrapnel shell	6
1800-1824	screw propeller, gas stove, locomotive, arc lamp, electric motor	5
1825-1849	internal combustion engine, electric generator, refrigerator, revolver, incandescent light bulb, vulcanized rubber, pneumatic tire, telegraph, telephone	9
1850-1874	Bessemer steel, elevator, oil drill, lead-acid battery, repeating rifle, torpedo, ironclad, revolving machine gun, barbed wire, dynamite, air brake, cable car, undersea telegraph cable	12
1875-1899	magazine for guns, induction motor, automobile, carburetor, machine gun, motor cycle, AC transformer, gasoline engine, thermal cracking, diesel engine, gas turbine, escalator	12
1900-1924	Dirigible, mercury vapor lamp, air conditioning, radio-telephone, neon lamp, airplane, tractor, sonar, Geiger counter, gyrocompass, hydroplane, parachute, liquid fuel rocket, Tank, tungsten lamp, machine guns in airplanes, radar, radio, wind tunnel	19
1924-1949	turboprop engine, jet engine, helicopter, bazooka, undersea oil pipeline, nuclear weapons, computer, cruise missile, mobile telephone, synthetic fuels	10

Figure 3.2. Major inventions in energy, transportation, and warfare.

The stories of oil technology and the age-old problem of intolerance come together in the first half of the 20th century. Some countries or groups teach their people that they are superior and have a right to dominate or kill other people. There is nothing new about these beliefs but by the early 1900s the energy available in fossil fuels combined with new transportation technologies made world domination by one group more possible than at any previous time. The race was on for world domination. The race would be won by the group that could capture and hold the world's most important physical asset—oil

Key Takeaways

- The most recent thousand years from 1000 to 2000 CE have had the most technological inventions by a factor of about 10. [3.1.1]
- In the most recent thousand years a large majority of the inventions were in the most recent 200 years. [3.1.2]
- Weapons technologies from 1st century B.C. were the catapult and trebuchet, blowgun, and iron. From the 1st century of the Common Era, Greek fire and gunpowder are examples. In the first 700 years of the 2nd century CE, the watertight hull, steel, fire arrows, rockets, and cannon were invented. [3.1.3]
- Energy technologies from 1700s were smelting iron using coke, the Newcomen steam engine, the Franklin stove, the Watt steam engine, and the steam car. From the 1800s, the gas stove,

locomotive, electric motor, arc lamp, internal combustion engine, generator, refrigerator, incandescent light, elevator, automobile, AC transformer, are examples. From the 1900s, the steam turbine and piston engine were invented. [3.1.4]

- Weapons technologies from 1700s were submarine, parachute, and shrapnel shell. From the 1800s, the revolver, repeating rifle, torpedo, ironclad warship, revolving machine gun, barbed wire, dynamite, and machinegun are examples. From the first half of the 1900s, the airplane, sonar, liquid fuel rocket, tank, radar, bazooka, nuclear weapons, and cruise missiles were invented. [3.1.5]

2 Physics and Chemistry of the Internal Combustion Engine

Learning Objectives

1. Define work as a method of transferring energy. [3.2.1]
2. Identify the relationships between compression, temperature, and ignition. [3.2.2]
3. Describe the method of determining octane rating of gasoline and its purpose. [3.2.3]
4. Identify the difference between gasoline and diesel engines. [3.2.4]
5. Describe the method of determining CN rating of diesel fuel and what values are typical for automobiles and trucks. [3.2.5]
6. Identify the codes used to identify the proportion of biofuel for gasoline and diesel. [3.2.6]

The invention of the internal combustion engine revolutionized transportation by creating a compact source of power that could fit in a vehicle or even in an airplane. Instead of traveling at ten or twenty miles per hour, airplanes could fly at hundreds of miles per hour. Instead of moving troops by train along fixed routes, they could travel anywhere on land in trucks and tanks. To understand the workings of an internal combustion engine and how it uses oil products like gasoline, you need to know the physics and chemistry of engines and fuels.

Energy and Work

Energy has many forms that can be active or stored. The energy can be transferred from one form into another. One way energy is transferred is for it to cause force that pushes something else through a distance. This type of transfer of energy is called work. Work is defined as force acting through a distance. This is a bit different than the usual use of this word. To a physicist, simply holding a heavy weight isn't doing work because the force you apply isn't moving through a distance and the energy is not being transferred.

Pressure

Think of a gas as a collection of atoms or molecules that are moving at about 700 miles per hour. The motion is disorganized and each molecule only moves a tiny fraction of an inch before it collides with another molecule and changes direction.

If the gas molecules collide with a solid, like the wall of a container, as shown in Figure 3.3, they bounce off the molecules that make up the wall and impart a force that *is* in an organized direction—outward. The amount of pressure depends upon the average speed of the molecules (temperature), the number of molecules, and their mass.

