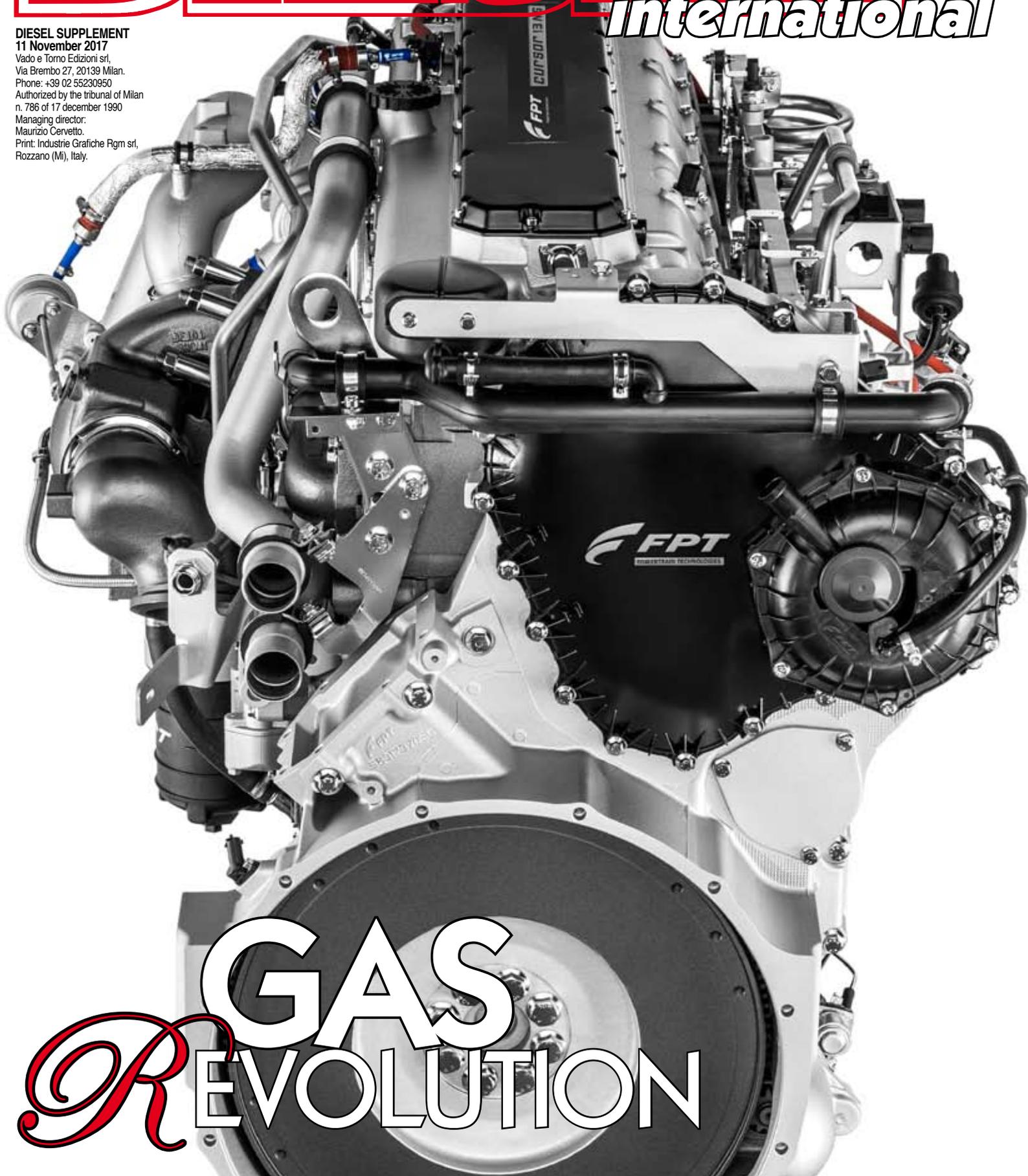


DIESEL

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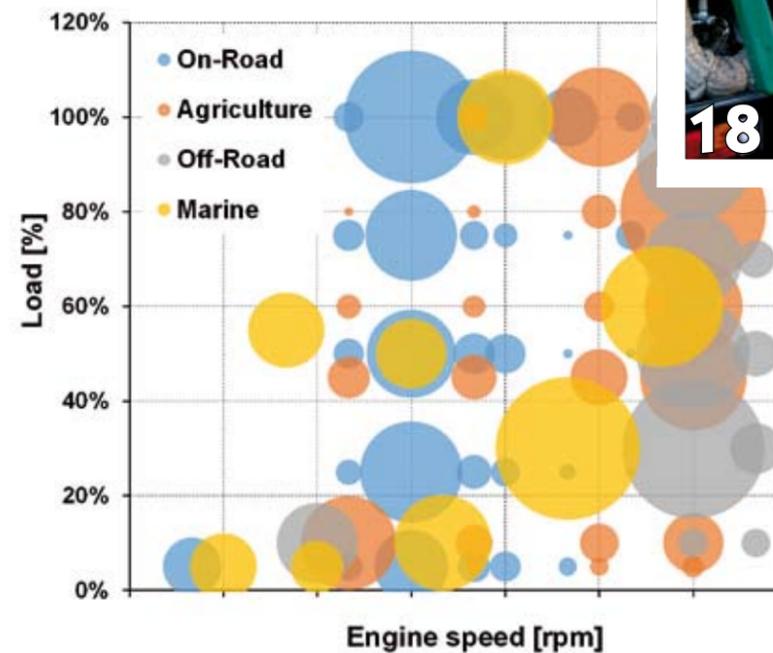
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11 November 2017

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LIEBHERR D9812

Colmar is the home of D9812, Diesel of the year 2017. We checked what's the buzz together with the Liebherr Colmar plant top management and... Yes, it feels good! Diethard Plohberger, Ingo Wintruff and Jens Krug



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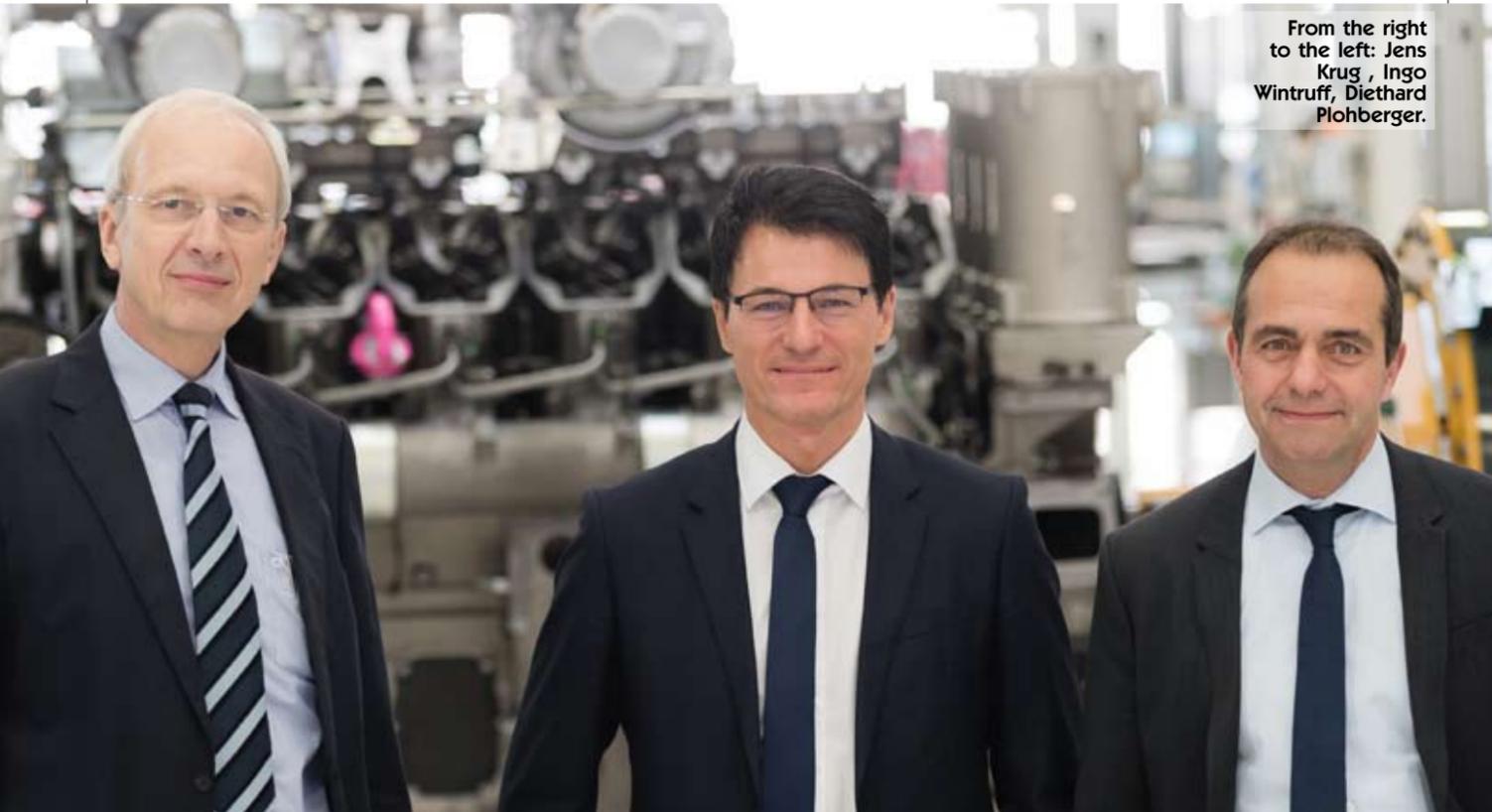
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From the right to the left: Jens Krug, Ingo Wintruff, Diethard Plohberger.

