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Heat Causes Expansion

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The concept of heat has become something ordinary for us. Despite the fact that some people don't pay attention to this theme, many of them do not even notice that it can be involved in various areas of our life, e.g. construction, energy, metallurgy, etc. In this article we will discuss what heat is and there will be highlighted both its physical features and its practical usage examples.

In order to bring a substance out of balance, sometimes you need to create special conditions. High-tension wires sag in the summer. The summer heat makes the wires expand. Most matter expands in response to heat. This response explains why spaces are left in bridge roadways. If no space is left for the roadway to expand into, the surface will buckle.

Scientists have developed a model to explain the fact why solids expand when heated. The molecules in a solid vibrate about fixed positions. As energy is added to a solid, its temperature increases. That is, the molecules' kinetic energy and speed increase. The molecules vibrate faster and move farther away from their fixed positions. As the molecules separate, the solid expands.

Like the molecules of a solid, the molecules of a liquid also move apart when they are heated. The mercury thermometer is a common everyday example. As heat is transferred to the bulb, the mercury molecules speed up and move apart. The liquid expands. We interpret this expansion as a rise in temperature [1].

A tightly sealed can containing water may explode if heated too long. At 100º C the water changes into steam. As the temperature of the steam rises, molecules move about faster. They hit the sides of the can harder, exerting a greater force on the sides. The faster the molecules move, the greater the force they exert. If the force becomes great enough, it makes the can split apart at the seams. The can explodes.

As the gas molecules hit the sides of the can with increasing force, the pressure is said to build up. Pressure is the force exerted on each unit of area of a surface. Pressure is measured in a unit called the pascal (Pa). One pascal is equal to one newton of force pushing on one square meter of area [2].

Now, let's find out how the volume, temperature, and pressure of a gas are related.

1. Pressure and Temperature. When you ride a bicycle, friction between the road and the tire heats up the air inside the tire. How does this rise in temperature affect the air pressure? As the temperature of the air increases, the molecules move about more rapidly. The molecules hit the inner wall of the tire more often and harder. The pressure increases. So, as the temperature of a gas increases, its pressure increases.

2. Pressure and Volume. What effect does changing the volume of a gas have on its pressure? If you have ever used a bicycle pump, you know that the gas pressure increases as you push the pump handle down. Suppose all the gas molecules stay trapped inside the tire pump, and the temperature stays the same. As you push down on the handle, you decrease the volume. Molecules of air hit the sides of the pump more often. More hits each second result in greater pressure.

The relationship between the pressure and the volume of a gas is called Boyle's Law. This law states that if the temperature remains constant, a decrease in the volume of a gas causes an increase in its pressure.

3. Temperature and Volume. What happens to the volume of a gas when its temperature increases? A gas is trapped inside a bottle that has a straw attached to its top. A drop of water in the straw confines the gas inside the bottle. It also lets the gas expand without changing the pressure.

If you place the bottle in hot water, the temperature of the gas increases. As the temperature rises, the water drop inside the straw rises. This action occurs because the volume of the gas has increased. Charles' Law states that at a constant pressure, an increase in temperature causes an increase in the volume of a gas [3].

Would you believe that compressed gases can run a machine? This is the principle behind heat engines. A heat engine uses energy from a burning fuel to make something move. A gasoline engine is an example of a heat engine. Burning occurs inside the engine. So, a gasoline engine is called an internal combustion engine. Figure 1 illustrates how a gasoline engine works.

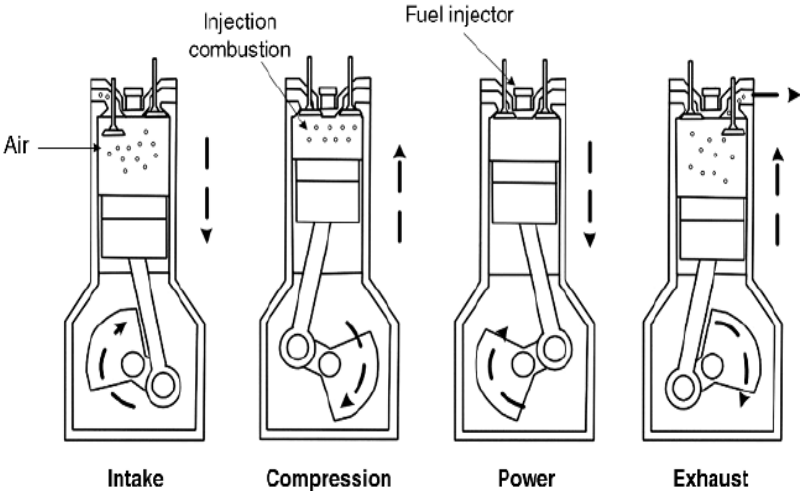

Figure 1: Four-Stroke Cycle Engine

Most gasoline engines burn fuel inside tubes called cylinders. A cylinder has two valves: an intake valve and an exhaust valve. A cylinder also has a movable part called a piston. The piston is connected by a rod to the crankshaft. The crankshaft rotates each time the piston moves up and down. The crankshaft is connected to gears, which move the car.

Most gasoline engines have a four-stroke cycle. A stroke is one up or down movement of a piston. During the first (or intake) stroke, the piston moves down. The intake valve of the cylinder opens and its exhaust valve closes. A partial vacuum is created in the cylinder. The partial vacuum draws in gasoline vapor that has been mixed with air. At the second stroke (the compression stroke) the intake valve closes and the piston moves up. The upward movement of the piston compresses the air-fuel mixture.

During the third (or power) stroke, a spark plug ignites the mixture. The resulting expansion of gases drives the piston down. In the fourth stroke (the exhaust stroke) the exhaust valve opens. The burned fuel leaves the cylinder. Then the cycle repeats itself [4].

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