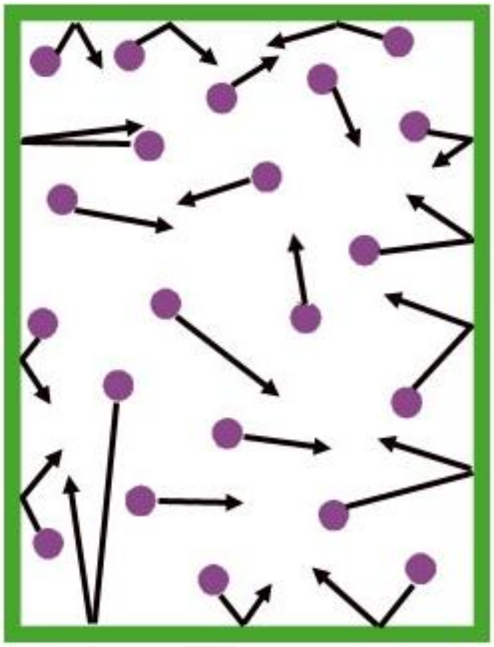


Figure 3.3. Gas molecules colliding with the walls of a container create pressure.

Compression and Temperature

If one of the walls of the container is moving, it will change the pressure and temperature of the gas:

- Increasing volume: If one of the walls of the container is moving outward—increasing the volume of the container—the gas molecules that bounce off of the retreating wall will have less average speed (lower temperature) and less heat energy.
- Decreasing volume: If one of the walls of the container is moving inward—decreasing the volume—the gas molecules that collide with the moving wall will have greater average speed (higher temperature) and more heat energy.

Decreasing the volume of a container without allowing the gas to escape is called compression. The ratio of the largest volume to the smallest is the compression ratio.

Compression and Ignition

If the gas that is being compressed is a mixture of vaporized hydrocarbons and oxygen, the oxidation (burning) process will start if the temperature is high enough. The temperature at which a particular hydrocarbon fuel and air mixture will start to burn is called its ignition temperature.

At the end of the 19th century, inventors like Rudolf Diesel thought of a way to make the old steam engine much smaller and lighter by replacing steam with a mixture of fuel and air that could be sprayed into a cylinder. If a piston was forced up the cylinder to compress the fuel-air mixture, the mixture would ignite and produce a small explosion that would force the piston down the cylinder. This force through a distance produces useful work that is transferred into a massive wheel called a flywheel, as shown in Figure 3.4.

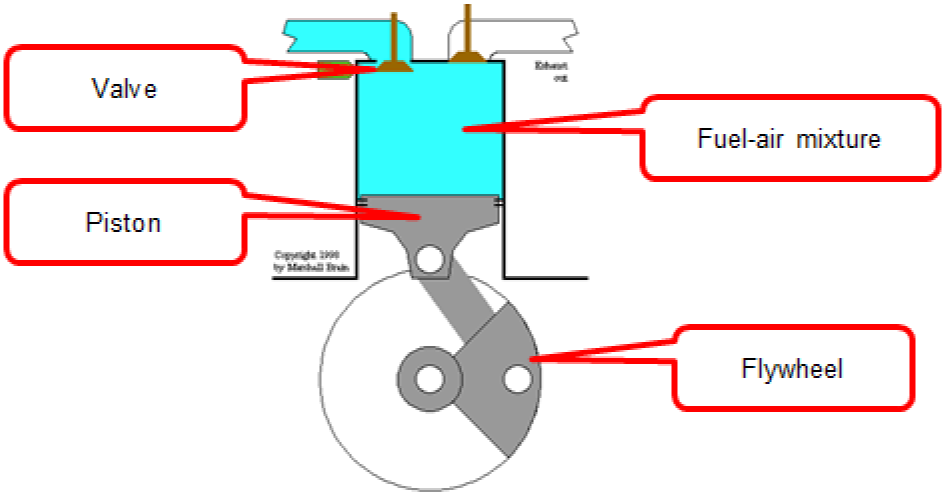


Figure 3.4. Gas molecules colliding with the walls of a container create pressure.

Some of the rotational energy that is in the flywheel is used to push the piston back up the cylinder to push the combustion gasses out and then draw in a fresh mixture of fuel and air for the next stroke. Each time the piston moves up or down the cylinder, it is counted as a stroke. A four-stroke engine has a downward power stroke when the fuel explodes, an upward exhaust stroke to expel the combustion gasses, a downward stroke to draw in a fresh fuel-air mixture, and a compression stroke to compress and ignite the fuel. (Brain n.d.) [Link]

Inventors tried several combinations of compression ratios and fuels to find a fuel that ignited at the right combination of temperature and pressure. The result is the diesel engine which has compression ratios of between 14 to 1 (usually written 14:1) and 25:1. In general, the higher the compression ratio, the more efficient it is at transferring energy from the fuel to the piston.