LIEBHERR D9812. DIESEL OF THE YEAR 2017. COLMAR PLANT

D9812 was born here

Diethard Plohberger, Ingo Wintruff e Jens Krug, aka the top management of Liebherr Components in Colmar. they are the best representatives to go back to the roots of the D9812 and help us to understand its mission. We're in Alsace, near Liebherr Mining Equipment facility

Colmar is home for Liebherr. The factory specifically designed for the D98 was completed in 2014. Why right here? Since 1961 Liebherr Mining Equipment manufactures, just a few hundred meters from here its "XXL" excavators, such as the R 9800, 11 meters high and 800 tons in running order. We are in Alsace, at the foot of the Vosges Massif, people speaks French and thinks German. The fairy architectural suggestions and skills in the mechanical industry are the linking point between the two banks of the Rhine river. We're about to have a long talk about the D98 and a visit to the factory along with three exceptional guides: **Diethard Plohberger, Ingo Wintruff and Jens Krug.**

Would you please briefly explain the technological genesis of this engine?

Plohberger: The D98 engine has been designed basically as a mine engine. This means a rugged design for challenging environments like dust, heat, humidity, heavy vibrations, etc. It is a perfect prerequisite for deriving the D98 design for other applications, like power generation, etc. To ensure this and achieve low production cost, low parts stock requirement and ease of maintenance, the engine has been strictly designed according to the tool box principle. The core engine and the auxiliary components are standardized and built in modules.

quisite for deriving the D98 design for other applications, like power generation, etc. To ensure this and achieve low production cost, low parts stock requirement and ease of maintenance, the engine has been strictly designed according to the tool box principle. The core engine and the auxiliary components are standardized and built in modules.

Diesel of the year prize means first of all innovation. What are the features of the innovation in D9812, the winner of Diesel of the year 2017?

Plohberger: The D98 engine features

20% more power density than benchmark engines in the market. The high peak firing pressure capability of 250 bars makes it perfectly suitable to fulfill the new exhaust emission limits in US (EPA Tier4) and Europe (EU Stage V) at simultaneously very good fuel consumption. The standardized and module based design allows different applications at minimum design adaptations.

During the Diesel of the year award ceremony Mr. Plohberger talked about the D9812 as a «benchmark in terms of efficiency and total cost of ownership».

Would you explain it in more detail?

Plohberger: The D98 engine family allows the adaptation to various applications finding the lowest cost of operation. For example, the excavator engines have been reduced in rated speed by 20%, resulting in lower fuel consumption and longer life of moving parts. As the engine family is totally standardized, the customer can choose between engine sizes for the same machine to be driven without changes in installation design. This may result in lower fuel consumption and lower

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investment cost, according to the individual application.

What are the features specifically conceived for mining applications? Can you describe them in detail? What is more important for these applications, power peak level, torque rise, flexibility of the torque curve, power density or other figures?

Wintruff: The main target for mining operators are competitive total costs of ownership. Therefore the engine has been designed to increase the operator's productivity while reducing his engine-related life cycle costs: this means best fuel consumption, high power density, optimized service intervals and maintainability, high lifetime of the engine, outstanding availability and reliability.

What are the main issues, pros and cons in the approach to Egr technology for the D9812?

Plohberger: Exhaust gas recirculation is a common means of NOx reduction for cars and on high way trucks, where totally defined operational conditions are prevailing. In industrial applications with rather low production numbers and an extreme wide variation of operational conditions the highly sensitive EGR technology is seen very critical in terms of development effort, operational safety for the customer. Liebherr therefore has decided to use the so called SCR-only technology for all diesel engines. The particulates and soot will be reduced inside the engine cylinder and combustion, using only a quite simple catalyst and AdBlue/DEF, like above mentioned passenger cars



and trucks, to eliminate NOx emissions. This enables the mentioned kind-of-a-tool-box design, using the same engine for the most stringent low emission as well as for other markets. The SCR system is just another module to be used.

How did Liebherr improve Scr technology in terms of process, consumption, urea injection, crystallization risks, etc.?

Plohberger: Liebherr Machine Bulle has a long lasting experience with this technology. We decided to use the same SCR converters for the smaller D96 and the larger D98 engines, according to engine size.

By this, the engineers can focus on only one layout design to make it working perfectly under all conditions. Hence, the (again) modular and standardized design of the exhaust system allows low production cost by design.

The 12-cylinder engine D9812 for mobile applications is intended to work in harsh environment. How did you solve the problems related to dust, humidity, environmental contaminants and high temperatures?

Plohberger: Sealing and filtration is key point. We use very high

quality sealings, sometimes double sealings at critical parts, to keep the dirt outside the engine. Filtration of air and especially oil is also on a very high level. The residual risk is backed up by using special materials for bearings, etc. to make the engine less sensitive to dirt contamination. Electrical parts, especially connectors, are prone to disturbances by water and moist. High quality electrical harness and connectors are used to ensure engine reliability.

Can you compare the D9812 with its main competitors (i.e. MTU and Cummins)?

Wintruff: The D98XX is a brand new series, while some of the competitor's engines in the market have been developed 20 or 30 years ago. Using state of the art technology we are convinced that our engine will set the benchmark in the market in terms of efficiency and power density. To reach this target we use modern common rail high pressure injection technology developed by Liebherr, an advanced turbocharging technology, high peak firing pressure, downspeeding options to further improve efficiency and downsizing options to offer cost advantages in existing machines.

What are the crucial items of the common rail and the ECU and



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what are the differences between these systems and the common rail and ECU of the other Liebherr engines families?

Plohberger: Liebherr uses their own ECU and common rail systems. The larger and the smaller engines are using very similar or equal ECU hardware, the same software and common parts in high pressure fuel pumps and fuel injectors. This ensures an economy of scale in view of commercial aspects as well as technological and development aspects. More parts in common mean again less development time, higher maturity level and less cost in the supply and maintenance chain.

And what about other Liebherr components set in the D9812?

Plohberger: Besides the mentioned components in common we share a lot of development modules and results in the Liebherr Diesel engine community. This builds up a stable and well backed-up set of know-how to be used in terms of designing new engines or in trouble shooting.

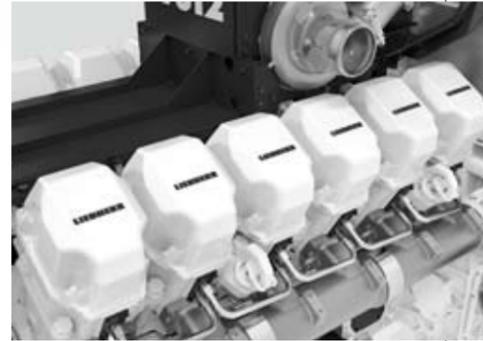
Can you explain the agreement with Kohler for the powergen version, the features of the genset application and if Liebherr engineering has updated the new engine together with Kohler or in house?

Krug: Kohler and Liebherr are strategic partners collaborating on these engines development since 5 years to successfully innovate through vertical integration. The G-Drive Application features have been a co-development between Kohler and Liebherr and have been tested under rigorous operating conditions. These features were exclusively developed for power generation to ensure optimal voltage and frequency performance as required in this application.

Which are the best markets for mobile machinery (dumper and excavators)?



On the right side, one bank; on the left the common rail system. Below the mine truck.



Wintruff: There is no 'best market' or specific target market, but we target all global mining regions by responding to the specific regional/local requirements by cold configuration for mine sites in "arctic environment", high altitude configuration

for elevated mine sites, Tier 4 solution for highly regulated markets and heavy duty kits for very extreme and harsh conditions.

Brent is slowly rising up. How should D9812 equip oil & gas

applications and which of them?

Wintruff: The D98 engine is already in serial production for genset applications. With the built-in features for harsh and demanding operations, its high efficiency and capability of high load profiles in continuous applications, the engine fits perfectly for oil & gas operations, e.g. as drilling gensets or high horsepower fracking. The above mentioned points on total costs of ownership will also support oil & gas operators worldwide.

Which are its potential rail applications?

Wintruff: The D98 Series fits well to the locomotive application, both mainline or shunting locomotives. Low costs of ownership thanks to the high efficiency of the engine and optimized maintenance schedule are key factors for the operators. We also target a high engine availability to avoid any equipment delay, based on our robust mining engine design.

Fabio Butturi

Agricultural machinery engine MAN D3876 LE



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DIESELGATE. The timeline. What happened in a decade

FROM 2007 TO 2017

Volkswagen executives were struck by the Dieseltgate on September 17, 2015. The scandal, however, stems its roots in 1998. The matter was closed on January 2017. Figures and facts about the scoop who shook the diesel milieu

The dieseltgate story appeared in the headlines of September 17, 2015. But what really happened? March 1998. Volkswagen introduces the EA188 turbodiesel engine with pump – injector, surpassed in the next five years by competitors adopting Bosch common rail; Wolfsburg moves to the new technology with its EA189 engine. **May 2007.** According to US Justice, in these days VW technicians realize that the TDI EA189 2 liters engine is not in line with US anti-pollution standards, particularly for NOx. The Volkswagen brand manager Wolfgang Bernhard asks to implement the Scr, resulting in a higher cost of at least 300 euros per engine. **November 2007.** In a mail between Vw and Wolfsburg US headquarters evaluate for the first time the technical implications of implementing a “defeat device”, some well-concealed code lines in the injection con-

trol unit software to circumvent the tests. Meanwhile, Bernhard is dismissed for “managerial differences”. **April 2013.** The defeat device adds more upgrades and the steering angle input (the power steering was available). On the test roller bench, of course, the front wheels cannot turn. **September 2013.** VW USA provides the International Council for Clean Transportation and West Virginia University a VW Jetta and an Audi A3 for test drives using a Pems system; Bmw also accepts and provides an X5, Mercedes declines the invitation. **May 2014.** The California Air Resource Board (Carb) receives from the University of West Virginia the test results which show that Volkswagen diesel emissions are off the charts (from 5 up to 35 times the maximum limit) and seek clarification from VW USA. The file is public, but data are

known only to researchers. **November 14, 2014.** Martin Winterkorn, CEO of VW Group, receives a confidential report on the ongoing US problem referring to the defeat device and the € 20 million estimate costs of a recall campaign. **December 2014.** The US headquarters of Volkswagen talks of a ‘software bug’ and proposes to Carb to solve the issue of EA189 engine emissions with an upgrade of the control units when servicing the cars. The upgrade procedure is activated to reduce NOx emissions. **June 2015.** Volkswagen Internal Product Safety Committee creates a task force to address further Carb’s claims that motors would be banned even after upgrading. The team is joined by a well-known international law firm. **27 July 2015.** Carb refuses to homologate models equipped with EA189 engine for 2016; VW USA management fly to

