Introducing the world's largest gas engine

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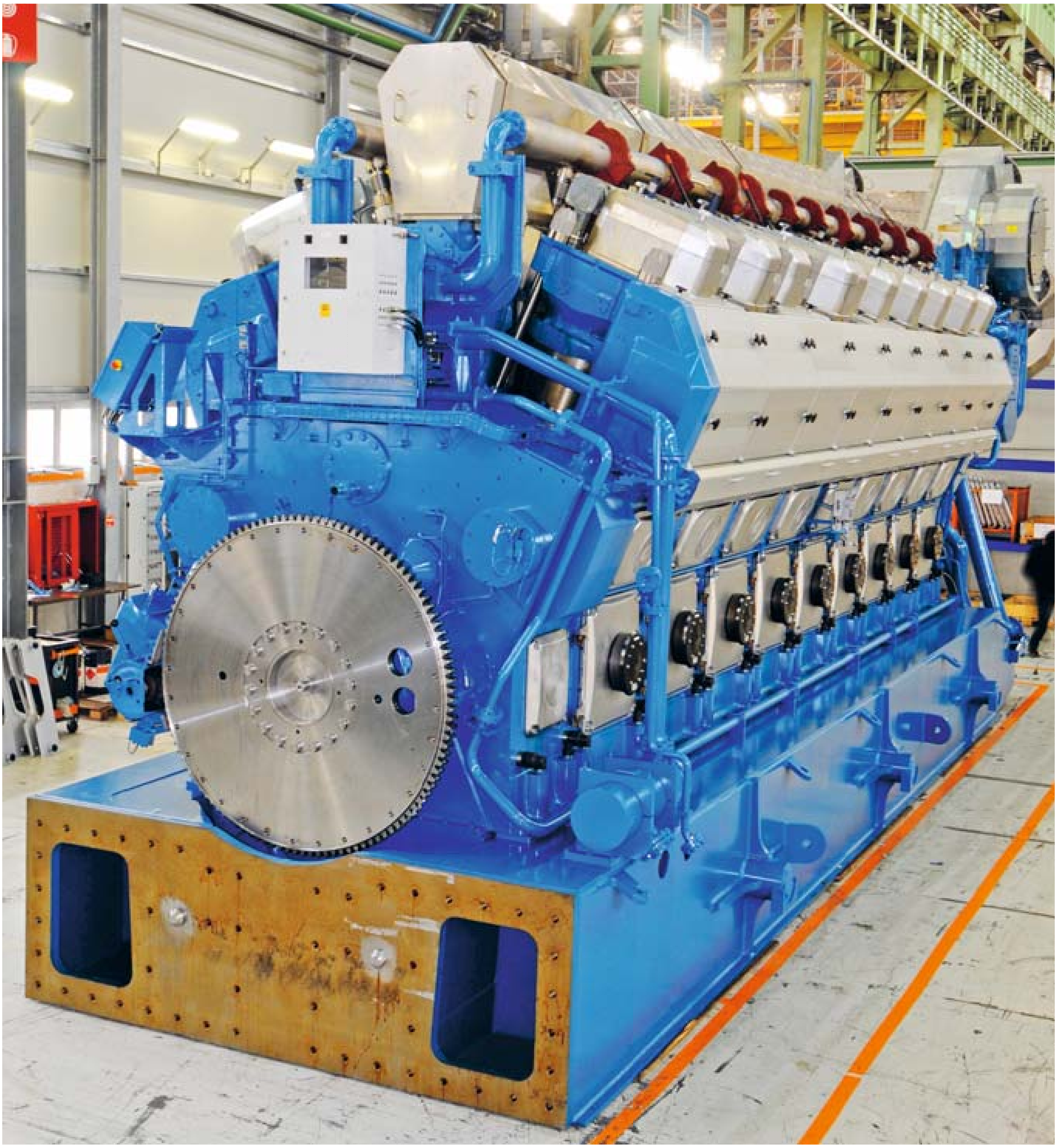

Wärtsilä has introduced the largest gas engine on the market. Based on the well-proven technology of the Wärtsilä 34SG and 50DF engines, the Wärtsilä 18V50SG has an output of 18 MW and offers an alternative to gas turbines for large power plants.