Diesel fuel is a mix of hydrocarbons with chains about 14 carbons long and gasoline is a mix of hydrocarbons with chains about 8 carbons long. Because crude oil is made up of mostly long-chain carbon molecules it takes less energy to separate diesel fuel from the petroleum than it does the gasoline. This makes diesel fuel less expensive to refine. Because there is more carbon in each molecule of diesel fuel and the compression ratio is higher, diesel engines are more efficient and get more miles per gallon in vehicles. Early diesel engines did not burn all of the carbon in the fuel very well and they produced clouds of black soot. They usually responded slower to changes in speed and had lower top speeds. Consequently, gasoline engines were used for passenger vehicles and diesel engines used for trucks.

An exception is for boats where the engine is below deck where fumes can accumulate. The diesel fuel doesn't vaporize as easily as gasoline and so diesel fuel is safer to use in boats where gasoline vapors could collect below deck and explode.

Chemistry of Gasoline

The gasoline engine is another four-stroke engine that is similar to the diesel engine but which has lower compression ratios of between 8:1 and 12:1. It uses a spark plug to ignite the fuel-air mixture. It operates at higher revolutions per minute (rpm). Because of its higher speed of rotation, timing is critical in this type of engine so it has spark plugs that ignite the fuel-air mixture at precisely the right time. The spark occurs just before the piston reaches the top of the cylinder so most of the explosive force occurs on the down stroke. If the fuel explodes too soon due to the heat of compression during the compression stroke while the piston is still on its way up, the force of the explosion pushes against the piston and the flywheel. The resulting noise is called engine knock.

Gasoline is mostly a mix of octane (8 carbons) and heptane (7 carbons). The shorter heptane ignites at much lower temperature and pressure than octane. If a gasoline has a higher percentage of heptane, it is more likely to explode too soon on the upstroke of the piston causing engine knock. To rate a petrol's resistance to knocking, an interesting rating system was developed. Octane is assigned an arbitrary value of 100 and heptane is assigned an arbitrary value of zero. If a sample of petrol ignites at a temperature and pressure as if it were made of 100% octane, its octane rating is 100. If it has an ignition temperature as if it were a mix of 80% octane and 20% heptane it has an octane rating of 80. Because higher compression engines are more efficient and powerful, they require a fuel mixture that has a higher octane rating. If a fuel can take even higher compression ratios than 100% octane without knocking, it has an octane rating higher than 100. For example, pure ethanol has an octane rating of 116 even though it has no octane in it. Gasoline is available in several different octane grades, as shown in Figure 3.5.

Figure 3.5 Gasoline available with different octane ratings.

When you buy gasoline, choose the octane rating that matches the compression ratio of your engine. Buying petrol with a higher octane rating than is appropriate for the compression ratio of the engine is a waste of money. This recommended octane rating for the engine is usually in the owner's manual. (Octane Rating 2007) [Link]

Additives can increase the ignition temperature of a fuel mixture which in turn makes it possible to lower cost mixtures. A molecule with an atom of lead (Pb) connected to four ethane groups called tetra-ethyl lead increases the mixture's ability to reach higher pressures without igniting thereby increasing its octane rating. The lead also prevents wear on the valves. Unfortunately, this lead ends up in the atmosphere we breath and causes heavy-metal poisoning. Lead is no longer added to automotive gasoline in the United States and other additives are used to protect the engine parts. Gasoline is called petrol in many parts of the world because it is refined from petroleum.

Recall that ethanol is an alchohol that has two carbon atoms. Ethanol is produced from sugar and water by yeast and it is separated from the water by distillation. The principal source of sugar for ethanol in the U.S. is corn but sugar cane is a better source in countries where it can be grown such as Brazil.

Mixtures of gasoline and ethanol are indicated with an E followed by a percentage, e.g. E10 is 10% ethanol and 90% gasoline while E85 is 85% ethanol. Ethanol has less energy per molecule and less energy per gallon of fuel than 100% gasoline. Expect a car to get 3-4% less miles per gallon on E10 and 25-30% less for E85. (U.S. Department of Energy 2011) [Link]

Chemistry of Diesel Fuel

The definition of diesel fuel is any fuel that will work in a diesel engine. Traditionally, diesel fuel has been made by separating the hydrocarbon chains that are about 14 carbons long from petroleum.