Wolfsburg for a heated meeting where the defeat device’s illegal character clearly emerges. **August 18, 2015.** The law firm supporting VW USA and Wolfsburg’s top executives define the procedure to be adopted by technicians when meeting with Carb, where they will admit the existence of the defeat device. **September 3, 2015.** During a meeting with Carb, Volkswagen engineers admit the existence of the defeat device; the day after the US Environmental Protection Agency (EPA) opens an infringement procedure for the entire United States involving all diesel cars (half a million) sold since 2009. **17-18 September 2015.** The copy of the document signed by VW engineers leaks on the Web during a press conference at Frankfurt Fair visited by the German chancellor Angela Merkel. **September 22.** Within two days (Monday 21 and Tuesday 22) the Volkswagen stock loses 30 billion euros of capitalization. The damage of the dieseltgate is estimated by analysts over 60 billion. **September 23, 2015.** Volkswagen CEO Martin Winterkorn resigns and is replaced by Porsche CEO Matthias Mueller, followed by other members of VW top management; stock exchange market looks at VW as “too big to fail”; Merkel cabinet succeeds to prevent collapse. **January 4, 2016.** US Justice department starts a procedure for a 46 billion dollars fine to Volkswagen. **April 22, 2016.** The release of 2015 balance of Volkswagen Group shows over 4.1 billion euros in losses, due to the 16.2 billion loss of the Dieseltgate. **October 25, 2016.** Volkswagen comes to an agreement with US Justice department: VW will provide 10.3 billion dollars to compensate customers through buyback programs and will finance a 4.7 billion clean engines research project. A few days later VW officially stops selling diesel cars in the USA. **22 December 2016.** Volkswagen signs a confidential agreement regarding the six cylinders, three liters diesel engines which provides for ‘substantial compensation’ to 80,000 customers. **January 10, 2017.** A definitive agreement with US Justice department ends the lawsuit regarding the defeat device: VW pays a 4.3 billion dollars fine. The dieseltgate story comes to an end in the United States.

Franz Hoffler

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FPT INDUSTRIAL TECH-DAY AND CURSOR 13 NG

It's time of gas rEvolution

Cursor 13 turns to gas delivering 388 kilowatt and 2,000 Newtonmeter for long haulage transports and will probably adapt to off-road applications. The presentation at the end of a day focused on Fpt Industrial prospects in gas. Among the fields the biomethan allows to reach the goal of self-consumption

During Tech Day Fpt Industrial unveiled to the world of industrial engines the Cursor 13 NG, which points to long-haulage commercial missions and could become the most powerful off-road gas engine on the market for heavy-duty applications. 'Repetita iuvant' ('it's useful to repeat'), as ancient Romans used to say, and that's why we use the same headline of Diesel International's cover. 'Gas (r)evolution' is the path chosen by Fpt Industrial, leading to a gas range specular to diesel units with a few steady points: stoichiometric combustion, Multipoint injection and three-way catalyst.

NG and Cursor 13

Following the announcement of the N6 Ng, which took place at Farm Progress in Decatur, Illinois, a 6.7 liters, 132 kW and 740 Nm unit, the Cursor 13 Natural gas was the representative of Natural Gas family at the Tech-Day in Turin on Monday, October 30. The 6-cylinder features the same engine block of the powerful 13 liters diesel unit (BxS 135x150 mm), which reaches up to 500 kW and 2,900 Nm thanks to double stage, leaving behind all competitors (only 13.5 by John Deere gets close delivering 448 kW and 2,754 Nm). The gap in performance compared to the diesel unit

is inevitable, but despite leaving the double turbo for waste gate and the physiological difficulty in reproducing the original curves, the Cursor 13 Ng delivers 388 kW at 1,900 and 2,000 Nm already available at 1,100, claiming the first place on the scale: 1,240 kilos instead of 1,430. Progression compared to the 8.7 liter Ng is worth 15 percent in power and 18 in torque. The Cursor 13 Ng is an all-around gas fuel unit, using CNG, LNG and biomethane. A perspective, this one related to biomasses, that follows the target of circular economy in the agricultural environment. Its sturdiness also stems from the choice of materials such as Compacted graphite iron (well known as Cgi) for cylinder heads and Nickel-Resist cast iron for the



exhaust manifold.

The presentation took place at the end of a marathon introduced by Annalisa Stupenengo, Brand President of Fpt Industrial, followed by an academic panel discussion on biogas circular economics, technology legacy and gas prospects in Fpt's experience, a case

history 'Natural Gas in a transport fleet' on 'Methane infrastructure diffusion'. The day ended with test drives with NG powered vehicles. The complete gas marathon reports will be published on the upcoming issues of DIESEL, DIESEL International and dieselweb.eu.

Paul Klee



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WHEN SCIENCE IS PREDICTION

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Multi-dimensional numerical models allow to quickly study the combustion process and identify the most promising solutions to reduce of fuel consumption and emissions.

The main strength of diesel engines is represented by their high efficiency, which makes them suitable for different applications in the 5 kW to 5 MW power range. As needed by current and future regulations, the need to reduce emissions and fuel consumption requires a continuous engines development in different areas such as combustion, turbocharging and after-treatment systems. Even heavy-duty engines are following the path of partial electrification. Concerning combustion, studies are currently focused on the need to maintain high efficiencies reducing particulate and NOx emissions at the same time in order to avoid excessively complicated and heavy exhaust systems. This aspect is a key factor in heavy-duty engines, since a single engine is usually adopted for different applications such as road or naval transport, agricultural traction and stationary applications.

Optimizing combustion...

