STEAM ENGINES TYPES

High pressure steam engines are of various types but most are either reciprocating piston or turbine devices.

Reciprocating

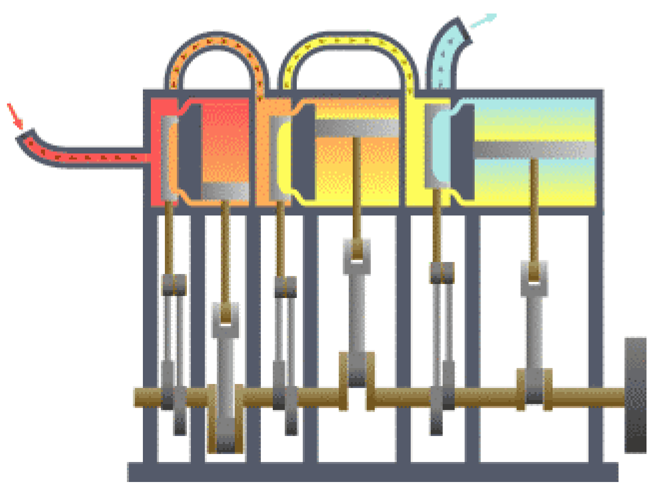
Double-acting

After the development of pressurized steam technology, the next major advance was the use of double-acting pistons, with pressurized steam admitted alternately to each side while the other side is exhausted to the atmosphere or to a condenser. Most reciprocating engines now use this technology. Power is removed by a sliding rod, sealed against the escape of steam. This rod in turn drives (via a sliding crosshead bearing) a connecting rod connected to a crank to convert the reciprocating motion to rotary motion. An additional crank or eccentric is used to drive the valve gear, usually through a reversing mechanism to allow reversal of the rotary motion.

When a pair of double acting pistons is used, their crank phasing is offset by 90 degrees of angle; this is called quartering. This ensures that the engine will always operate, no matter what position the crank is in.

Some ferryboats have used only a single double-acting piston, driving paddlewheels on each side by connection to an overhead rocker arm. When shutting down such an engine it was important that the piston be away from either extreme range of its travel so that it could be readily restarted.

Multiple expansion



An animation of a simplified triple expansion engine. High pressure steam (red) enters from the boiler and passes through the engine, exhausting as low pressure steam (blue) to the condenser.

Another type uses multiple (typically three) single-acting cylinders of progressively increasing diameter and stroke (and hence volume).

High pressure steam from the boiler is used to drive the first and smallest diameter piston downward. On the upward stroke the partially expanded steam is driven into a second cylinder that is beginning its downward stroke.

This accomplishes further expansion of the relatively high pressure exhaust from the first chamber. Similarly, the intermediate chamber exhausts to the final chamber, which in turn exhausts to a condenser.

The image at the right shows a model of such an engine. The steam travels through the engine from left to right. The valve chest for each of the first two cylinders is to the left of the corresponding cylinder while that of the third is to the right.

One modification of the triple-expansion engine is to use two smaller pistons that sum to the area of the third piston to replace it. This results in the more balanced unit of a total of four pistons arranged in a vee-configuration.

The development of this type of engine was important for its use in steamships, for the condenser would, by taking back a little of the power, turn the steam back to water for its reuse in the boiler. Land-based steam engines could exhaust much of their steam and be refilled from a fresh water tower, but at sea this was not possible. Prior to and during World War II[[16]] , the expansion engine dominated marine applications where high vessel speed was not essential. It was however superceded by the steam turbine where speed was required, for instance in warships and Ocean liners. HMS Dreadnought (1906) of 1905 was the first major warship to replace the proven technology of the reciprocating engine with the then novel steam turbine.

Multiple expansion can also result in greater efficiency, as the steam expends more of its energy driving pistons before leaving the engine. Some steam locomotives used double expansion. The most common arrangement was two sets of driving wheels. A set of high pressure cylinders drove one set and the low pressure cylinders drove the other set. A rarer arrangement was called the tandem compound, in which the high and low pressure cylinders were coaxial and had a common piston rod.

Other steam locomotives were simple, or single, expansion only. Most compound steam locomotives had a "simpling valve" which fed high pressure steam to all cylinders to help start a train.