Diesel fuels are rated by comparing them to a mixture of cetane ($C_{16}H_{34}$)—which is a simple straight chain alkane that ignites and burns rapidly—and isocetane which is a complex branched molecule that does not ignite or burn as rapidly. Cetane is arbitrarily assigned a value of 100 and isocetane is assigned a value of 15 (a different hydrocarbon was used originally and assigned a value of zero but it was replaced for practical reasons.) The mixture is rated with a cetane number (CN) that compares a fuel to 100% cetane.

The CN number indicates the time delay for a fuel mixture to ignite at a given temperature. A higher CN value means the fuel will ignite with less delay. Most diesel fuels are a complex mixture of hydrocarbons that are longer than 14 carbon atoms which have CN values ranging from 40 to 55. Diesel engines that rotate more slowly such as those used in trucks and ships use fuel with CN values between 40-46 and engines that rotate faster such as those used in automobiles use CN fuels rated between 45 and 50. Automotive diesel fuels contain additives that keep them from turning into gel at low temperatures. Truck drivers often leave their trucks running in cold weather if they are concerned that they might not start due to cold fuel.

The problem of obtaining diesel fuel from petroleum is that it often includes sulfur that can turn into sulfuric acid in the atmosphere. Other sources of hydrocarbon chains of this length are viable alternatives. Diesel fuel can be made from recycled cooking grease or plant oils that have less sulfur by breaking down their complex hydrocarbon fats that might have 50 or more carbon atoms into simpler, shorter hydrocarbon chains with about 14 carbon atoms. Diesel fuel obtained from recently living plants or animals rather than fossil fuels is called biodiesel.

Biodiesel is often mixed with petroleum fuels. The percentage of biodiesel in the mixture is indicated with a B followed by the percentage of biodiesel, e.g. B20 is 20% from animal or plant sources and 80% from petroleum, as shown in Figure 3.6.

Figure 3.6 Diesel and petrol with biodiesel and ethanol blends

A gallon of diesel fuel has more energy than gasoline or ethanol and diesel engines typically more efficient because of the higher compression ratios. For these reasons, diesel powered cars and trucks get higher about 14% higher miles per gallon of fuel.

Devices that help complete the combustion of carbon, called catalytic converters, reduce the soot problem from diesel engines. Modern diesel engines are commonly used for personal vehicles in Europe where fuel prices are higher than in the U.S.

Key Takeaways

- Work is force acting through a distance. [3.2.1]
- If work is done on a gas by compressing it, the energy transferred to the gas increases its temperature. If the gas is a mixture of fuel and air, it will ignite when it gets hot enough. [3.2.2]
- If the gasoline ignites at a certain temperature and pressure as if it were pure octane, it is rated as 100 octane. If it ignites like a mixture of octane and heptane, it is rated by the apparent percentage

of octane. [3.2.3]

- Diesel engines are designed to have high compression ratios that will ignite the fuel-air mixture. Gasoline engines have lower compression ratios and use a spark plug to ignite the gasoline. [3.2.4]
- The CN value is a comparison of the fuel's ignition characteristics to a blend of cetane and isocetane where characteristics of 100% cetane would have a CN number of 100. Slower engines like those used in trucks use fuel with CN numbers from 40-46 while faster auto engines use fuel with CN numbers from 45-50. [3.2.5]
- Gasoline that has ethanol added is rated with an E followed by the percentage of ethanol. E85 is 85% ethanol. Biodiesel has a B followed by the percentage of biodiesel. B20 is 20% biodiesel. [3.2.6]

3 Explosives

Learning Objectives

1. Identify the characteristics of a useful explosive. [3.3.1]
2. Identify the drawbacks of nitroglycerin and how it was made safe to use for explosives and propellants. [3.3.2]
3. Identify the three atoms that are common to most explosives. [3.3.3]
4. Define plastic explosive and identify two common types. [3.3.4]
5. Identify the most common explosive used in mining and civil engineering and the two primary ingredients. [3.3.5]

Another use of petroleum is to make explosives. Explosives are very useful for blasting passages in rock. Deep mines, tunnels and roads through mountains would not be practical without explosives. They also make it possible to kill many people at once.

Chemistry of Explosives

An explosion is a very rapid chemical reaction that converts molecules that have weak bonds into molecules that have strong double-or triple covalent bonds. Examples of such molecules are carbon dioxide, CO_2, carbon monoxide, CO, and nitrogen, N_2. Most commercial explosives are organic molecules that contain carbon, oxygen, and nitrogen.

In a gasoline or diesel engine the carbon comes from the hydrocarbon fuel which is mixed with oxygen from the atmosphere to form CO and CO_2. The mixture can explode because the fuel and oxygen molecules are near each other. Even wheat flour can explode if it is mixed with air. Hydrocarbon fuel can be stored safely if it is not mixed with oxygen. Natural gas can cause explosions in the home if some of it leaks into the house where it can mix with the oxygen in the air before it is exposed to a flame. Explosions can be very useful if they are controlled as they are in an internal combustion engine.