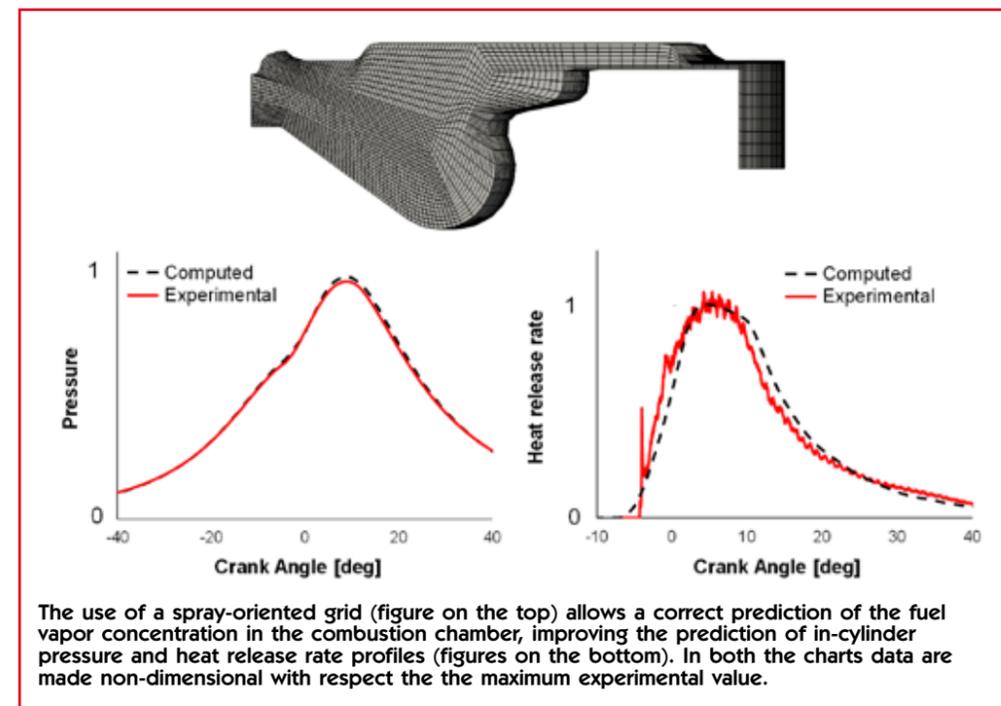
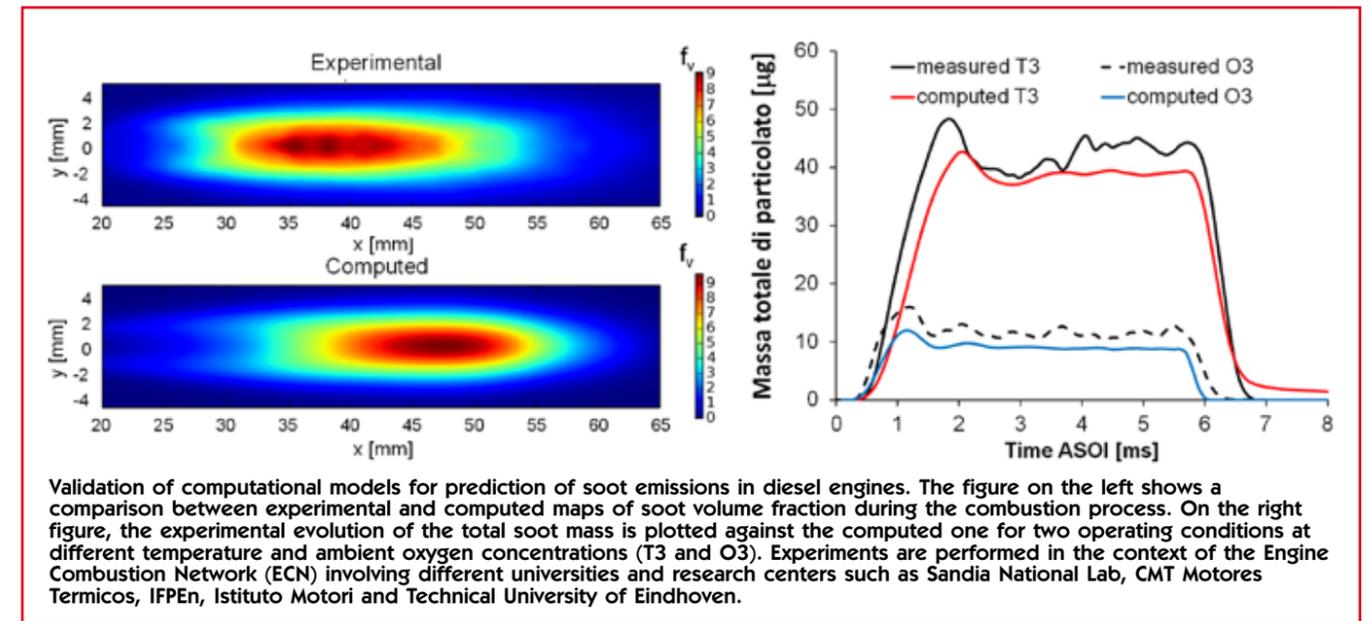
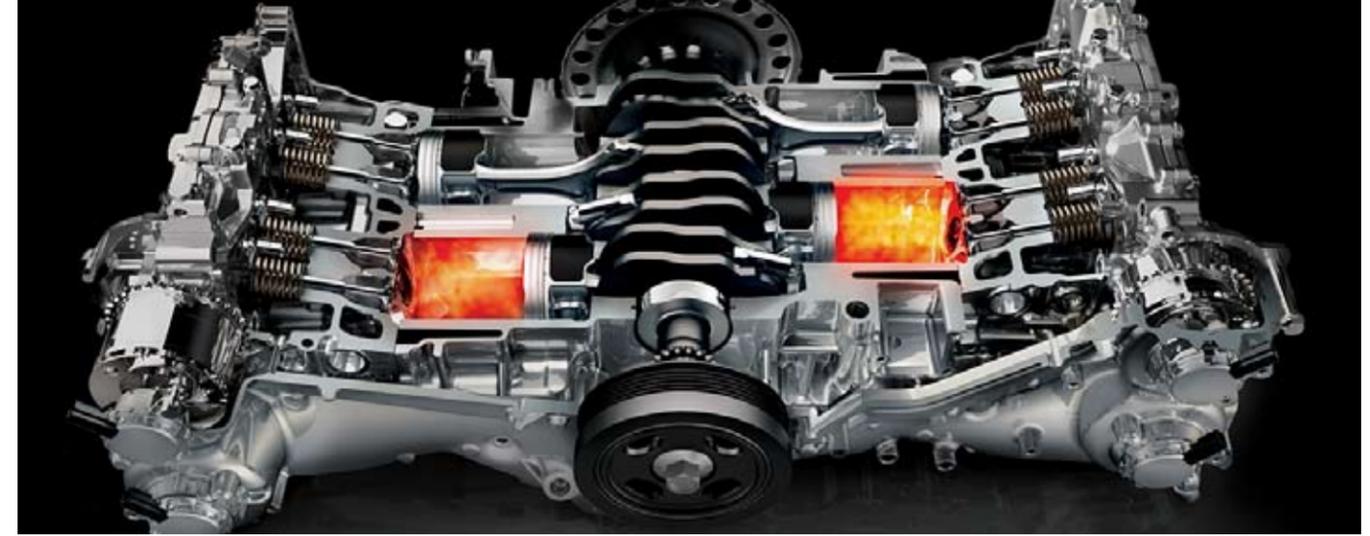
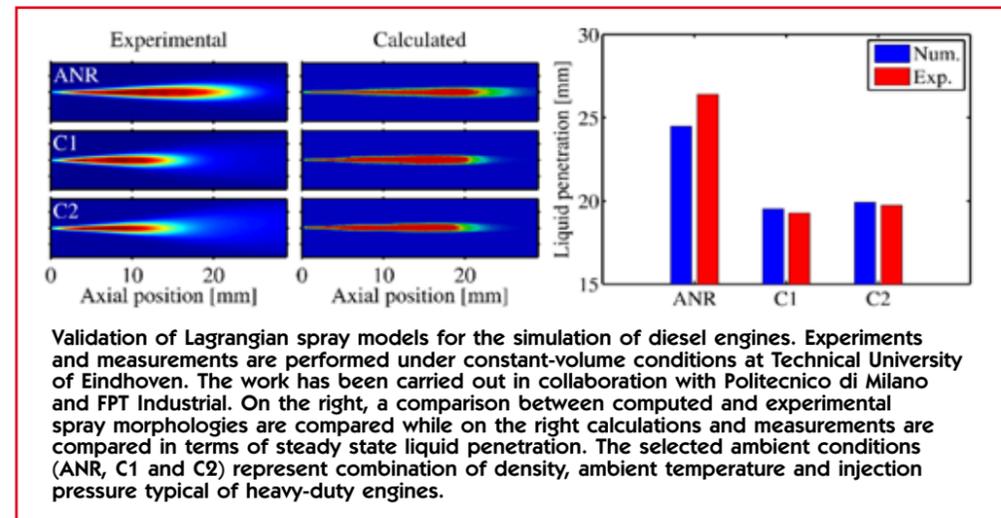
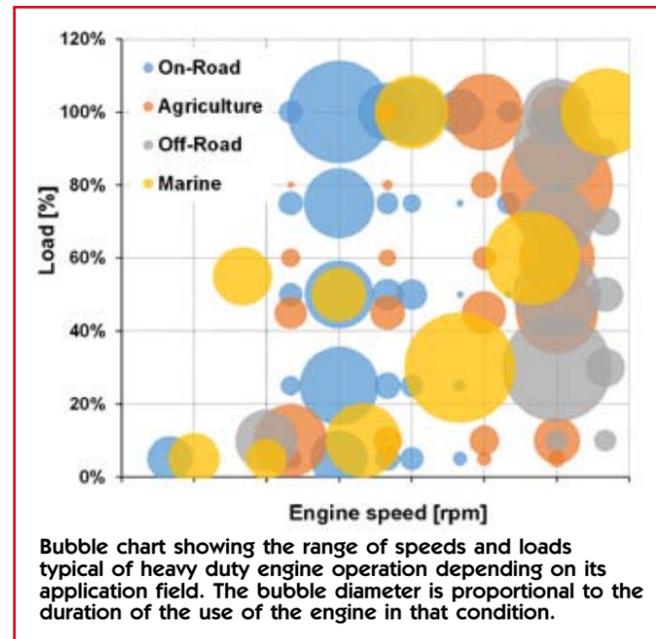
The need to optimize the combustion process in such a wide range of rotational speeds and loads requires accurate simulation models that allow to properly and rapidly design the piston and head geometry and define an appropriate injection strategy once adequate injection pressure and fuel spray targeting are identified. In this context, 3D simulation models - also known as CFD (acronym for Computational Fluid Dynamics) - are widely used in diesel engine combustion systems. A CFD simulation usually requires a first pre-processing step in which the computational grid is generated, initial conditions are set and numerical models to be used are identified; the following processing phase normally requires a number of processors between 8 and 24. Once the calculation phase is done, data are processed (post-processing) in order to perform a quantitative and qualitative analysis of the results.

In order to allow for a correct compromise between results accuracy and calculation times, combustion process in diesel engines is usually simulated in a sector of the combustion chamber whose angle depends on the number of injector holes. The spray is modeled by means of the Lagrangian stochastic approach, where each particle represents a set of droplets featur-

ing the same properties. This provides acceptable grid resolutions, avoiding a detailed representation of the liquid-vapor interface for each fuel drop. Mass, energy and momentum conservation equations are solved for each particle taking into account the interaction with the surrounding air. This approach shows however relevant simplifications thus requiring appropriate sub-models that need an accurate calibration to correctly reproduce the experimental data. Concerning the modelling of the combustion phase, both chemical kinetics of the fuel and its interaction with the turbulence in the combustion chamber must be taken into account. The most used models characterize diesel fuel as a surrogate of one or more components to describe its oxidation through about 50 species and a thousand reactions. The use of a detailed kinetic scheme makes possible to correctly predict the ignition delay under different operating conditions, including those with multiple injections, high EGR or partially premixed combustion. Including the turbu-

lence effect on fuel oxidation rate allows instead a correct prediction of the heat release law and the pressure curve into the cylinder. The kinetic scheme also includes