Uniflow

Another type of reciprocating steam engine is the "uniflow" type. In this, valves (which act similarly to those used in internal combustion engines) are operated by cams. The inlet valves open to admit steam when minimum expansion volume has been reached at the top of the stroke. For a period of the crank cycle steam is admitted and the poppet inlet are then closed, allowing continued expansion of the steam during the downstroke. Near the bottom of the stroke the piston will expose exhaust ports in the side of the cylindrical chamber.

These ports are connected by a manifold and piping to the condenser, lowering the pressure in the chamber to below that of the atmosphere. Continued rotation of the crank moves the piston upward. Engines of this type always have multiple cylinders in an inline arrangement and may be single or double acting. A particular advantage of this type is that the valves may be operated by the effect of multiple camshafts, and by changing the relative phase of these camshafts, the amount of steam admitted may be increased for high torque at low speed and may be decreased at cruising speed for economy of operation, and by changing the absolute phase the engine's direction of rotation may be changed. The uniflow design also maintains a constant temperature gradient through the cylinder, avoiding passing hot and cold steam through the same end of the cylinder. (The uniflow concept is also employed in two stroke supercharged diesel engines used for marine, locomotive, and stationary applications. Such diesels do not need the economizer feature and use a simpler sliding camshaft for reversing.)

Turbine type

Steam turbines for high power applications use a number of rotating disks containing propeller-like blades at their outer edge. These moving "rotor" disks alternate with stationary "stator" blade rings affixed to the turbine case that serve to redirect the steam flow for the next stage.

Owing to the high speed of operation such turbines are usually connected to a reduction gear to drive another mechanism such as a ship's propeller. Steam turbines are more durable, and require less maintenance than reciprocating engines. They also produce smoother rotational forces on their output shaft, which contributes to their lower maintenance requirements and lower wear on the machinery they power.

The main use for steam turbines is in electricity generation stations where their high speed of operation is an advantage and their relative bulk is not a disadvantage. They are also used in marine applications, powering large ships and submarines. Virtually all nuclear power plants generate electricity by heating water and powering steam turbines. A limited number of steam locomotives were manufactured that used turbine technology. While they met with some success for long haul freight operations in Sweden and elsewhere, steam turbine technology did not last long in the railway world and was rapidly replaced by diesel locomotives.

Rotary type

In theory, it might be possible to use a mechanism based on a pistonless rotary engine such as the Wankel engine in place of the cylinders and valve gear of a conventional reciprocating steam engine. Lack of control of the cutoff is a major problem with such designs, and none has been demonstrated in practice.

Jet type

Invented by Australian engineer Alan Burns and developed in Britain by engineers at Pursuit Dynamics, this underwater jet engine uses high pressure steam to draw in water through an intake at the front and expel it at high speed through the rear. When steam condenses in water, a shock wave is created and is focused by the chamber to blast water out of the back. To improve the engine's efficiency, the engine draws in air through a vent ahead of the steam jet, which creates air bubbles and change the way the steam mixes with the water.

Unlike conventional steam engine, there is no moving parts to wear out, and the exhaust water is only several degrees warmer in tests. The engine can also serve as pump and mixer.

This type of system is referred to as 'PDX Technology' by Pursuit Dynamics.

Rocket type

The Aeolipile represents the use of steam by a rocket jet technique, although not for direct propulsion.

In more modern times there has been limited use of steam for rocketry -particularly for rocket cars. The technique is simple in concept, simply fill a pressure vessel with hot water at high pressure, and open a valve leading to a suitable nozzle. The drop in pressure immediately boils some of the water and the steam leaves through a nozzle, giving a significant propulsive force.

It might be expected that water in the pressure vessel should be at critical pressure; but in practice the pressure vessel has considerable mass, which reduces the acceleration of the vehicle. Therefore a much lower pressure is used, which permits a lighter pressure vessel, which in turn gives the highest final speed.

There are even speculative plans for interplanetary use. Although steam rockets are relatively inefficient in their use of propellant, this very well may not matter as the solar system is believed to have extremely large stores of water ice which can be used as propellant. Extracting this water and using it in interplanetary rockets requires several orders of magnitude less equipment than breaking it down to hydrogen and oxygen for conventional rocketry.[17]

Steam powered vehicles

Nicolas-Joseph Cugnot [[18]] demonstrated the first functional self-propelled steam vehicle, his "fardier" (steam wagon), in 1769. Arguably, this was the first automobile. While not generally successful as a transportation device, the self-propelled steam tractor proved very useful as a self mobile power source to drive other farm machinery such as grain threshers or hay balers.