Some mixtures of chemicals can be combined in solid form that will explode when ignited by a spark. The characteristics of a useful explosive are:

- A lot of energy is given off per molecule
- It only explodes when and where you want it to
- It can be manufactured safely

Some molecules already contain the oxygen, carbon, and nitrogen atoms. Because they do not need atmospheric oxygen, and the atoms are already close to each other, they can explode very rapidly. An early explosive chemical was nitroglycerin. It is an unstable molecule of nitrogen, carbon, and oxygen molecules, as shown in Figure 3.7. (The three carbon atoms are not shown. They are in the middle.)

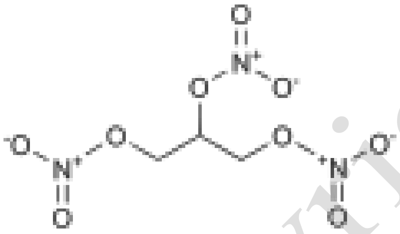


Figure 3.7 Nitroglycerine molecule

The molecule can break down and recombine into molecules of CO and N_2 and release large amounts of energy quickly. It has a lot of energy but it explodes unexpectedly and is sensitive to shocks. Building roads through mountains and mining require the use of explosives to break up formations of rock. Without explosives, train tracks and highways through mountains would be impractical. The railroad companies tried to use nitroglycerine but its use was banned in most countries after several accidental explosions.

A Swedish chemist—Alfred Nobel—discovered in 1867 that nitroglycerin could be made safer by mixing it with diatomaceous earth—a chalk-like sedimentary rock which is the fossilized remains of a type of algae. He called the mixture dynamite. Dynamite is widely used for blasting rock to make tunnels and roads through mountains, as shown in Figure 3.8.

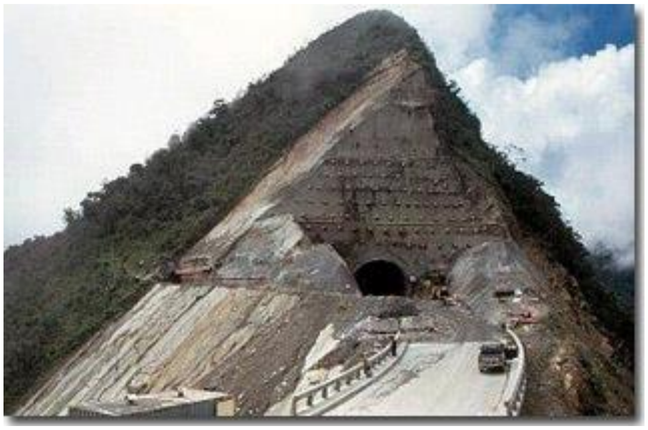


Figure 3.8 Dynamite makes it possible to build roads, tunnels, and canals through rock

Nitroglycerine was combined with cellulose to make a safe replacement for gunpowder that could be used to propel shells and bullets. It did not produce smoke which improved visibility during battle and helped the users hide their location. Dynamite was also used in artillery shells to kill people. Nobel's discovery was used to make weapons more effective at killing people. When Alfred Nobel’s brother Wilfred died, a French newspaper mistakenly published an obituary of Alfred titled Le marchand de la mort est mort ("The merchant of death is dead"). (Short Biography of Alfred Nobel 2007) Alfred was shocked by the way he was perceived by the public so he revised his will and left over $100 million dollars (in today’s money) to fund annual prizes in literature, physical science, chemistry, medical science or physiology, and peace.

Another explosive was developed in the late 1800s that started with a ring-shaped carbon molecule—methylbenzene. (A ring of six carbon atoms is called benzene.) You can guess from what you already know about the names of alkanes that the methyl prefix implies that one of the hydrogen atoms might be replaced by a methyl group. This molecule is also known as toluene. A chemical process replaces three of the other hydrogen atoms with nitrous oxide groups, NO_2, to create tri-nitro-toluene which is better known as TNT, as shown in Figure 3.9.

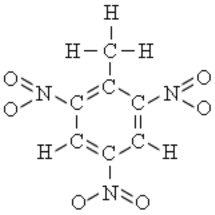
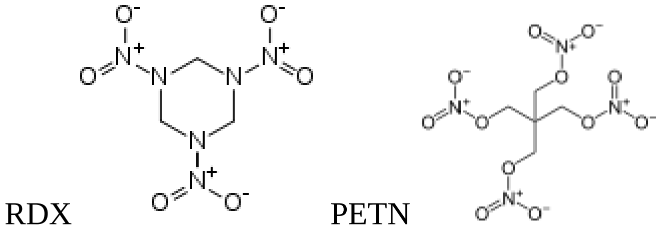


Figure 3.9 Molecule of TNT

TNT is a solid at room temperature but melts like wax so it can be poured into containers. It does not explode easily from rough treatment so it makes an ideal explosive for use in artillery shells and armor piercing bombs.