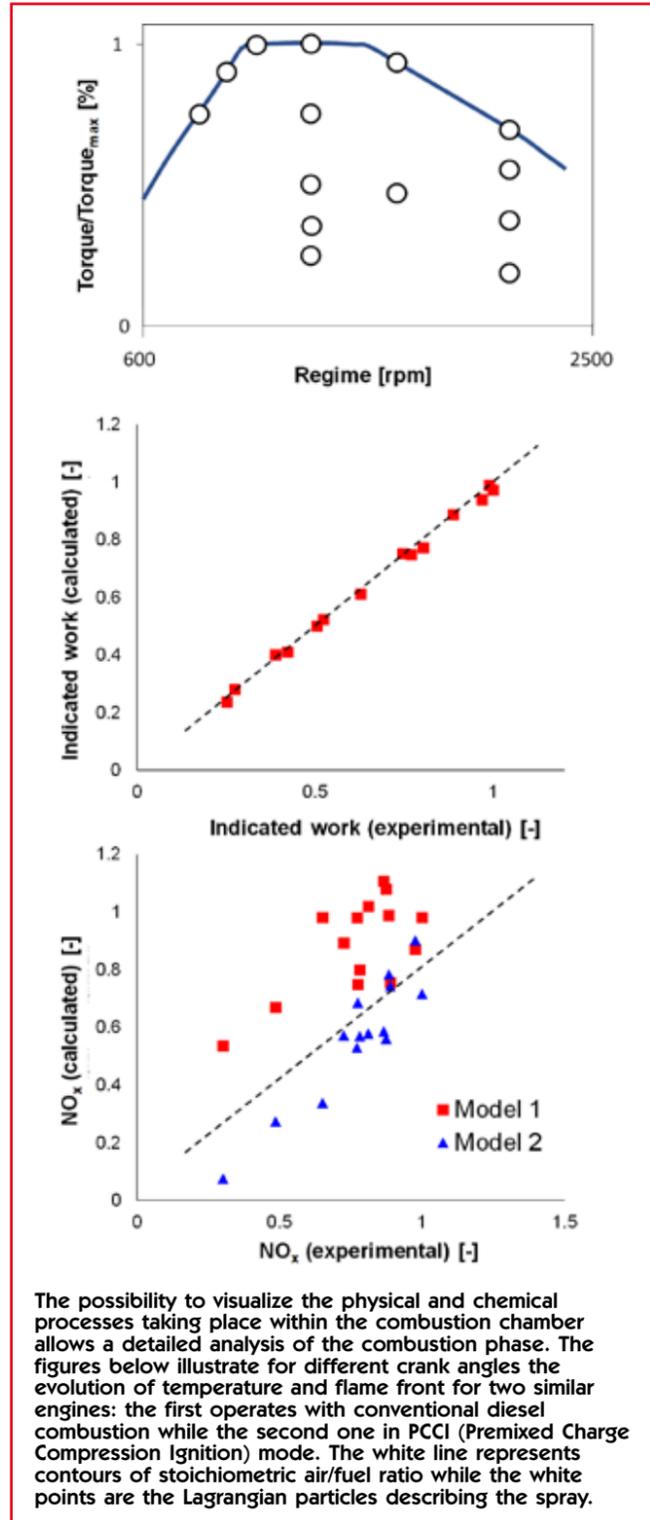
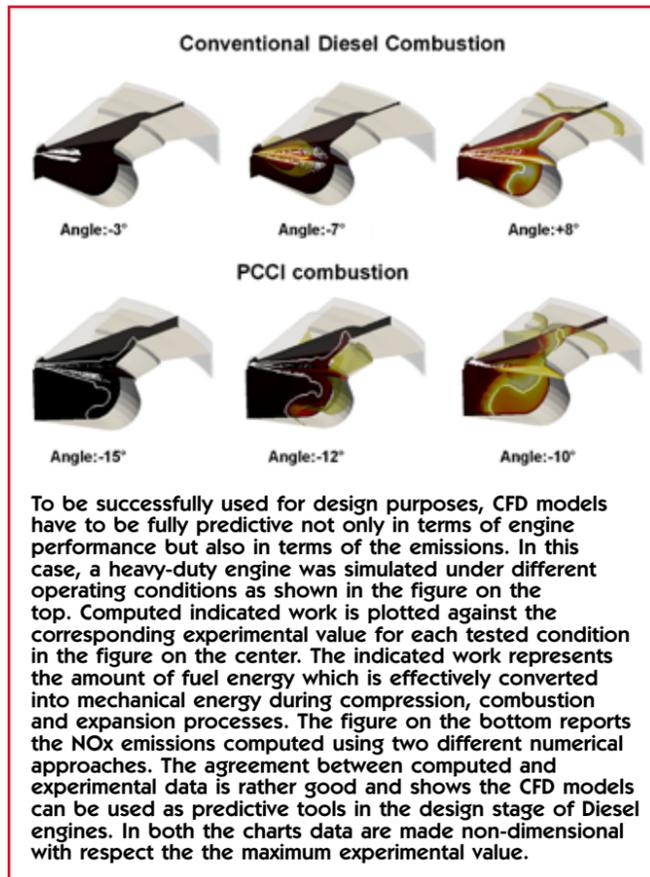
chemical reactions that describe the formation of NOx in detail, while semi-empirical approaches are usually employed to predict soot, describing in a simplified



way the inception, surface growth, coagulation and oxidation phases of the soot particles.

CFD and Politecnico Milano

CFD modelling of combustion in diesel engines is one of the main research topics of the Internal Combustion Engine Research Group of Politecnico di Milano, which has been involved for years in the development of the open-source Lib-ICE code which is based on the OpenFOAM® technology. The code is continuously developed and consolidated thanks to its use in academic and industrial collaborations, in which LibICE is used as a research and design tool. In the developed methodology the computational mesh is automatically generated and is spray-oriented, to correctly predict the the air-fuel mixture formation process. The evolution of the spray is described using a Lagrangian approach, in combination with sub-models capable of describ-



ing the atomization of the fuel jet and the subsequent secondary breakup of the fuel droplets. The RIF approach (acronym for 'Representative Interactive Flamelet') is used to predict the combustion process that is considered equivalent to a sequence of laminar diffusion flames, whose intensity is related to fuel distribution and turbulence. Fi-

nally, the Leung-Lindstedt and Jones model is used to predict particulate and describes the evolution of its volumetric fraction and particle number density, assuming that they are generated from a precursor (usually acetylene) and increase their concentration due to surface growth and coagulation processes. The oxidation of the particulate is promoted

by oxygen and OH radical. The pictures in the article show some examples of application and validation of the LibICE code, using experimental data under constant volume conditions and real Diesel engines. The former are very useful for the validation of individual calculation models, thanks to the possibility to precisely control environment conditions and perform

optical measurements to characterize the air-fuel mixing process, auto-ignition, flame stabilization and soot formation. Engine simulation results are an example of the current state of the art in CFD simulation of Diesel engines, which is now a predictive and consolidated tool for designing clean and efficient engines.

Prof. Tommaso Lucchini

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CREATING POWER SOLUTIONS.





Giorgio Paris, Segment Head Industrial and President Region Emea & Apac. He has been working for Volvo Penta for twenty years. Right, the D13 manufactured in the Brazilian factory.



Volvo Penta has no interest for compact engines, looking instead at top displacements starting from its 16 liters. Both industrial and marine segments show positive results, where Ips has become the trendsetter. Here we will focus on off-road and power generation markets. In order to have an in-depth overview we met Giorgio Paris, President Region EM & Apac (excluding Old Europe and America) and Segment Head Industrial (in charge of offroad strategies).

Volvo Penta strategies in the words of Giorgio Paris

NO-STOP GROWTH

The industrial market keeps growing in double digits. Marine applications are also on the rise. It's compatible with Hvo, gas is not a priority, and an eventual range extension would look upwards. We've been in Skövde, in the historic Volvo foundry, where the work environment is almost 'sterilized'

Mr. Paris, what can you tell us about 2016 and the beginning of 2017?

Since 2015 the off-road segment growth trend continues at a constant 30 percent rate, which is confirmed in the first quarter of 2017. Power generation is stable, due to the crisis of China, where we boast big market shares. With such a start we expect the rest of the year to be aligned with our targets. Market share is of course increasing, but we'll hardly be able to confirm these growth rates in the next 3-4 years.

Which are the differences in the Volvo Penta offroad market between Europe - Emea, Far East and America?

Europe is driving our growth, especially in Germany, Italy and the United Kingdom. De-

spite the economic situation China, which is not completely out of the crisis but benefits from a slight recovery, is showing positive results. United States also show an encouraging dynamism. Europe benefits from high power engines, the 'Scr only' system and, above all, the ease

of installation, a Volvo Penta trademark. Just think of the success of the Ips in Marine applications, a plug & play approach that we transplanted into Industrial market. The keyword is 'support'.

Speaking of support, what flex-

ibility grade do you provide for small and mid-oem?

We privilege a direct approach to the Oem. We provide a customization level that guarantees radiator, air filter, scr, pipes and fittings besides the engine. We work with the same flexibility regardless of engine size, scope of supply and localization.

How interaction with Volvo CE and enhancement of the service network in agricultural market are going?

We have monitored the service network and in the last three years we worked to cover white spots. We essentially adopted two strategies: the opening of new Volvo Penta Centers and the cooperation

with Volvo CE. We do not delegate; following specific customer requests we can integrate the Volvo Penta network with any Volvo (Truck or CE) service point, if needed.

Does power generation fully exploits the potential of Volvo Penta engines?

Volvo Penta is probably among the top three players in the market. We are known for being independent suppliers who meet the needs of customers, not competing with them as genset manufacturers. All South Europe is a key area and we feel comfortable even in the United Kingdom, despite all its peculiar dynamics. In Italy we are the main supplier of Pramac, starting from 100 kVA. In Dubai we introduced the 700 kVA that is now catching up. The 16-liter range is very important for Volvo Penta, thanks to its high power den-

sity and an unmatched calibration range, from 450 kVA to 700 kVA (770 in emergency) at 1,500 rpm.

How the manufacturing of 13 liters in Brazil is going?

The 13 liters is manufactured in Skövde (Sweden) since ever. We introduced it to Brazil for the local market, a very complicated one from the fiscal point of view, which rewards engines manufactured locally. Curitiba factory is a Skövde clone, boasting the same production system. Brazil also suffered in 2016. This year the country seems to be on the rise anyway.

What about the so-called alternatives, LNG, CNG, biogas?

Last year we converted some engines for truck applications to operate with 6 or 7 types of biofuels. We unveiled at Bauma the compat-

ibility of our engines with Hvo.

Any arrangements to cover the compact 4-cylinders range?

I can tell you that if we ever widen the range we probably would do it upwards, not downwards. Low entry provides large volumes but limited profits.

What about Stage V?

From a commercial point of view, Stage V summarizes in the word 'smart', and I refer to the ease of installation. Once launched the off-road range, from D5 to D16, we used the same technology into the same 'casing' to maintain the same space in the engine compartment regardless of the regulation 'compliance'. We will maintain the actual power range. In Stage5 we will have non cooled egr (aka light egr) on all 5, 8, 11, 13, 16 liters range (in

stage 4 we have today cooled egr for 5 and 8 liters and non cooled egr for 11, 13 and 16 liters). We work on flexibility. We will add dpf, except on 16 liter, integrating it into major sizes such as the D13, keeping it separate in the small ones, 5, 8 and 11 liters, which will keep two separate boxes. Volvo Penta is focusing its engineering efforts on automatic regeneration, trying to avoid 'parked regeneration'.

What about Hybrid?

We capitalize on the technologies of Volvo group, both in marine and industrial applications. Volvo CE has developed 'demo' hybrids in both mining and construction areas. The hybrid is standard on buses. About 3,000 hybrid vehicles run under the Volvo brand. Electrification will come before we can imagine.