Power plants based on multiple engines have many advantages. For example, since operators need run only as many engines as are required, they offer flexible power output with high plant efficiency. Operators can also carry out maintenance without shutting down the entire plant.

But as plant sizes increase increase, there is a need for units with higher output. The most engines that Wärtsilä has installed to-date in a single plant, is the 28 Wärtsilä 34SG units for a 270 MW power plant in Turkey. This seems to be the point at which operators tend to opt for gas turbines due to their larger unit size.

With the introduction of its latest gas engine Wärtsilä can now offer a product directly competing with the gas turbine technology. By doubling the output of the Wärtsilä 34SG, the new Wärtsilä 50SG gas engine once again makes combustion engines an attractive alternative to gas turbines for large power plants.

Design and development

The Wärtsilä 50SG is a four-stroke, spark-ignited gas engine that works according to the Otto principle and the lean-burn process. The engine runs at 500 or 514 rpm for 50 or 60 Hz applications, and produces 18,810 and 19,260 kW of mechanical power respectively.

This represents maximum electrical power outputs of 18.32 MW and 18.76 MW respectively, at which the Wärtsilä 50SG has an efficiency of 48.6 percent at the generator terminals – 2.3 percentage points higher than the smaller Wärtsilä 34SG. This is a big step, since typically product improvements result in efficiency improvements of around 0.5 percent per year.

The Wärtsilä 18V50SG is based on the same design principles as the well-proven technology used in the Wärtsilä 34SG and Wärtsilä 50DF engines.

As the engine was based on existing technology, its development was very quickly implemented. Development started in 2008, and the first 6-cylinder laboratory engine was built in 2009. Assembly of the first customer engine began the following year and its testing was completed at the Trieste facility by the end of 2010.

The engine frame is based on the Wärtsilä 18V50DF dual-fuel engine, with the same advanced integrated lube oil and cooling water channels.

The combustion system is based on →

Table 1 – The output of the Wärtsilä 50SG engine.

	50 Hz/500 rpm	**18V50SG**
Power, electrical	kW	18 321
Heat rate	kJ/kWh	7411
Electrical efficiency	%	48.6
	60 Hz/514 rpm	**18V50SG**
Power, electrical	kW	18 759
Heat rate	kJ/kWh	7411
Electrical efficiency	%	48.6

Table 2 – Dimensions and weights of the Wärtsilä 50SG generating set.

Lenght	mm	18 800
Width	mm	5330
Height	mm	6340
Weight	tonne	360

the Wärtsilä 34SG, but has a larger bore size to maximize the power potential of the engine block.

Increasing the bore size from 340 mm to 500 mm on a spark-ignited engine was a key area of technology development.

In a modern gas engine, lean-burn technology is a necessity in achieving low emission levels without external exhaust gas after-treatment. In lean-burn technology, the charge in the cylinder has far more air than is actually needed for complete combustion of the gas.

Ignition of the extremely lean fuel charge is very difficult, and the right ignition technology is needed to provide a high-energy ignition source.

The choice of ignition technology most suited for a pure gas engine with a large bore was discussed extensively at the beginning of the project.

Spark ignition with a pre-chamber, also known as SG technology, is used on existing pure gas engines. However, the consequences on performance when scaling the technology to a bore of 500 mm were unknown.

An alternative option of using a micro pilot liquid fuel ignition through a pre-chamber was also proposed. This was a new technology for Wärtsilä, and thus required more design and research work. Furthermore, its performance and possible consequential benefits were also unknown for this bore size.

Both concepts were tested and found to perform equally well. Based on proven reliability and lower cost, it was decided to opt for the spark ignition with pre-chamber technology.

