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Diesel engine design and manufacture – a history

The first decade of the 1900s proved to be a time of experimentation and success in the area of diesel engine design and manufacture. The installation of diesel engines into river and coastal craft was eagerly anticipated, however, there still remained some scepticism in the performance abilities of the combustion engines on long, seafaring journeys.

Rudolf Diesel patented his engine in Germany, on February 28, 1892 and he later obtained patent rights in most industrialised countries. In 1894, Diesel contacted David Halley, the managing director of Burmeister and Wain (B&W), requesting the company experiment with his design, which eventually laid the ground for a most successful career in the design and manufacture of diesel engines.

While the *Selandia*, built 1912, remains heralded as the first seagoing diesel engined vessel, in 1905, the 125 ton vessel, *Venoga*, built by Sulzer, became the worlds first recorded diesel engine vessel and was used on Lake Geneva.

The *Selandia* was a four-stroke reversible twin cylinder vessel and was conspicuous to all who viewed it, as the design had three masts and lacked a funnel, thus being identified as a motorship. *Selandia* pointed the way for future passenger liners and prompted the widespread adoption of the diesel engine for marine propulsion purposes. The end product, however, was an accumulation of steps taken not only by B&W but also by other companies eager to experiment with or improve upon Rudolf Diesel's original design.

Such simultaneous developments occurred throughout Russia and Europe as the competition for navigation routes and naval supremacy heightened. Naval architects in France, Russia, Belgium, Sweden, Britain and Germany designed ships to be fitted with diesel engines.

At Bar Le Duc, France in 1898, the managing director of "Societe Francaise des Moteurs Diesel", Frederic Dyckhoff, patented the invention of a diesel engine which he exhibited in 1900 at the World Exposition in Paris.

Dyckhoff's creation, a 3 cylinder, 4 stroke reversible propulsionary engine equipped with 2 camshafts, one ahead, one astern, was named the *Petit Pierre*. The French company was experimenting with peanut oil as a fuel, which tested successfully on this 8 HP diesel engine. Because the engine was small it was never part of a finalised operating combustion, however, as the *Petit Pierre* could be run without supervision, it was utilised on barges upon Belgium canals. This reversing system was put forward to Burmeister and Wain (B&W) for further developments and eventually installed, in 1910, in the *Vulcanus*. Later, Dyckhoff collaborated with Adrien Bochet and designed a marine diesel engine of 25 HP which was suitable for barges in use between the Rhine and the Marne.

One of the problems encountered with fitting diesel engines on barges was that barges of standardised design, 270-290 tons, had flat bottoms

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and the accelerating forces from the vertical engines damaged the vessels. Responding to this, Dyckhoff and Adrian Brochet, in concert with Diesel, designed a single cylinder, four-stroke engine with a horizontal cylinder and two opposed pistons.

The “moteur a pistons opposes” was designed so that the combustion chambers had valves in the middle of the cylinder block, thereby allowing the crank shaft to pass underneath it. The centre lines of the shaft and the cylinder crossed each other in a common point. With this arrangement it was possible for the engine framing to turn around the shaft when placed on two bearing supports mounted on a common bedplate.

Further diesel experiments were occurring in Rochefort, France, where Sautter-Harle and Cie designed an engine similar to that of Dyckhoff’s. It ran at 120 HP and was tested in the French naval submarine, Z. In Russia, Rudolf Diesel’s patent was taken over by the engine works of Ludwig Nobel of St. Petersburg on February 16th, 1889. In 1899, Noble began building a 20 HP diesel engine of cross head type. Some changes were made to Rudolf Diesel’s original design in an attempt to facilitate the manufacture and operation of the engine as well as the accessibility to the engine parts for inspection. The utilisation of the diesel engine was not solely used on marine vessels. In a rush to exploit the petroleum oil fields throughout Russia, the government installed a pipeline from Baku at the Caspian Sea to Batum at the Black Sea.

The original plans for the pipeline had designated four pumping stations to be equipped with diesel engines; the rest were to receive regular pumps. In the end however, the proven increase in efficiency impressed the authorities so much that all 52 stations were fitted with diesel engines of 150 HP each. Russia’s desires for diesel engines did not terminate at the drilling stations. In 1903 Russia put forth a request to B&W for a diesel engine ship.

However, because B&W did not own the rights to Diesel’s Russian patent, they were not able to comply and fill the order. The vessel, the *Vandal*, measuring in length: 7.45 m, beam: 9.68m and built in 1903 by Ssormowo at the shipyard Nischnij Nowgorod. At this early developmental stage because there were no marine diesel engines in use, the vessel’s engine consisted of diesel electric machinery of 3 stationary diesel engines of 120 BHP. Russia therefore exploited the new invention for both drilling petroleum and steam navigation on the Caspian Sea.

