The ultimate solution for maintaining your nationwide generator network

Otto Cycle Principal of Engines Used in Generator Set Systems

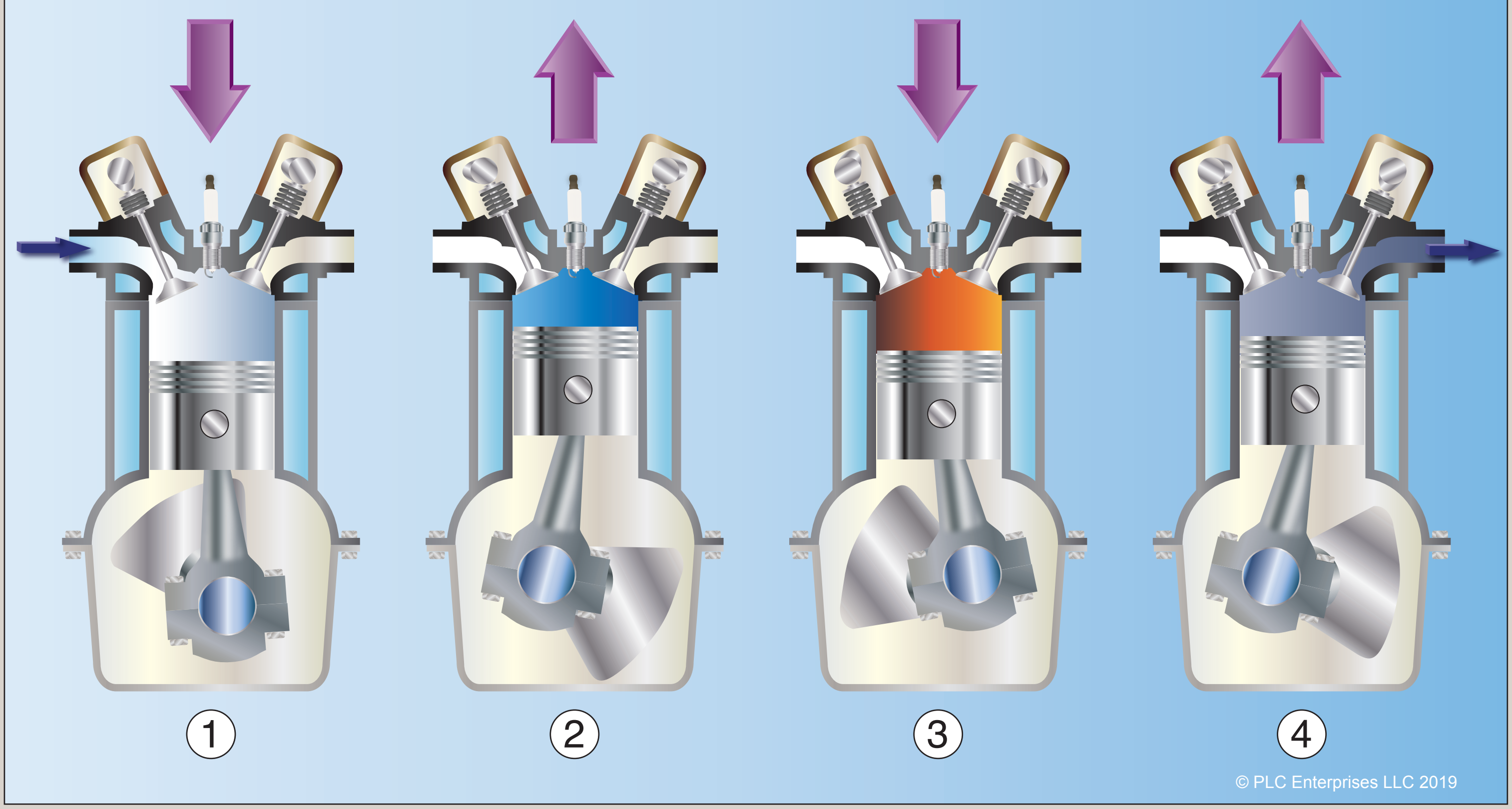
1.0 Introduction:

Standby and prime power generator systems are traditionally the combination of an internal combustion engine coupled to a generator. The mechanical power produced by the engine turns the generator, which in turn produces the electrical power. In understanding the principals of how a generator system works, it is important to understand how an internal combustion engine operates. Knowing the operational characteristics of the engine is very useful in comprehending all the elements within a generator system, the importance of maintaining various components within the engine, and ensuring a reliable power source is always available. Current EPA compliant 4-stroke engines operate on the Otto cycle principal.

This information sheet discusses the principals of the Otto cycle, combustion components within the engine, fuel sources, and key maintenance procedures to follow for reliable operation.

