KDI Assembly Line

Reggio Emilia Plant

Kohler/Lombardini: innovation *Made in Italy*

The Lombardini factory in Reggio Emilia has been named a centre of excellence in the KOHLER Group. The production facility at Reggio Emilia will produce the new, innovative KDI engine that was developed to meet the Final TIER 4 - Stage IIIB regulations set to take effect on January 1, 2013.

A quest for excellence in product quality, customer service and competitiveness has been the “driver” behind the wheel of every decision - even choices that have to do with production processes. The conflicts between some of these "drivers" were resolved by adopting a specific production strategy.

In fact, although cost objectives often require that products be produced in Asian countries such as China and India, the pursuit of high standards of product quality - and especially the need to offer a superior level of service involving short delivery times - required that the strategy adopted by KOHLER include the importation of components from emerging countries and the creation of the assembly process in Italy. The most important machining procedures will still be performed internally (crankshaft, camshaft, and all finishing operations on the crankcases, including honing of the cylinders and precision machining). The latter in particular is essential for achieving targeted performance in terms of reduced emissions and oil consumption, and therefore received the most significant investments in the entire project.

Furthermore, because the two most important Italian seaports on the Mediterranean (Genoa and La Spezia) are nearby, materials are received frequently and consigned quickly, so the plant can easily meet the needs of customers in Europe and around the world.

Finally, the technical office at the plant is able to provide the immediate, appropriate support that is required during the startup phase of a product as technologically advanced as the KDI engine.

Kohler/Lombardini: the KDI engine on the test bench

The assembly line for the KDI is distinguished by highly automated systems and a painstaking quest for excellence.

It is divided into three sub-lines: the first, called “short block”, assembles the elements that are common to all models. These include the crankcase, bedplate, oil pan, camshaft, crankshaft, connecting rods and pistons.

The second sub-line, termed the “long block”, completes the upper section of the engine and customizes it to obtain the particular version involved. Assembled in this phase are the gears, cylinder head, valve gear cover, oil pump, water pump, injection system, starter motor and alternator. Finally, the third sub-line (running parallel to and not subsequent to the “long block”) assembles the cylinder head.

The entire assembly line extends over a distance of 236 meters and consists of 39 stations, of which 11 are automated (14 stations, of which 7 are automated, for the Short Block - 25 stations, 4 being automated, for the Long Block). The cylinder head line is made up of 6 stations, of which 3 are automated, ensuring the highest possible quality in the assembly of half-cones and in the testing of valves for proper sealing.

The two main sub-lines (Short and Long Block) are connected by an AGV (automatic guided vehicle).

The theory underlying this approach is “objectification of the production process”: the creation of an industrial design that introduces a *best practice* for performing each operation, which leads the user to

execute the operation correctly by eliminating possible errors due to distraction.

Months of work have been devoted to creating an FMEA for the process, and special attention has been given to applying the *poka-yoke* principle of error prevention.

Each station is equipped with LIPS (Lombardini Information Production System), a computerised system of instructions that accompanies the engine at each step in its assembly. This system supports the operator at every station by providing him with guidance on the configuration that must be executed and on the technical specifications that must be met for completing assembly correctly.

The use of sophisticated computerised controls ensures compliance with the production specification, since the line will not move on to the next step unless the check points at previous station are successfully passed.

The objectification of each production step has been raised to the highest level, in order to minimise acceptance testing on the bench.

To accomplish the latter, the plant will adopt a mixed process involving short acceptance tests on hot running engines and tests on engines that are externally driven when cold. In particular, hot tests will be required on engines equipped with mechanical injection, and cold tests will be performed on engines with the common rail system. The entire process will employ the finest, most advanced technologies in the field of diesel engines for industrial and automotive applications.

Kohler/Lombardini: the KDI engine by the numbers

The currently installed production capacity for the KDI is 33,000 engines/year with two work shifts, which can easily be doubled with a lead time of 8-10 months.

With regard to the machining required for finishing the crankcases, we have come up with a flexible solution with two (for 26,000 units/year) to five (for 65,000 units/year) latest generation machining centres that are specifically designed for cast iron. These centres are included in a robotised cell that can handle any type of 3 or 4-cylinder crankcase simultaneously. The cell feeds a cylinder honing machine, a high-pressure washer with positioned sprays, and a sealing test machine. The entire system is designed to offer maximum precision and cleanliness before assembly.

The system is an important example of a production solution that achieves the optimum compromise between cost competitiveness and high standards of quality. In fact, although castings and semi-finished components are imported from emerging countries, hi-tech finishing is performed internally with dedicated processes. And, everything is in a close relationship with the assembly line.