DIESEL Magazine

A FOUNDRY THAT RESEMBLES A SUPERMARKET

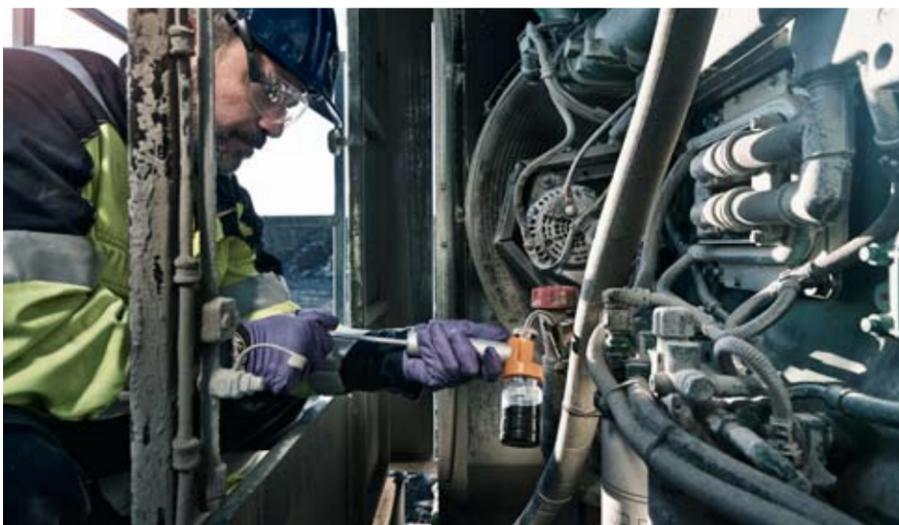
Several facts has happened at the Volvo Trucks Operations factory in Skövde, Sweden, since the start of the foundry in 1865. Currently the 13 and 16 liters engines to the Volvo Group's brands are assembled here in a 265,000 sqm area where 2,800 employees work. In 2016 the Skövde site manufactured 89,070 engines using three assembly lines. The Volvo factory in Skövde also manufactures engine components such as cylinder heads, cylinder blocks, crankshafts, camshafts, gears and flywheels.

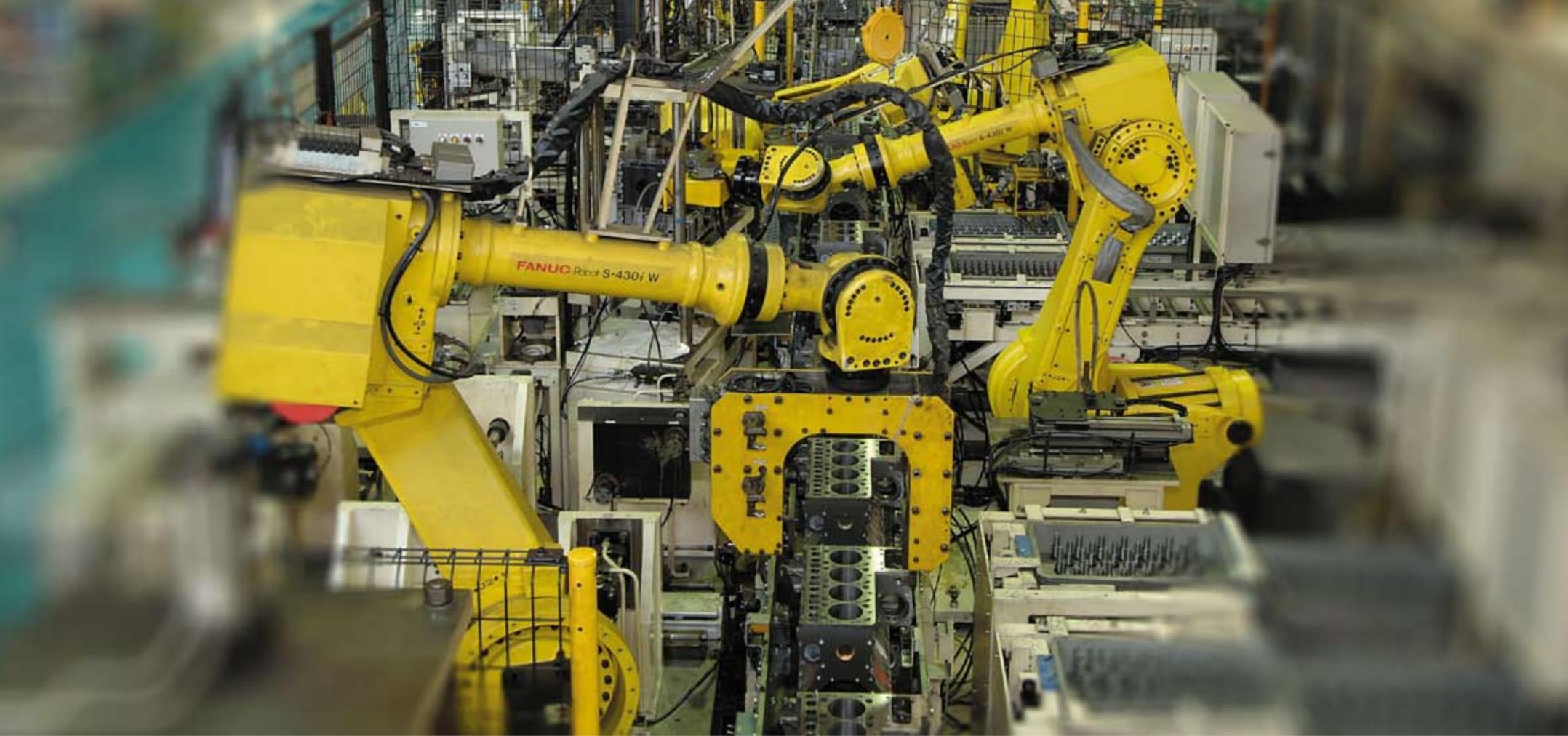
What impresses of Skövde is its aseptic, supermarket-like (or better still, well managed ware-

house) atmosphere. The inner perimeter of the foundry is full with plants, decorative elements and environment indicators. The melted capacity in the foundry is 150,000 tons of raw material per year. The level of automation in the melting department is very high. The

melting process takes place in a cupola furnace. The furnace is also equipped with a cooling system. The temperature is up to 1,430 degrees, the cooling happens in two stages to bring down the temperature to about 650 degrees.

All engines in the assembly line are customer order built. The materials are provided to the assembly lines in sequences. The system, pick to light, is an efficient and ergonomic way of working. The manufactured engines are tested in two different ways: around 70 percent of them are cool-tested, while the remaining 30 percent is hot-tested.





Tony Tonegawa and Kubota point of view

FROM OSAKA WITH FURY!

Over 150,000 engines sold to Oems in 2016, an international profile, confirmed by two-thirds of turnover coming from abroad. Tony Tonegawa is Director of Engine Division in Europe, and the best representative to understand more about the present and the future of Kubota

Established in October 2016 at the helm of the European Engine Division, Tony Tonegawa has the mission of enhancing the presence of Kubota under the bonnets of European Oems. Kubota is an extremely widespread brand among materials handling and industrial Oems areas in general, such as specialized tractors, harvesting machines and genset, and is focused on compact and ultracompact segment. The 3,3 and 3,8 liters are the stars in its range. Kubota raised the LNG market with dual fuel engines, which has a fertile market in indoor applications. The corporate project is ambitious, as evidenced by the announcement of the new liters Stage V 5.

Mr Tonegawa, Kubota Group planned in 2013 to increase significantly the revenue within 2020. What's the role of the engine division in that strategy?

Kubota Engine has pinpointed two main objectives in supporting the corporate growth. The first one is supplying engines to our internal

products (tractors, harvesters, green and/or other agricultural equipment and construction machinery). Kubota has decided to enter into the "real" farming market which corresponds to a power range above 200 HP (147 kW). Today, we offer 6.1L engine for above 150 HP range, and in order to further expand our product offerings, we have just announced the introduction of new 5L engine during the ConExpo. Another goal of the Engine Division is to develop the Oem business globally. As a matter of fact,

60% of Kubota's total engine sales comes from Oems, and we are today the first engine manufacturer brand in under 73,5 kW segment (the fateful 100 HP threshold). The goal of our division is to further expand our product range and also expand our business areas both within existing market as well as new markets.

How many engines did Kubota sell to European Oems in 2016? What's the forecast for 2017?

Engine sales to OEM in 2016 was

approximately 150,000 units. Our engine is not only intended for agricultural and construction fields but is also used in various market segments and this is one of Kubota's strength. A diversified customer base enables us to stabilize our business under unstable economic circumstances. As for 2017, we see a potential growth in Europe, China and other emerging countries. North America market seems to be fairly slow at this time but this may change based on the new president's policy.

Kubota introduced at Conexpo the V5009, a 4 cylinders, 1.25-liter per cylinder, 157.3 kW engine. Can you draw the future of this engine?

Kubota Engine's basic product strategy is "Providing OEM and OEM's customer with the best and most convenient engine for every application". As mentioned above, our product range and business areas are expanding, and this 5 liters engines perfectly fits this strategy. The base design concept of this new 5L inherits the core engineering know-hows accumulated throughout our long history. Its compactness and low fuel consumption offer added values both to Oems and their customers. Kubota's strength is to design engines with a perfect balance between quality, performance and cost. The balance between those three aspects are what we focus on along with other elements.

There is a gap at the moment between 86.4 kW (V3800-Tief 4B) and 157.3 kW of the upcoming 5 liters engine. May we expect a 'surprise' at Agritechnica, maybe a 129 kW, 4.2/4.4 liters engine?

That's a good question, but I do not have an answer today (we're in the second quarter of the year). If there is a demand in such power range

we may consider to fill the gap. But again, the important thing is not to just offer an engine, but to make sure our product supports OEMs business.

What about Stage V? Egr, Dpf, Scr?

Kubota has already manufactured more than 400,000 engines with Diesel Particulate Filter (DPF) in compact engine segment and we have accumulated so many experiences (good or bad), this enables not only Kubota but also our customers to look with confidence toward Stage V. So, yes, we are 100% ready for Stage V. We knew this new regulation was coming when we first decided to adopt this strategy while other engine manufactures took a relatively easier path. It is all about timing. Kubota focuses not only on each emission device but on the whole system. That's why we decided to use Egr, we think this device is necessary to make the entire system efficient and this can be said also for other components such as aftertreatment devices.