Two other explosives in common use are RDX and PETN which are molecules that combines carbon (not shown at the corners), Nitrogen, and Oxygen, as shown in Figure 3.10.



RDX PETN

Figure 3.10 Molecule of RDX used to make C-4 explosive

RDX and PETN can be combined with a plasticizer to make C-4 and Semtex which are plastic explosives that can be molded like putty. They can be easily shaped and are very stable and safe to handle. They cannot be detonated by a gunshot or being set on fire. They are detonated by extreme heat or shock from the small explosion of a detonator. The safety and flexibility of plastic explosives make them a favorite for military use but they are also used by terrorists for the same reasons. An attempt was made to destroy an airline using plastic explosive hidden in a shoe but the detonator would not ignite—possibly because of sweat— before the terrorist was apprehended.

The most commonly used explosive for mining and civil construction is a simple combination of fuel oil and nitrogen fertilizer. The acronym, ANFO stands for ammonium nitrate and fuel oil. The fuel oil provides the carbon atoms and the fertilizer provides the nitrogen and oxygen, as shown in Figure 3.11.

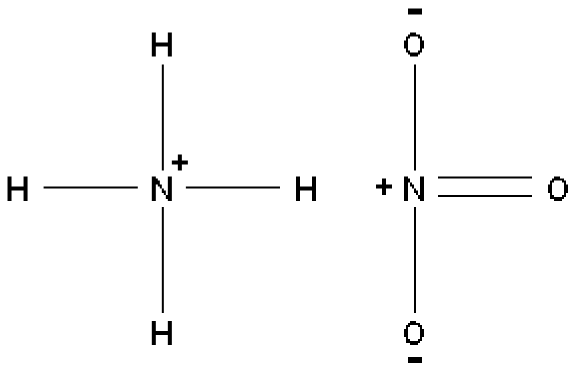


Figure 3.11 Ammonium nitrate fertilizer provides the nitrogen and oxygen in ANFO

Unlike other explosives, its ingredients are commonly available and inexpensive. A bomb made with fuel oil and fertilizer was used by American terrorists to destroy a federal building in Oklahoma City in 1995, and in Oslo in 2011 as shown in Figure 3.12.

Figure 3.12 Fuel oil and fertilizer bomb used in Oklahoma City and Oslo

The Oklahoma City and Oslo bombings demonstrated that individuals could obtain and build powerful explosive weapons from ingredients that were intended for peaceful purposes.

Key Takeaways

A useful explosive gives off a lot of energy per molecule, it only explodes when and where it should, and it is safe to manufacture. [3.3.1]

Nitroglycerin is unstable and will explode with a minor shock. It can be made safer by mixing it with diatomaceous earth to make dynamite or with cellulose to make smokeless gunpowder. [3.3.2]

Most explosives are molecules that contain carbon, nitrogen, and oxygen. [3.3.3]

Plastic explosives such as C-4 and Semtex are made from RDX and/or PETN with a plasticizer that makes them moldable like putty. [3.3.4]

The most commonly used explosive for civil engineering projects like mining or road building is ANFO which stands for ammonium nitrate and fuel oil. [3.3.5]

4 Oil, Intolerance, and World War

Learning Objectives

1. Identify practices that lead to intolerance and prejudice. [3.4.1]
2. Identify the primary source of energy for transportation in WWI and when it occurred. [3.4.2]

3. Identify the total number of people killed in WWI (civilian and military) on both sides to the nearest million and the percentage of population killed for the U.S, Germany, and the Ottoman Empire. [3.4.3]
4. Identify the primary source of energy for transportation in WWII. [3.4.4]
5. Identify the total number of people killed in WWII on both sides and the percentage of population killed for the U.S, Germany, Japan, and the Soviet Union. [3.4.5]

The technologies of transportation and explosives were combined with the prejudices and intolerance of the dominant countries of the day. The combination resulted in a new level of death and destruction.

Intolerance

It is important to remember that any large group of people is made up of a mixture. The median or average of the two groups might be different but that doesn't tell you much about individuals. For example, one might say that men are stronger than women. It might be true that if you measured the physical strength of groups of adult men and women that the average of the two groups would be different where the men would have a higher score. This does not mean that all of the men are stronger than all of the women and it is not appropriate to pre-judge the strength of an individual based on whether the person is male or female without considering that individual's strength. Making a judgment based on an individual's apparent membership in a group without taking time to know the individual is called pre-judgment or prejudice. Prejudice is particularly harmful if it prevents someone from considering that an individual might differ from their expectations or from examining the facts of a situation objectively.