Steam engine powered automobiles continued to compete with other motive systems into the early decades of the 20th century. However steam engines are less favored for automobiles, which are generally powered by internal combustion engines, because steam requires at least thirty seconds (in a flash boiler) or so to develop pressure.

On February 21, 1804 at the Pen-y-Darren ironworks in Wales, the first self-propelled railway steam engine or steam locomotive built by Richard Trevithickwas demonstrated.

Advantages

The strength of the steam engine for modern purposes is in its ability to convert heat from almost any source into mechanical work. Unlike the internal combustion engine, the steam engine is not particular about the source of heat.

Most notably, without the use of a steam engine nuclear energy could not be harnessed for useful work, as a nuclear reactor does not directly generate either mechanical work or electrical energy - the reactor itself simply heats water. It is the steam engine which converts the heat energy into useful work. Steam may also be produced without combustion of fuel, through solar concentrators. A demonstration power plant has been built using a central heat collecting tower and a large number of solar tracking mirrors, (called heliostats) [[19]].

Similar advantages are found in a different type of external combustion engine, the Stirling engine, which offers efficient power in a compact engine, but which is difficult to operate over a wide range of operating conditions, difficulties which are readily addressed by the modern hybrid vehicle.

Steam locomotives are especially advantageous at high elevations as they are not especially adversely affected by the lower atmospheric pressure. This was inadvertently discovered when steam engines operated at high altitudes in the mountains of South America were replaced by diesel-electric engines of equivalent sea level power. They were quickly replaced by much more powerful locomotives capable of producing sufficient power at high altitude.

In Switzerland (Brienz Rothhorn) and Austria (Schafberg Bahn) new rack steam locomotives have proved very successful.

They were designed based on a 1930s design of Swiss Locomotive and Machine Works (SLM) but with all of today's possible improvements like roller bearings, heat insulation, light-oil firing, improved inner streamlining, one-man-driving and so on. These resulted in 60 percent lower fuel consumption per passenger and massively reduced costs for maintenance and handling. Economics now are similar or better than with most advanced diesel or electric systems. Also a steam train with similar speed and capacity is 50 percent lighter than an electric or diesel train, thus, especially on rack railways, significantly reducing wear and tear on the track. Also, a new steam engine for a paddle steam ship on Lake Geneva, the "Montreux" was designed and built, being the world's first ship steam engine with an electronic remote control. The steam group of SLM in 2000 created a wholly-owned company called DLM to design modern steam engines and steam locomotives.

Efficiency

To get the efficiency of an engine, divide the number of joules of mechanical work that the engine produces by the number of joules of energy input to the engine by the burning fuel. In general, the rest of the energy is dumped into the environment as heat. No pure heat engine can be more efficient than the Carnot cycle, in which heat is moved from a high temperature reservoir to one at a low temperature, and the efficiency depends on the temperature difference.

Hence, steam engines should ideally be operated at the highest steam temperature possible, and release the waste heat at the lowest temperature possible.

In practice, a steam engine exhausting the steam to atmosphere will have an efficiency (including the boiler) of 5%, but with the addition of a condenser the efficiency is greatly improved to 25% or better. A power station with exhaust reheats, etc. will achieve 30% efficiency. Combined cycle in which the burning material is first used to drive a gas turbine can produce 60% efficiency. It is also possible to capture the waste heat using cogeneration in which the residual steam is used for heating. It is therefore possible to use about 90% of the energy produced by burning fuel - only 10% of the energy produced by the combustion of the fuel goes wasted into the atmosphere.

One source of inefficiency is that the condenser causes losses by being somewhat hotter than the outside world, although this can be mitigated by condensing the steam in a heat exchanger and using the recovered heat, for example to pre-heat the air being used in the burner of an external combustion engine.

The operation of the engine portion alone is not dependent upon steam; any pressurized gas may be used. Compressed air is sometimes used to test or demonstrate small model "steam" engines.

Source: http://engineering.wikia.com/wiki/Steam_engine