Kubota relaunched Lpg for industrial applications; what do you think about it and Lng?

Kubota is one of the few engine ma-

nufacturers who offers alternative fuel options with diesel base case. We see a clear market trend pointing at our LSI engines not only for indoor applications. Many big cities such as Paris and London are banning diesel powered machines today. Lng also is something we get inquires today but it is not yet feasible for compact machines.

What about Cng, biogas and hybrid drivelines? Downsizing could help Kubota to be in pole position after 2020, when CO2 and greenhouse gas struggle will be the new challenge?

Kubota already offers engines with Cng fuel option. Biogas is a new option especially for agricultural applications but still not so popular. Our goal is anyway to fulfill these future demands. We also think the trend seen in automotive industry is surely affecting the industrial machinery market.

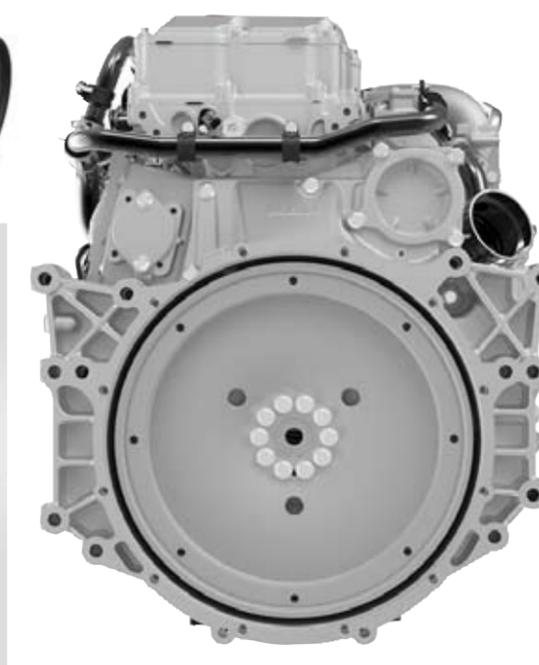
A 'Shakespearean' question for Kubota engines: to be captive or to be free market oriented? Or both?

"To be, or not to be..." We have no intention to choose one from another. Our business policy is often compared with motorcycles. Our captive

market ensures us a stable business which also helps our Division to develop new engines, while our Oem market ensures us to enhance our engines to make sure we stay ahead of competitors. In short, we will continue to support both captive and Oem markets.

Is Kubota rising up as a global manufacturer?

Our CEO Mr. Kimata often uses a keyword "Kubota, becoming a GMB" (Global Major Brand). More than 65% of Kubota's corporate revenue comes from outside Japanese market today. He believes it is not a matter of how much we gain from overseas market, but thinking and acting with a "global mindset" to compete on global markets. Entering into the "real" agricultural market is part of this strategy. If you look at the potential business growth for our company, there are many business segments we can enter worldwide. From this point of view, Kubota has many things to do not only in agricultural and/or professional garden markets, but also in other business areas such as Food, Water and Environment. Engine business also has many potential opportunities for growth.



From Conexpo to Agritechnica

2017 GOOD REASONS

The trend that led to multiplication of engines and fuels during this glittering 2017 is almost a Bible parable. The countdown to Stage V kick-off began in Las Vegas event, which has proven to be more than ever the place to be of engineers. The trends that crossed the Atlantic Ocean, the common denominators of the crossroads of North American construction and the Fair for Farming, are top - range expansion and segmentation, in order to allow manufacturers becoming Oem's unique suppliers. The second trend is fuel diversification: engine manufacturers are trying to compete against gas and electrification (see box, Cummins and Deutz). A third trend is the inertial 'bend' towards Stage V: from Stage V ready of Intermat 2015 to certifications earned on the test bench. What judgments did Conexpo issue? About segmenting and redesigning top of the range both **Fpt Industrial** and **Kubota**

This year is a milestone in the industrial engines epic. So many top-of-the-range, more segmentation, efficiency in the sights, focus on gas conversion and investments in electrification. And 2018 will be the Stage V eve. Intermat, Eima and Bauma China the next expeted events

surprised the audience with brilliant strikes. V20 is the sign that revive the credentials of Vector, 8 V-cylinders, 2.5 liters per cylinder (BxS 145x152 mm), after a moment of reconsideration that brought in the data from Cursor family: power density and high torque. Translated in figures, it is

worth 258.7 kW per cubic meter and 4,100 Nm. **Kubota** broke its confidentiality policy and announced its top of the range, still in development, as production start is scheduled for 2020. We know it will be a 4 cylinders, 5 liters, a competitive range (see comparison at page

30), which surpasses the 200 HP threshold delivering 157.3 kW and meets stage V through particulate filter and technical urea nebulizer. His name is V5009. Other news are expected, maybe at Intermat in Paris. **Liebherr** did not spare efforts. The company is the winner of last

Diesel of the year prize thanks to its with the D9812 and unveiled in Las Vegas where two six cylinders in line units, D956 and D966, using the same monobloc and meeting the required approvals by exhaust gases recirculation in Stage IIIA, a solution that relies on Scr only (SCRonly) after-treatment for current requirements and SCRFilter for Stage V. Kilowatts of the first unit stay in 320 - 400 range, while the second unit is in

360 - 450 range, showing a 40 kW overlap. Sharing dimensions, connections and interfaces makes the two 6 - cylinders attractive in terms of Tco, simplifying maintenance and reducing stock references. Versatility in off-road applications is favored by three auxiliary PTOs delivering up to 700 Nm. A brand new 4 cylinders, 9 liters for heavy-duty applications is expected at Agritechnica. But there's more. At this point,

Liebherr's fate crosses **Deutz**. The agreement between the two brands, which brought to the 9 liters launch in Shanghai (particularly compact in length and depth) was the first step of a strategy that delivered 12, 13.5 and 18 liters engines. Deutz is particularly active and boasts the acquisition of Iml, which will enable Cologne to directly control the Italian and Romanian markets, and the Stage V approval for Tcd6.1, which will be shortly followed by 3.6, 4, 1 and 7.8 liters. Tcd3.6 was converted to gas in collaboration with Same Deutz-Fahr. Las Vegas was the stage of **Jcb** 3 liters (see box) and Stage V approved **Volvo Penta** D8, which uses egr unlike Scania's cousins. Another American star, **John Deere**, launched the first unit of a brand new family of engines, the 13.6 liters, delivering 10 percent more of power and torque compared with 13.5 liters and 18 percent less in size (see page 42). Cummins and Mtu played in advance at Bauma Monaco and crossed the current year without any particular surprise. As a matter of fact, on the Pacific shore of North America **Cummins Westport** gave a real message with the gasification of B67, L9, Isx12 triad for automotive applications. As stated by Rob Neitzke, President of Cummins Westport

(see also box on 'electric' diesel): «We are particularly pleased that the Isx12N is supporting the L9N in providing our customers who manufacture onroad vehicles with performance benefits and reliability within such a low emission threshold that Southern California District Air Quality managers called it equivalent to that of an electric vehicle».

Stage V: Kohler and Perkins
Approaching Agritechnica the spotlights focused on transition to Stage V. Together with Deutz also **Kohler** (see page 24 the focus on Reggio Emilia strategies) and **Perkins**, who organized an event in Peterborough to announce Stage V and SmartCup (see page 26) will take a challenge in Hannover. We talked about hybrids and gasification. Speaking of gas **Fpt Industrial** draw attention on October 30th as a 'gas queen' at TechDay, where the company unveiled the Cursor 13 (see page 10). **Man** played in Las Vegas the D38 card for the American market and officially announced its 9 liters. That's an historic step for this displacement, which points to a more and more competitive segment. Historically Man engines are designed for trucks, then converted to industrial applications. *DIESEL Magazine*

WHEN DIESEL BECOMES ELECTRIC

Electrification is the future, we know the song. It is however peculiar how two 360 degrees specialists of diesel engines like CUMMINS and DEUTZ are betting on it. Cummins has never hide his interest in electric traction and unveiled the Aeos Electrified Power Semi Trailer, a class-7, urban 4WD demo tractor weighing over eight tonnes and providing a 160 km operating range thanks to its 140 kWh

battery, according to the manufacturer. And what about Deutz? Let's add the 'e' letter (eDeutz) and you will understand the acquisition of Torqeedo, which produced over 70,000 electrical propulsion systems. Here we have two reference market: marine applications, where Torqeedo is well rooted, and the transfer into the industrial segment of E-Drive expertise.



430 DIESELMAX: 3 LITERS BY JCB

Under the spotlights in Las Vegas we've also seen the Jcb 430, a three liters that is currently under 56 kW threshold. Its 55 kW and 400 Nm make the JCB in line with the 4.4 liters low entry, showing obvious differences in terms of specific curves, power density, weight (about one third less than 4.4), and specific consumption (8 percent, according to Jcb). Following the imprinting that won the Ecomax the Diesel of the year in 2011, the Tier 4 Final 750 cc cylinder doesn't make use of any after-treatment device. Automatic valve regulator makes its debut on Dieselmax, eliminating the

recurring valve checkthus reducing machine stops. Built-in spark plugs ease cold start, improve overall efficiency and reduce leaks and unburned deposits. Engineering also optimized air mass flow calibration, thanks to a monitoring system that allows the electronic control unit (which can be installed directly on the engine or on the chassis) to deliver the correct amount of fuel regardless of conditions outside the combustion chamber

such as temperature, altitude and air density. The mounting interface is shared with those of 1.1 and 1.2 liters. The tilt up to 45 degrees facilitates matching the layout of the machines. Graeme MacDonald, CEO of Jcb, said on the '31 million pounds baby' (this is the cost of 3 liters engine development): «It's hard to believe that just 12 years ago Jcb did not manufacture engines. Today, Jcb has made 400,000 high-performance diesel engines».