One of the important outcomes of this course is the ability to recognize practices that lead to intolerance. The worldwide search for oil brought countries and cultures into contact that would otherwise have remained separate. Their customs and prejudices affected their decisions on how they related to each other. There are many ways that intolerance and prejudice are taught and practiced. As you study the interaction of countries and their use of energy resources, identify the following practices that lead to intolerance and prejudice:

- groups that have something in common such as race, tribe, religion, or country teach that those who are not a member of their group are inferior
- oppressed or victimized groups reconcile themselves to their state by teaching that there is at least one other group to whom they are superior
- a group blames its failures on another group instead of taking responsibility for its actions

- members of another group are labeled with disparaging words
- hatred and suspicion of neighbors is used to divert attention from domestic problems
- assumption that wealth is a sign that the group is superior to those with less
- each new generation is taught about the past misdeeds of a rival group to justify current mistreatment of living members of that group

World Domination

At the beginning of the 20th century petroleum was used for lighting and coal was used for power and transportation. In the space of few years the roles were reversed and transportation vehicles that used oil became an absolute necessity for a country's survival. This story is told in detail in the book *The Prize* by Daniel Yergin. In this story, you learn about the technologies that changed the world once again and how intolerance and prejudice played a role.

The desire for one culture to dominate others combined with the technologies that harness the power of fossil fuels made world war possible. The use of gasoline engines in airplanes, tanks, and trucks made it possible for the Germans and Japanese to move rapidly and outmaneuver their opponents which was a major advantage.

The First World War (WWI) was fought using coal and steam to power trains and ships. Near the end of WWI, tanks and airplanes were introduced and ships were powered with oil that allowed them to be refueled at sea and greatly extend their range.

Refer to the following charts in Figures 3. 10 and 3.11 that show how much more deadly the Second World War was compared to the first. Also compare the deaths of U.S. soldiers and civilians compared as a percentage of population with those of other countries. Look at the highlighted statistics. Notice that the percentage of the population killed in each war is much less for the U.S. than the other countries. This difference affects the perception of these wars by people from other countries. Large numbers of civilians were killed due to ethnic prejudice in the Ottoman Empire in WWI. In WWII and Gypsies and Jews were specifically targeted by the Germans and millions of Chinese civilians were killed by the Japanese.

Notice the difference in civilian deaths between the two wars where civilian populations were targets of large scale aerial bombing in intentional extermination in WWII.

World War One: 1914-1918

Entente Powers

	Population Millions	Military Deaths	Civilian Deaths	Total Deaths	Military Wounded	Percent of Pop. Killed
France	39.6	1,397,800	300,000	1,697,800	4,266,000	4.3%
Italy	35.6	651,010	589,000	1,240,010	953,886	3.5%
Japan	53.6	415		415	907	0.0%
Romania	7.5	250,000	430,000	680,000	120,000	9.1%
Russia	158.9	1,811,000	1,500,000	3,311,000	4,950,000	2.1%
Serbia	4.5	275,000	450,000	725,000	133,148	16.1%
United Kingdom	45.4	885,138	109,000	994,138	1,663,435	2.2%
United States	92	116,708	757	117,465	205,690	0.1%
Others	353	308,985	296,000	1,587,985	516,214	0.5%
Total (Entente Powers)	789.9	5,696,056	3,674,757	10,353,813	12,809,280	1.3%

Central Powers

	Population Millions	Military Deaths	Civilian Deaths	Total Deaths	Military Wounded	Percent of Pop. Killed
Austria-Hungary	51.4	1,100,000	467,000	1,567,000	3,620,000	3.0%
Bulgaria	5.5	87,500	100,000	187,500	152,390	3.4%
Germany	64.9	2,036,897	426,000	2,462,897	4,247,143	3.8%
Ottoman Empire	21.3	800,000	4,200,000	5,000,000	400,000	23.5%
Total (Central Powers)	143.1	4,024,397	5,191,000	9,415,397	8,419,533	6.6%

Figure 3.10 Casualties in World War I

World War Two: 1939-1945

Axis Powers

Country	*Population 1939*	*Military deaths*	*Civilian deaths*	*Jewish Holocaust deaths*	*Total deaths*	*Deaths as % of population*
Germany	69,623,000	5,533,000	1,600,000	160,000	7,293,000	10.5%
Japan	71,380,000	2,100,000	580,000		2,680,000	3.8%
Italy	44,394,000	301,400	145,100	8,000	454,500	1.0%
Totals	***185,397,000***	***7,934,400***	***2,325,100***	***168,000***	***10,427,500***	***5.6%***