Kohler/Lombardini: integration of production

The new production line for KDI engines is not an innovation for innovation's sake. In fact, thanks to the SAP integrated system of corporate resource planning, production will be managed in a tight relationship with all company processes - from purchasing to planning, and from sales to logistics.

Kohler/Lombardini, about KDI

In preparation for new regulations on emissions that are soon to take effect (final TIER 4, above 19 kW in the US; Stage IIIB, above 37 kW in the EU), Kohler is presenting a new line of KDI (Kohler Direct Injection) diesel engines.

Fully optimized to meet market demands, the design was developed using the most advanced technology currently available. Clean combustion achieved with a high-pressure (2000 bar) Common Rail system of the latest generation, combined with an electronically triggered EGR valve that makes circulate the right amount of exhaust gases (which are liquid-cooled by a water/air heat exchanger), enables emission levels to comply with the new regulations while providing exceptional performance - and all without the use of after-treatment systems. The added value of KDI and the technology employed to create it result in "Best Comfort" for the user, thanks to the compact size of the engine, and its performance, sturdiness, low levels

of vibration and noise emissions, and low operating and maintenance costs.

The three models with direct injection, each with a different displacement (1.9L – 2.5L – 3.4L), are available in two different configurations:

- Mechanical injection: compliance with Tier 3/STAGE IIIA emission requirements
- Common Rail injection: compliance with Tier 4/STAGE IIIB emission requirements

Main technical specs	Engine Model				
	KDI 1903M	KDI 1903TCR	KDI 2504M	KDI 2504TM	KDI 2504 TCR
No. of cylinders	3	3	4	4	4
Stroke (mm)	102	102	102	102	102
Bore (mm)	88	88	88	88	88
Displacement [cc]	1861	1861	2482	2482	2482
Power[kW@RPM]	31.0@2800	42.0@2600	36.4@2800	55.4@2800	55.4@2600
Max. torque [Nm@RPM]	133.0@1500	225.0@1500	170.0@1500	230.0@1500	300.0@1500

Main technical specs	Engine Model			
	KDI 3404M	KDI 3404TM	KDI 3404TCR	KDI 3404TCR-SCR
No. of cylinders	4	4	4	4
Stroke (mm)	116	116	116	116
Bore (mm)	96	96	96	96
Displacement [cc]	3357	3357	3357	3357
Power[kW@RPM]	53.0@2600	80.0@2600	55.4@2600	100.0@2400
Max. torque [Nm@RPM]	250.0@1500	400.0@1500	385.0@1400	480.0@1500

Only target data is supplied for the 3.4L model, since the unit is still in the design stage.

About Global Power Group

Within the Kohler Global Power Group, Kohler Engines and its subsidiary Lombardini Srl respectively produce petrol engines (up to 30.0kW) and Diesel engines (up to 56.0kW) marketed throughout the world under the brand names of KOHLER and LOMBARDINI.

Also forming part of the Kohler Global Power Group are Kohler Power Systems and SDMO Industries, both manufacturers of generators (marine, residential, industrial and mobile) marketed throughout the world under the brand names KOHLER and SDMO.

Founded in 1873 in Kohler, Wisconsin, USA, Kohler Co. is one of the largest and oldest private companies in the United States. Kohler Companies incorporates a wide range of products within its numerous activities; from petrol engines to power stations, from ceramics to furniture, from hotel chains to golf courses

About Lombardini and KOHLER

Lombardini maintains a strong position as a market leader for expertise and manufacture of diesel engines up to 56kW. The Company has contributed to the group's growth since its acquisition in 2007 and is incorporated as an integral part of the Kohler Global Power Group. Synergy and integration are the key points of this partnership. Kohler manufactures, and distributes worldwide, single and twin cylinder petrol engines in the power range of 3 up to 30.0kW. It is household name in the US market, and its engines are used in numerous applications, but most commonly in the Lawn and Garden sector. Lombardini produces and distributes single and multi-cylinder diesel engines, covering a range of 3.5 up to 56kW, suited to a wide range of machinery in numerous sectors including agriculture, industrial, generating sets, construction, automotive and marine. Together in 2011, Kohler/Lombardini launched the KDI range (Kohler Direct Injection) range of 3 and 4 cylinder water cooled engines. Representing a considerable investment, these innovative engines comply with Stage IIIB/TIER 4 Final Emission legislations, without the need of a Diesel Particulate Filter (DPF), for outputs under 56kW.

The strong presence of both Kohler in the USA and Lombardini in Europe is supported by four commercial subsidiaries in France, Spain, Germany and the UK. This, together with ongoing development in all markets, creates a strong base for a widespread penetration of both new and existing products worldwide.

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