Pre-chamber

The pre-chamber is the ignition source for the main fuel charge, and is an essential component of a lean-burn spark-ignited gas engine.

It should be as small as possible to deliver low NO_X values, but big enough for rapid and reliable combustion.

Extensive calculations and simulations had to be performed to scale-up the size and shape of the combustion pre-chamber in order to ensure the best combustion process.

In addition to the size and shape of the pre-chambers, some of the key design parameters considered were: the mixing of air and fuel; gas velocities and turbulence at the spark plug; cooling of pre-chamber and spark

plug; and the selection of material.

Advanced three-dimensional, computerised fluid dynamics were used during design to deliver:

- Reliable and powerful ignition
- High combustion efficiency and stability
- Extended spark plug life
- Very low NO_X levels.

The engines use a ported gas admission system, whereby gas is admitted to the pre-chamber through a mechanical, hydraulic-driven valve.

The gas admission valves are located immediately upstream, and are electronically actuated and controlled to feed the correct amount of gas to each cylinder.

Since the gas valve is timed independently of the inlet valve, the cylinder can be scavenged without risk of the gas escaping from the inlet directly to the exhaust.

Various parameters, such as engine load, speed, and cylinder exhaust temperatures, are monitored and used as input to the Engine Control System (ECS). The ECS is Wärtsilä's latest UNIC (Unified Controls) C3 system, which controls the entire engine.

This solution has proved to be extremely reliable and it results in an excellent mixture in the pre-chamber.

Ignition system

The Wärtsilä 50SG ignition system has been specifically designed for the new engine and is closely integrated with the ECS. The ignition module communicates with the main control module, which then determines the global ignition timing.

The ignition module controls the cylinder-specific ignition timing based on the combustion quality. The cylinder-specific control ensures optimum combustion in every cylinder with respect to reliability and efficiency.

The ignition coil is located in the cylinder cover and is integrated into the spark plug extension. The coil-on-plug design minimizes the number of joints between the spark plug and the ignition coil, and thus increases reliability.

The spark plug has been specially developed for long life, and to withstand the high cylinder pressure and temperature resulting from the high engine output.

Engine frame

The engine frame is based on the proven design of the Wärtsilä 50DF, and the block is made from cast iron. The engine has an under slung crankshaft, which imparts high stiffness to the engine block and provides excellent conditions for maintenance. The engine block has large crankcase doors to enable easy maintenance.

Cooling system

The Wärtsilä 50SG is designed with a Wärtsilä open interface cooling system for optimal cooling and heat recovery.

The system has four cooling circuits: the cylinder cooling circuit (jacket), the low temperature charge air (LTCA) and high temperature (HTCA) cooling circuits, and the circuit for the lube oil cooler (LO) built onto the auxiliary module.

The LTCA cooling circuit and jacket cooling circuit have water pumps integrated within the cover module at the free end of the engine coolers, and the temperature of the water exiting the jacket cooling circuit is controlled by external thermostatic valves.

The default cooling system is a single-circuit radiator unit whereby the cooling circuits on the engine are connected in series. For heat recovery applications, each cooler can be individually connected to an external cooling system.

Lubricating oil system

The engine has an engine-driven lubricating oil pump and is provided with a wet sump oil system. Before entering the engine, the oil passes through a full-flow automatic back flushing filter. A duplex cartridge filter is installed in the back flushing line, and both filters are equipped with differential pressure switches.
A separate pre-lubricating system is used before the engine is started to avoid engine wear.

Pistons

The pistons are of the low-friction, composite type, with a forged steel top and nodular cast iron skirt. Their long life is ensured through the use of a skirt-lubrication system, a piston crown with shaker-cooling, hardened piston ring grooves, and low-friction piston rings. →

Piston ring set
The two compression rings and the oil control ring are located in the piston crown. This three-ring concept has proven its efficiency in all Wärtsilä engines. Most of the frictional loss from a combustion engine originates from the piston rings. A three-ring pack has proven to be the optimal solution, offering both function and efficiency. In a three-pack, each ring is dimensioned and profiled for the task it must perform.