The dilemma of patent ownership was one that hindered the development of diesel engine vessels. Finally, Diesel obliged the requests for design permits and he established a system of mutually bound concessionaires, who were willing to take over his patent rights within territories where his patents were in force. He authorised the concessionaires to manufacture his engines under license.

Because of this, the Nobel Brothers ordered a second vessel: the *Sarmat*, a diesel tanker built with an electrical transmission to stimulate the propellers. This system known as the Del Proposto System was implemented to minimise electrical waste. When an engine was running at full speed, full power was utilised. This was a progressive step and one that was patented on August 4, 1904. Although a good concept, a license fee was charged for its usage. Therefore the Del Proposto System was not popular because on top of the license fee to Del Proposto for electrical coupling, builders also had to pay a fee to Allgemeine Gesellschaft fur Dieselmotoren for using the design of the diesel engine.

The two vessels, *Vandal* and *Sarmat* were in use throughout 1904/1905. They became models for the design and the building of a series of ships for the Imperial Russian Navy as they proved that a) it was possible to use diesel for the propulsion of ships and b) ship design could be easily adapted to fit a diesel engine. Russia had a favourable situation because of the petroleum fields and because of their geographical location; the Russian diesel powered vessels were set upon inland waters, they had yet to conquer the open seas. The Russo-Japanese war of 1904 impacted the pace of development, however their innovations did not falter.

Research began into the design of ocean-going diesel vessels with the sole purpose of developing a liner that could travel from Kronstadt to the Yellow Sea and back again without needing to stop for fuel. Because of the war, Russia did not build such a vessel, and instead, concentrated upon increasing the naval fleet. They became the first to develop a light, fast burning diesel powered vessel. The military diesel vessels had reversible engines and were modelled after the gunboat of the Kars class.

1910, A Turning Point …

The early years of experimentation in the field of diesel engine design established a platform from which, by 1910, massive steps were taken in the utilisation of diesel engines on sea faring vessels. Here with some details of the landmark year of 1910: Diesel's long standing patent on the diesel engine expired in 1910. All engine works could thus freely manufacture diesel engines. B&W approached Russian manufacturers in an attempt to fulfil a request for building engines, which they had earlier declined. This was spurned on by discovering the effects heavy oil had on large vessels. The managing director of B&W had undertaken such studies in 1903 at the Russian petroleum plants.

Following this, B&W tried to secure abundant supplies of cheap diesel oil to fuel engines. Because B&W were seen as one of the leading manufacturers of diesel engines, they were approached in 1909 by Werkspoor, a Dutch engineering firm who, themselves bidding to be leaders in the industry, suggested that they refrain from selling diesel engines in each others country. B&W declined such a suggestion and then contacted J. & H. W. van des Ploeg through whom they went on to sell diesel engines in the Netherlands. Werkspoor developed two diesel engines. However, unlike those manufactured by B&W, these were not reversible and they had variable pitch propellers. In 1910, the Werkspoor motor vessel, the *Vulcanus*, sailed as part of the Dutch East Indies fleet and remained in commission until 1931, sailing from Rotterdam to Stockholm.

B&W benefited from their monopoly of patents in that they were able to manufacture a variety of engines, such as steam turbines after the Charles Parson system and steam engines manufactured after the Stumpfs system. However, they still needed to design a patent that did not infringe upon already existing patents, in order to solidify their position as leading designers and manufacturers of diesel engines.

On October 27 1909, B&W filed a patent application for a reversing device for internal combustion engines with a moveable camshaft. Patent number 13701 was granted on the September 8 1910. Prior to that, in June 1910 while such developments were occurring, B&W were also testing a four cylinder, stationary diesel reversible marine engine for the Fredericia Power Station. The purpose of the test was to change the function of the inlet/outlet valves during the reversed running by means of a change over valve in the charging and discharging pipe. Later that autumn, an 8 cylinder reversible marine diesel engine, the DM830X, by B&W became the first enclosed diesel engine with forced lubrication to be manufactured.

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This engine was intended for placement in a small ship ordered by the East Asiatic Company, but the company's managing director, Anderson, changed the order so that the diesel engines would be placed in large ships. Anderson requested three diesel engine ships, the *Selandia*, the *Fiona* and the *Jutlandia.* The Selandia and the Fiona were built by B&W; the Jutlandia was constructed by Barclay, Curle & Co in Glasgow. The *Selandia* had two main engines and became the first ocean going motor vessel. The race for claiming such a title was fierce.

The *Monte Penedo*, built by Howaldswerke in Kiel for Sudamerikanischen dampfschifftahtrsgesellschaf in Hamburg, had the same size and speed as the *Selandia* and it was also equipped with two reversible, twostroke diesel engines.