



Hikers in the
Central Taurus
Mountains, Turkey.

AUXILIARY TURBO-GENERATION WORKS

Trials in Turkey last year showed that, after retrofitting a turbo-generator, a generating set will produce about 1% more power with no increase in fuel consumption and no impact on engine performance. The product is now available as an option for new power plants too.



A turbo-generator turns exhaust energy into electricity. Wärtsilä gas engines use a waste gate, a turbocharger turbine bypass that controls boost pressure on the compressor side. It is impossible to recover the whole energy flow through the waste gate, but it can be used to generate more electricity.

The waste flow perfectly matches the generator's size so we are able to avoid the typical challenge of rematching the engine turbochargers.

COMMON SHAFT AND SPEED

At the core of this technology are two building blocks, the turbo-generator itself and a power electronics unit; one cannot work without the other. The turbo-generator is a six-phase, permanent magnet generator.

Since the turbo-generator and the turbine are installed on a common shaft the nominal rotating speed of the generator is in the range of 30,000 rpm. This speed requires special attention to rotor design, bearings and internal cooling.

Power is generated at a high frequency, around 1.2 kHz, which is more than 20 times the normal grid frequency. Consequently the turbo-generator cannot be connected directly to the grid. This is where the power electronics is needed.

The energy produced must first be rectified to direct current (DC) and then converted back into alternating current (AC) by an inverter, which works in a similar manner to an uninterrupted power supply or a regenerative frequency drive converting the DC power into a 3-phase 400V 50Hz power.

The turbo-generator must be controlled at all times in order to keep it inside optimal operation parameters. This is done by a controlled DC/DC converter placed between the rectifier and inverter stages.

Efficiency is a key point. After all, the intention is not to create more heat inside the power plant but to generate additional power by harvesting the energy that used to be lost into the exhaust gas stream.

FIRST TESTS IN SPAIN

After extensive concept development, Wärtsilä decided in 2011 to test a turbo-generator at our validation power plant in Bermeo, Spain. The basic tests went very smoothly but, because the demo unit did not have enough capacity for the Wärtsilä 34SG engine used, we were unable to check the full potential of the concept.

Nonetheless, the findings from these tests were very impressive and promising. The unit could deliver about 1% extra electricity per generating set and was totally invisible from the engine side, meaning there was no additional consumption. During ramping it responded very fast to engine load change.

The tests in Bermeo justified a product development project, which was ongoing during 2012 and 2013. The project had two parts; one was to upgrade existing products to match the Wärtsilä 34SG engine family and the second was to develop a bigger unit that would match the Wärtsilä 50SG engine.

In March 2013 the upgraded standard system was ready and field testing of the new turbo-generator set began. The turbo-generator is primarily intended for Wärtsilä spark-ignition gas engines so the tests were conducted in Tirenda, a plant in western Turkey equipped with six Wärtsilä 34SG engines.

VALIDATION IN TURKEY

There were several reasons for choosing Turkey. As a country with a relatively warm climate but substantial variability of ambient temperature throughout the year, it provided the opportunity to verify the unit's performance in the most challenging conditions. Moreover, Wärtsilä has more than 300 engines installed in Turkey and maintains very good relationships with its customers there.

The project was an example of seamless cooperation between Wärtsilä divisions. Power Plants provided expertise in the turbo-generator, while Wärtsilä Services was responsible for the design of the mechanical and electrical installation, coordination of site works, and project execution. Wärtsilä Services in Turkey performed on-site installation of the equipment.

Some challenges were encountered during the installation process and the tests. A retrofit is by nature more difficult than fitting a turbo-generator into a new power plant exhaust system because of the need to adjust all the connections to existing piping routes as well as non-standard civil structures.

During the tests in Tirenda, many improvements were made by Wärtsilä and the system supplier Bowman. The project team obtained a great deal of operational experience and feedback while the unit was designed and installed, and in the creation of a control strategy and verification

THE IDEA IS TO HARVEST THE ENERGY THAT USED TO BE LOST INTO THE EXHAUST GAS STREAM.



The turbo-generator is a six-phase, permanent magnet generator, quite different from typical Wärtsilä generators.

[IN-DEPTH]



process for performance modelling. This will be valuable in further development of the device.

The project was a success from the customer's perspective too. The turbo-generator proved to be able to generate additional power of approximately 1% with no increase in fuel consumption and no impact on the engine performance and its operation.

EXCITEMENT AMONG PLANT OWNERS

Even during the installation phase, news about the new device spread among the power plant owners within the Turkish market. Interest increased again when the unit's significant performance benefits were discovered. The message about the new invention was spread during a customer seminar organised in Turkey in November 2013.

In a parallel installation during autumn 2013, a larger turbo-generator was connected to a Wärtsilä 50SG engine at a plant in Urfa, Turkey.

When the system was started up in mid-December, the unit produced about 5% more power than predicted. Tests will be continued during most of 2014 to check unit operation at different ambient conditions and various engine loads. Following these successful tests, the Power Plant Technology department is now working on having the turbo-generator fitted into standard gas plant layouts. The product is already available as an option for any new gas power plant project.

The turbo-generator unit is not only a way of improving the efficiency of new power plants but is also a perfect retro-fit option for existing plants. Wärtsilä Services and Power Plant Technology work together to optimise the design for each application. The turbo-generator can be installed as part of other performance improvement packages, and can extend a power plant's lifetime by raising operational efficiency. ●

Carbonate travertines with blue water - a unique natural wonder in Pamukkale, Turkey.