Cylinder head
The engine uses four-screw cylinder head technology. At high cylinder pressures this technology has proven to be superior, especially when liner roundness and dynamic behaviour are considered. In addition to easier maintenance and reliability, it provides the freedom to employ the most efficient air inlet and exhaust outlet channel port configurations.

A distributed water flow pattern is used for proper cooling of the exhaust valves, the cylinder head flame plate, and the pre-chamber. This minimizes thermal stress and guarantees a sufficiently low exhaust valve temperature. Both inlet and exhaust valves are fitted with rotators for even thermal and mechanical loading.

Cylinder liner and anti-polishing ring
The cylinder liner features an anti-polishing ring, which reduces lube oil consumption and wear. The bore-cooled collar design of the liner ensures minimum deformation and efficient cooling. Each cylinder liner has two temperature sensors for continuous monitoring of piston and cylinder liner behaviour.

Connecting rod and big-end bearings
The connecting rod is designed for optimal bearing performance. It features a three-piece design, in which combustion forces are distributed over a maximum bearing area, and relative movements between mating surfaces are minimized. The design also allows the compression ratio to be varied to suit gases with different knocking resistance. The three-piece design reduces the height required for piston overhauling. Piston overhaul is possible without touching the big-end bearing, and the big-end bearing itself can be inspected without removing the piston. The big-end bearing housing is hydraulically tightened, resulting in a distortion-free bore for the corrosion-resistant precision bearing.

Crankshaft and bearings
The crank gear has to be able to operate reliably at high cylinder pressures. The crankshaft must be robust and the specific bearing loads maintained at acceptable levels. This is achieved by careful optimization of the crank throw dimensions and fillets. The specific bearing loads are conservative and the cylinder spacing, which is important for the overall length of the engine, is minimized. In addition to low bearing loads, the other crucial factor for safe bearing operation is oil film thickness. Ample oil film thickness in the main bearings is ensured by optimal balancing of the rotational masses, and in the big-end bearing by un-grooved bearing surfaces in the critical areas.

Turbo charging system
The Wärtsilä 50SG is equipped with a single pipe exhaust turbo charging system designed for minimum flow losses on both the exhaust and air sides. The interface between the engine and turbocharger is streamlined, The engine uses high-efficiency turbochargers, with the engine lubricating oil also being used for the turbocharger.

Automation
All engine functions are controlled by the UNIC C3 engine control system, a microprocessor-based distributed control system mounted on the engine. The various electronic modules are dedicated and optimized for specific functions, and they communicate with each other via a CAN databus.

Cylinder pressure control
Each cylinder is equipped with a pressure sensor. The cylinders can be individually set to run at their optimum point to achieve the highest engine power and efficiency. This also applies if operating conditions change, as in the case of varying methane numbers and ambient temperatures. Additionally, this means that the engine can be run with increased safety and reliability. Cylinder pressure measurements provide significantly improved engine control.

From the signal emitted by the pressure sensors, UNIC can instantaneously determine the rate of heat release, the magnitude and location of peak pressures and the knock severity. The sensors can also be used to determine the indicated mean effective pressure, which is essentially a measure of the power developed in each cylinder. The sensor is designed to withstand high cylinder temperatures and pressures – up to 300°C and 300 bar. The maintenance interval of the sensor equals that for the cylinder head overhaul, i.e. around 16,000 hours. The location of the pressure sensor is also important. The measuring membrane of each sensor is flush-mounted in the combustion chamber, to ensure measurement of correct and reliable data.

