1903 Air Injected Diesel Engine and Generator

The Coolspring Power Museum (CPM) has been the home for a very rare and historically significant engine-driven generator set for the last thirteen years or so. The generating plant was installed on Heligoland Island in the North Sea off of the coast of Germany. The 12-horsepower engine and six-kilowatt generator were built in 1903 in Germany, the engine by "Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nurnberg" (VMAMN, Incorporated around 1908 into "Maschinenfabrik Augsberg Nurnberg" or MAN), the generator having been built by Siemens and Halske.

The engine and generator were built at a time when German industry and scientific advancement were at a high state of development, achieving great economic success. This led to large companies like Siemens-Halske and VMAMN branching out into the rapidly expanding industrial world with the commercialization of new ideas born late in the 19th century. Two areas of advance during this time period were electric power and internal combustion engines.

Our engine was constructed based on the developments and design features perfected by Dr. Rudolf Diesel, who invented a compression-ignition engine with the goal of improving efficiency over other forms of oil burning engines. His knowledge of the science of gasses led him to realize that the best way to improve efficiency in a reciprocating engine was to increase the expansion ratio in the engine, which is directly related to what we call compression ratio today.   Diesel wanted to increase the compression pressure so high that the fuel would ignite automatically due to its exposure to the high temperature air in the cylinder when it was injected at the beginning of the power stroke. Thus, ignition did not depend on external heat sources or electrical ignition systems to initiate combustion like existing oil and gas engines of the time required. The compression pressure achieved in the engine (500 psig or so) resulted in the air being heated to over 1000 degrees F, which is hot enough for most hydrocarbon fuels to ignite very quickly after atomization and evaporation.

The unique feature of what we know today as the Diesel cycle, is that Dr. Diesel determined that to maintain the best theoretical efficiency, the cylinder pressure during combustion should not exceed compression pressure. He designed the fuel injection system to admit fuel just fast enough to keep cylinder pressure constant, and right around 500 psig. In contrast to gas engines running on the Otto cycle, wherein the cylinder pressure greatly exceeds compression pressure during combustion, original Diesel engines are very quiet, with only mechanical noises from the valve train and breathing sounds being audible, besides a stentor "thump" when they fire under heavier loads.

Dr. Diesel's ideas stemmed from the nascent science of thermodynamics, or the study of heat flow in mechanical systems like heat engines and refrigerators.

Developed by early experimenters and scientists like the Reverend Dr. Robert Stirling and Sadi Carnot earlier in the 19th century, this new branch of science allowed one to use basic principles to develop designs for practical machines. Eventually applied to everything from artillery and small arms to heat engines and refrigeration, thermodynamics and electrical theory that came to the forefront in the late 19th century set the stage for 20th century engineering, which is based on scientific theory that is used to develop practical applications.

Dr. Diesel used high-pressure air to force the fuel into the cylinder, at the correct time for combustion to occur. Using high-pressure air to inject the fuel into the combustion space ensures adequate atomization to promote evaporation, ignition and combustion. Other contemporary engines were using solid, mechanical injection plungers moving in barrels to force fuel oil into cylinders and pre-combustion chambers ("vaporizers"), but Diesel wanted to achieve finer atomization and distribution of the fuel to completely burn the fuel. Diesel's engine used the cylindrical space directly above the piston as its combustion space, so extensive distribution of fuel and atomization is required to avoid wasteful, unburned exhaust products. Machining capabilities of the late 19th century did not allow for the precision required for the use of mechanical injection to get good atomization and distribution of fuel into the cylinder of his new engine, so Dr. Diesel stuck with the air blast method to inject fuel into the cylinder.

As one can imagine, the high-pressure air used to force fuel into the cylinder has to come from somewhere, and Dr. Diesel developed air compressor designs that were incorporated into the engine, being directly driven from the crankshaft. Developing pressures above 1000 psig, these compressors required one or more stages of compression, and as the Diesel engine developed over its commercial life span, compressor design changed as problems and operational issues were encountered.

The air compressor on a Diesel engine is also a source of parasitic loss, hurting overall engine efficiency due to the power lost in compressing the air. This was one of the great downfalls of the original Diesel engine, leading to its abandonment after World War I when advances in machining techniques developed during that conflict led to very precise machining, making possible inexpensive mechanical injection equipment. This abandonment long before World War II and its voracious appetite for scrap iron and steel has resulted in early Diesel air injected engines being very rare today.

Experience led Diesel to select Krupp steel for construction of his engine, to survive the pressures he hoped to achieve during compression. Then he chose to team up with an industrial firm to support the expensive development work required to perfect the new engine, choosing VMAMN's long experience with machinery design and construction as well as their willingness to take on the project. Coaxing theory into practice can rival an Edison-style, brute-force method of development, and getting the engine from a scientific theory to a profitable, practical item was quite a task, taking several years to complete.

By 1899, VMAMN and Dr. Diesel were ready to place the engine on the market and introduce the world to an efficient alternative to low-pressure gas and oil engines, as well as a counter to the still-dominant steam engines. The engine now at CPM hails from this early generation of engines that proved to be the vanguard of high-pressure oil engines that came to rule the world in terms of reciprocating, piston powered engines.

The Siemens-Halske generator coupled directly to the engine crankshaft and it produced DC power. Near the end of the 1920's, the engine was added to the Henry Ford collection in Dearborn, Michigan for inclusion in the growing collection Ford gathered in order to preserve the early history of engines, vehicles and mechanical power.

Luckily, the engine was removed from Heligoland Island long before World War II, because at the conclusion of that conflict, the British used immense demolition charges to destroy fortifications and facilities built on the strategically placed island while Hitler was in power. After more than 50 years in the Ford collection, the engine and generator were sold off in the mid 1980s when the collection was thinned. After a stint in Florida, the engine and generator were sold and displayed at the Owl's Head Museum in Maine, where they were mounted on a wooden base, upon which both machines sit today.

Eventually, the set was sold to a Michigan-based collector who moved it from Owl's Head to CPM in 2007. In 2018, the engine and generator were donated to the museum.

The Diesel engine and generator will be erected in a setting simulating a German powerhouse of the early 20th century, using architectural elements visible inside and outside of the section housing the Diesel generating set. To complete the appearance of pre-World War I Germany, topical items will be placed inside the "motorraum" portion of the building.

The generator will need to be cleaned and inspected to determine if it can produce electrical power again. This will include evaluation of the commutator, brushes, windings and bearings. Regardless of its ability to operate again, a switchgear panel including generator controls will be recreated to complete the display.

Besides the building to house the machinery, the engine will need to be torn down and inspected/cleaned in preparation for running again. The air storage bottles and piping from the air compressor to them and back to the engine are missing, so they will have to be re-created.

Once it can run again, the generating set at Coolspring will be the older of the two early, air-injected Diesel engines running in the US.

The Coolspring Power Museum is actively gathering funds to support the installation of the engine and generator inside a new building to be built on the museum grounds. To accommodate other early high-pressure oil engines incorporating air injection that are part of the CPM collection, the building design will allow for expansion as funds become available to support restoration and installation of these engines in the future.

Will you join us in getting the engine set up and running again? Donations can be made directly to the CPM by check or money order, its GoFundMe page or via Facebook/PayPal.

Restoration and installation of this set and the other air-injected engines will be a large task, but one well worth pursuing to preserve these rare, early oil-burning engines.