The 4-strokes of an Otto Cycle Internal Combustion Engine

Cycle	Description of Cycle	Cycle	Description of Cycle
1	**Air/Fuel Mixture** - Air fuel mixture drawn in on a down cycle with inlet valve open	3	**Combustion** - Ignition occurs at the top position on the down cycle, producing power
2	**Compression** - Air fuel mixture compressed on the up cycle. Both valves are closed	4	**Exhaust** - Burnt gases are exhausted on up cycle with the exhaust valve open



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2.0 History and Invention of the Otto cycle:

The Otto cycle is named after Nikolaus Otto; however, the Otto cycle principal was developed over several years from various experiments to develop a reliable internal combustion engine. One key factor in the development and practical source of mechanical power was the ability to have a compressed fuel air mixture that burned at a progressive rate to provide a flow of energy through a cycle, rather than an explosion. Early developments were very inefficient at converting fuel energy into mechanical energy, had short lives, and were prone to exploding.

After a period 14-years or more, Otto finally created on May 9, 1876 what he termed a compressed charge internal combustion engine. Otto developed a way to layer a fuel air mixture into the cylinder to enable fuel to burn in a progressive manner, unlike previous engines that exploded the fuel, and in many cases the engine.

3.0 The 4-stroke Otto Cycle Developed by Nikolaus Otto:

At the time, development of an internal combustion engine was around lighter fuels such as gasoline which required a spark for ignition, every fueled engine that ignited fuel by compression, known as diesels, were not developed for several more decades. When we discuss the Otto cycle, we consider spark ignition. However the diesel engine, while igniting heavier fuel by compression, also follows the Otto cycle principal.

The following details the four-cycle principal of the Otto cycle as also depicted in the diagram on page one,

3.1 **First Cycle –** The piston within the cylinder is connected to the crankshaft by a conrod. The power stroke of the piston pushes the crankshaft around, and in the process converts fuel energy into mechanical energy.
The function of the first down cycle of the piston is to suck into the cylinder a mixture of fuel and air. An inlet valve in the cylinder head opens to let in the fuel air mixture as the piston moves down within the cylinder.

3.2 **Second Cycle –** When the piston has reached its bottom position in the cylinder, it then begins the second cycle. The inlet valve in the cylinder head closes and as the piston moves up the cylinder, the air/fuel mixture is compressed.

3.3 **Third Cycle –** The third cycle is the combustion cycle. When the piston reaches the top of the cylinder, the spark plug ignites the compressed air/fuel mixture. The mixture then burns with the resultant energy released pushing the piston down, which in turn pushes the crankshaft around, converting fuel energy to mechanical engergy to drive anything connected to the crankshaft. In the case of a generator set, the generator converts mechanical energy to electrical energy.

3.4 **Fourth Cycle –** The final and fourth cycle of the Otto cycle is the exhaust cycle. When the piston has reached the bottom position in the cylinder after the combustion cycle, it then commences its second upstroke to push out the burnt fuel/air mixture through the exhaust valve. As the piston commences its upward stroke, the exhaust valve in the cylinder opens to allow the burnt fuel to be expelled through the exhaust port.

The engine will continue to turn through the four cycles described as long as there is a fuel/air supply and ignition source on the combustion cycle. A flywheel connected to the crankshaft provides the kinetic energy to keep the crankshaft turning at a smooth pace through the four engine cycles.

The valves are moved up and down in the correct sequence for each cycle by a camshaft driven by gears, pulleys, or chain drive, depending on the engine design.

4.0 Sources of Ignition:

While the original Otto cycle engine used gasoline as a fuel source, diesel engines use the same 4-cycle operation through mixing a fuel/air mixture, fuel compression, downward combustion and exhaust. The difference being a diesel fuel/air mixture is ignited by compression instead of a spark. Spark ignition engines can use gaseous and liquid fuel variants.

5.0 Maintenance Points of Otto Cycle Engines:

Planned maintenance programs for engine driven generator systems should include the following to ensure reliable operation of the internal combustion 4-cycle engine. Your authorized distributor has maintenance programs for all engine models.

5.1 **Fuel Source –** If the unit is gaseous powered, the lines and connections carrying the fuel will be inspected, as will any regulators for pressure feed. Diesel fueled engines must ensure any stored fuel in the system is maintained with fuel management programs to ensure engine does not under-perform due to fuel quality. All fuel filters have to be changed at intervals recommended by the engine manufacturer.

5.2 **Ignition –** Spark ignition engines should follow an Ignition System Maintenance (ISM) service program. For standby applications, every 5-years. Prime power applications per the hours recommended by the manufacturer.

Diesel fuel systems will change and inspect fuel injection equipment and filters as recommended by the engine manufacturer.

5.3 **Filtration –** For engine life and efficient operation, all fuel and air into the engine should be filtered. Filters in a planned maintenance program (PM) will be changed as recommended by manufacturer.

Oil filters are changed at recommended intervals in a PM program.

5.4 **Mechanical Components –** An internal combustion engine as many moving parts. Manufacturers recommend at certain intervals major wearing components be changed. However, in standby power applications, these hours are unlikely to be reached. Older engines may require adjustment of tappets on cam followers, but most engines now employ hydraulic tappets.

5.5 **Coolant System –** Air-cooled engines - should check fan belts and fins for clogging. Water-cooled engines - should follow PM programs for the complete coolant system.