Allies and Victims

Country	*Population*	*Military*	*Civilian*	*Jewish*	*Total deaths*	*Deaths*

	1939	*deaths*	*deaths*	*Holocaust deaths*		*as % of population*
Soviet Union	168,500,000	10,700,000	11,400,000	1,000,000	23,100,000	13.7%
China	517,568,000	3,800,000	16,200,000		20,000,000	3.9%
Poland	34,849,000	160,000	2,440,000	3,000,000	5,600,000	16.1%
Indonesia	69,435,000		4,000,000		4,000,000	5.8%
India	378,000,000	87,000	1,500,000		1,587,000	0.4%
Yugoslavia	15,400,000	446,000	514,000	67,000	1,027,000	6.7%
French Indo-China	24,600,000		1,000,000		1,000,000	4.1%
Romania	19,934,000	300,000	64,000	469,000	833,000	4.2%
Hungary	9,129,000	300,000	80,000	200,000	580,000	6.4%
France	41,700,000	212,000	267,000	83,000	562,000	1.4%
United Kingdom	47,760,000	382,600	67,800		450,400	0.9%
United States	131,028,000	416,800	1,700		418,500	0.3%
Lithuania	2,575,000		212,000	141,000	353,000	13.7%
Czechoslovakia	15,300,000	25,000	43,000	277,000	345,000	2.3%
Greece	7,222,000	20,000	220,000	71,300	311,300	4.3%
Burma	16,119,000	22,000	250,000		272,000	1.2%
Latvia	1,995,000		147,000	80,000	227,000	11.4%
Netherlands	8,729,000	7,900	88,900	106,000	202,800	2.3%
Philippines	16,000,000	57,000	90,000		147,000	0.9%
Others	250,673,000	289,300	564,700	92,100	946,100	39.9%
Totals	***1,776,516,000***	***17,225,600***	***39,150,100***	***5,586,400***	***61,962,100***	***3.5%***

Figure 3.11 Casualties in World War II

Key Takeaways

Briefly stated, the teachings are:

- other people are inferior to one's own group
- if another group is clearly superior, there is at least one other group that is inferior

- failures are blamed on others
- using disparaging terms for people in other groups
- use hatred of other groups to distract attentions from local failings
- success and wealth is a sign of divine approval
- recall past offences by another group regardless of how long ago. [3.4.1]

WWI lasted from 1914 to 1918. Coal was used to make steam that was used in locomotives and ships for transportation in WWI. [3.4.2]

In WWI, approximately ten million people died on both sides. The U.S. lost one tenth of one percent of its population, Germany lost 3.8% and the Ottoman Empire lost 23%. [3.4.3]

WWII lasted from 1939 to 1945. Oil was the primary source of energy. [3.4.4]

In WWII, approximately ten million people died on the axis side but the allies lost 57 million, many of whom were civilians that were intentionally killed by axis powers because of their race or religion. The U.S. lost three tenths of one percent of its population, Germany lost 10.5%, Japan lost 3.8%, and the Soviet Union lost 13.7%. [3.4.5]

Key Terms

Ammonium Nitrate Fuel Oil (ANFO)

explosive made from nitrogen fertilizer and diesel fuel

Benzene

carbon ring of six carbon atoms that alternate with single and double covalent bonds where other bonds are with hydrogen

Biodiesel

diesel fuel from animal or plant oil

C-4

plastic explosive made primarily with RDX

Catalytic converter

device used to complete the combustion of fuel

Cetane number (CN)

ratio of cetane to isocetane or a fuel of equivalent performance

Compression

reducing the volume of a fixed quantity of gas

Compression ratio

largest volume divided by the smallest volume

Diatomaceous earth

a chalk-like sedimentary rock which is the fossilized remains of a type of algae

Diesel engine

internal combustion engine that uses high compression ratios to ignite the fuel-air mixture

Dynamite

explosive that is a safer mixture of nitroglycerin and diatomaceous earth

Engine knock

noise resulting from spontaneous ignition of the fuel-air mixture while the piston is still on the compression stroke

Flywheel

massive wheel used to store energy to smooth out variations in a piston engine

Gasoline

mix of hydrocarbons that is mostly octane and heptane

Ignition temperature

temperature at which a fuel-air mixture will spontaneously explode

Nitroglycerin

liquid explosive that is sensitive to shocks

Octane rating

ratio of octane to heptane or an equivalent performance

petrol

term for gasoline in Europe and Canada

Prejudice

prejudging someone based on their apparent race, ethnicity, or other group membership

Revolutions per minute (RPM)

rate at which an engine rotates

Semtex

plastic explosive made primarily with PETN

Tetra-ethyl lead

an additive used to raise octane rating that contains lead

Toluene

benzene ring with one hydrogen replaced by a methyl group

Tri-nitro-toluene (TNT)

standard explosive used in bombs and artillery shells in WWII

Work

force acting through a distance

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