Main control module
The core of the engine control system is the main control module. This is responsible for ensuring the engine's reliable operation and for keeping the engine at optimum performance in all operating conditions, including varying ambient temperatures and fluctuating gas quality. The main control module reads the information sent by all the other modules. Using this information, it adjusts the engine's speed and load control by determining reference values for the main gas admission, air-fuel ratio, and ignition timing. The main control module automatically controls the start and stop sequences of the engine and the safety system. The module also communicates with the plant control system.

Cylinder control module
Each cylinder control module monitors and controls three cylinders. The cylinder control module controls the cylinder-specific air-fuel ratio by individually adjusting the gas admission for each cylinder. The cylinder control module measures the knock intensity, i.e. uncontrolled combustion in the cylinder, which is used to control the cylinder-specific ignition timing and gas admission.

Monitoring modules
Monitoring modules are located close to groups of sensors, which reduces the amount of cabling on the engine. The monitored signals are transmitted to the main control module, and are used for the engine control and safety systems. The monitored values are also transferred to the Wärtsilä Operators Interface System (WOIS) on the plant automation system.

Customer benefits
In addition to higher efficiency and increased power output, another key benefit of the Wärtsilä 50SG, as with all Wärtsilä engines, is its ability to run up and down in load without affecting the maintenance schedule. This is useful for peak applications, or in markets where there is a significant amount of wind power on the grid – it can reach full power in 10 minutes in the event of a sudden drop in wind capacity. The engines can also be stopped in one minute and reloaded in just five minutes, something that is not possible with gas turbines.

Compared to gas turbines, the performance of the engine is also less sensitive to ambient conditions. There is little drop-off in efficiency or power output at higher ambient temperatures.

Already customers are keen to take advantage of this new engine. The first has been installed at the Aksa Samsun power plant in Turkey, and will serve as a pilot engine, allowing Wärtsilä to continue its field testing. At the beginning of March, an order was also placed by Odas Elektrik Uretim, an independent power producer, for the installation of seven engines at its new plant at Urfa in southeastern Turkey. Upon completion in autumn 2011, the plant will supply 135 MW of electricity to the national grid.

The new Wärtsilä 18V50SG spark-ignited gas engine has been developed in response to the increasing market need for larger gas engines to run power plants with outputs of up to the 500 MW range. It meets current and future requirements for overall cost of ownership, with very high simple and combined cycle efficiency. It is also designed for easy maintenance and many hours of maintenance-free operation.

REFERENCE: SAMSUN, TURKEY

The Aksa Samsun combined cycle plant will be equipped with the first Wärtsilä 18V50SG generating set.

THE NEW WÄRTSILÄ 50SG ENGINE MAKES ITS DEBUT IN TURKEY

Wärtsilä was awarded an engineering and equipment contract relating to the extension of the Aksa Samsun power plant in Samsun, Turkey.

The Aksa Samsun power plant has been extended to incorporate the Wärtsilä 18V50SG engine, the latest addition to Wärtsilä's gas engine portfolio. This is the very first installation of the Wärtsilä 18V50SG unit, which features an exceptionally high power plant efficiency rating of over 50 per cent in combined cycle mode. In converting the Aksa Samsun facility from HFO to gas-fired operation, its environmental sustainability is obviously enhanced. At the same time, the efficiency of the new Wärtsilä 50SG engine sets a benchmark for the industry.

The scope of supply also includes the controls, automation and auxiliary equipment related to the fuel gas, charge air, cooling and exhaust gas systems.

The Aksa Samsun combined cycle plant, owned by AKSA ENERJI, currently operates using seven Wärtsilä 18V46 engines running on heavy fuel oil (HFO), six of which will be converted to Wärtsilä 18V46GD engines for gas-fired operation. When the Wärtsilä 18V50SG engine has been commissioned in 2011, the power plant will have a total electrical output of approximately 130 MW in combined cycle mode, which will be fed to the national grid.

Wärtsilä already has a very strong presence in Turkey's energy market, and expects to have delivered close to 3 GW of power generating capacity by the end of 2011. Some 85 per cent of these power plants will be running on natural gas.