HATZ: BITING THE APPLE IS NOT A SIN

A two-liter Hatz engine for Apple Park. That's the best reference for a small (in terms of displacement) and powerful (in terms of power density) engine, designed to bring the future of the brand from Ruhstorf beyond Tier 4 Final and Stage V. At this point Cimolai Technology comes in, an Italian company that took benefit from Hatz's collaboration to write its name on the 'flying saucer'. This is the nickname of Campus 2 in Cupertino,

where two two-tonnes Cimolai forklifts were at work. Big wheel forklift were used as shuttles to transport the glass slabs used for the building roof. Two 4H50Tic feeded a lifter and a positioner,



moving the world's largest curved glass slabs. The radio controlled forklifts moved all the slabs of the 260,000 sqm of the flying saucer'. The Apple Park covers a total of 708,000 sqm. The 3 cylinder engine of the H Series maintains the family feeling in terms of power density and specific curves. What will be the equally prestigious scenario to match its four-cylinder big brother? V-drive.

LOAD DIFFERENTIAL



That's the difference between the truck and off-road version. Man diversified its recipe according to the applications. The industrial ones are suitable for different configurations that meet specific needs. Let's take a look at the affinities and differences

The D3876 is a turning point in Man's engines history. The 15.26 liters retired a star of Nuremberg, the D2868, the famous two-liter per cylinder developed together with Liebherr, and introduced such a set of advanced innovations that left behind the competitors. Bauma 2016 was the apotheosis of the industrial version introduced at Agritechnica 2015 and re-launched in major off-road events, from Munich to Las Vegas. During the 'mother of all fairs' the D3876 won the Diesel of the year 2016 prize. Among the motivations of the jury's choice, Man's flexibility in calibrating technological solutions (e.g. supercharging and exhaust gas recirculation) according to work cycle and specific loads of virtually all applications. A specific approach for truck engine, another one for large construction machines based on 2.500 bar Bosch common rail. The keypoints of this engine platform are the strength and rigidity of the monoblock in both configurations, due to the GJV-450 vermicular graphite iron base, showing the D3876family feeling and the cylinder with steel pistons and rods.

Top-Down Cooling

The engine features a 'top-down' type cooling through a cooling chamber on the cylinder head. The coolant runs along the injector sleeve to nozzles, valve seats and heat-sensitive points. Another joint feature is the head camshaft, driven by roller lever, and the dome valves, which are named after the reinforcement applied on the side of the combustion chamber, designed to avoid deformation. Two heterozygous twins, quoting Wim Wenders's movie, 'So far, so

close'. Which are then the differences between the two 'souls' of the D3876, the original onroad design and the one for offroad applications, taking into account all the technical insights we've been giving through newsletters and paper editions? The exhaust gas recycling strategy is immediately evident. Egr is under fire for its unpleasant feedback on the ra-

diators, which have to increase in size to meet the cooling needs of the thermal management stressed by lean fuel mixture. The German school, however, promoted it with no doubts up to Tier 4 Final. Double stage for Egr (high and low temperature) of the Tgx, to re-enter into the combustion chamber up to 40 percent of unburned gas, single stage egr for off-ro-

ad. Let's take a truck, the Tgx powered by 15.2 liters, a beet harvester (or any large harvesting machine) and a maxi excavator or a wheel loader: we find curves shaped on cycles that privilege maximum power within a stabilized engine speed when traveling on highways, and a diversified torque demand when working in fields or construction sites to power attachments, overcome the negative environmental impact in terms of soil roughness, filtration of impurities in air, oil and diesel lines, stress induced by vibrations, thermal excursion and high-altitude air, which involves derating (a critical issue on supercharged electronic engines). Specific curves therefore require elasticity, and that's why the two cooling stages are not used on off-road versions. Industrial applications require interface and configuration flexibility. Regarding versatility, the other key element besides recirculation is supercharging.

Double stage

Double stage used to optimize torque and power delivery in a steady and progressive way up to high rotation speeds is left behind to implement variable geometry single turbo to provide adequate air volume in the combustion chamber. It should not be forgotten that the main discriminant is the plurality of application variables, which result in working cycles showing different stress peaks and load modulations, compared to the linear profile of long-distance trucks. In a nutshell, a more dynamic response to stress. Tco is a key topic, inducing Man to extend oil replacement intervals to 100,000 kilometers on trucks and 500 hours on off-road engines.

Klaus Waltz



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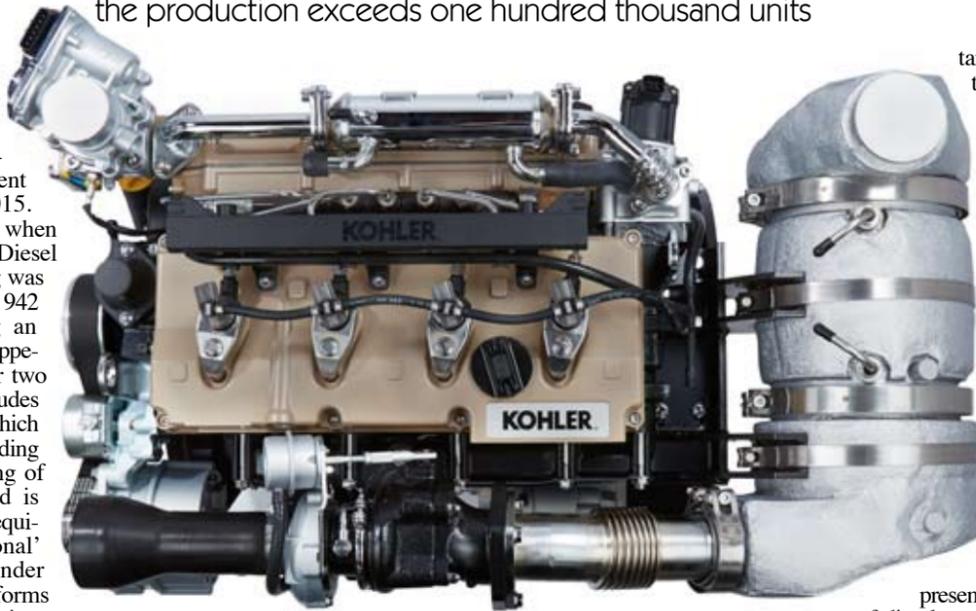


Stage V. After-treatment. Power increased. Gasoline engines

FLEX MY NAME IS KOHLER FLEX

Flex is Kohler's after-treatment paradigm, declined in all possible regulations. The main focus is obviously on the upcoming Stage V, which will deliver a change upwards in specific curves. Now the production exceeds one hundred thousand units

Kohler Flex is the access key to Stage V and oem hoods. This is the way Kohler designed its after-treatment module starting in 2015. It was Intermat time, when Kdi3404Tcr won the Diesel of the year, the canning was ultra-compact - just as 942 millimeters, featuring an 'all-in-one' design. It happened that way, and after two years Kohler Flex includes egr, doc, dpf and scr, which can be modulated according to regulations. Speaking of Stage V, the threshold is that of 56 kW, which requires a 'three-dimensional' variable approach: under this threshold egr performs the 'slimming' of the mixture working together with doc-dpf module, above 56 kilowatts recirculation disappears leaving its place to scr integrated in the canning. The thermodynamic parameters of Kdi engines, according to Kohler, minimized the dimensions of the module, which in Stage IIIB and Tier 4 Final escaped the 'trap' of



dpf. After-treatment is supplied both mounted on the engine or standalone thanks to the layout adaptability provided by axial and radial pipes rotation. Kohler dpf is supplied in two different sizes and maintenance intervals of 6,000 and 10,000 hours, which effectively covers the entire engi-

ne life cycle. As promised regeneration is going to be automatic in 95 percent of cases to reduce downtime.

Kohler Flex

Thanks to Kohler Flex the Kdi platform is able to improve specific curves, following the performance

target underlying the genesis of 620 and 850 cc cylinders: the top of the range, standing in the compact 3-3.8 liters range, will surpass the current limit of 100 kW and 500 Nm: 105 kW at 2,200 rpm and 640 Nm at 1,400 are the new top figures. A version without after-cooler is available. At

present, the production of diesel engines by the four factories (Reggio Emilia, Rieti, Martin, Slovakia and Aurangabad, India) exceeds one hundred thousand units, with a rising percentage of the multicylinder compared to the single cylinder, a traditional strongpoint of Lombardini era. In the photo You can see the Kdi 2504 Tcrev. **Pablo Garcia**

GASOLINE AT DEMOPARK

In June Kohler was at the Demopark, in Eisenach, in the professional garden reserve, where Otto cycle engines took over. The Command Pro Ch260, Ch270, Ch395 and Ch440 can provide a threefold alternative, gasoline, lpg and methane. Spotlights also focused on Ch740Lp., which may use both methane and lpg, a solution that improves TCO and also cuts exhaust emissions. In the above mentioned quartet, Command Pro Ch270 and Command Pro Ch395 feature filtering solutions designed to meet the end users' needs. The Quad-Clean filter system is a four-stage, heavy-duty filter fe-

aturing a cyclonic dust separator matching weight and dimensions of conventional filters. Another fashionable acronym is Efi, which indicates the electronic setting, the final frontier of mono and two cylinders gasoline engines. The closed loop Efi system is equipped with an oxygen sensor that constantly monitors information on combustion quality and adjusts the operating parameters of the engine. This means 'bye bye starter', ie reduction of purchase and maintenance costs. The Xtx775 was showed in Eisenach for heavy duty applications and lawn mowers.



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WHERE THE CHIP IS CHEAP

Perkins chose the Peterborough Cathedral to (literally) celebrate his 85th anniversary after the debut of the Stage V. The Syncro platform and My Engine App were under the spotlights together with SmartCup, which matches electronics and simplicity. The key topics are the optimization of regeneration and reconfirmation of exhaust gas recirculation

85 candles in the Peterborough cathedral and the official debut of Stage V. This is the summary of our visit at Perkins, that manufactured in 1932 the Vixen 4 cylinder and now is launching the Stage V Syncro family. Peterborough needs to make up lost ground in agricultural market, relying on solid synergies with Caterpillar and the good results in power generation coming from 400, 1100 and

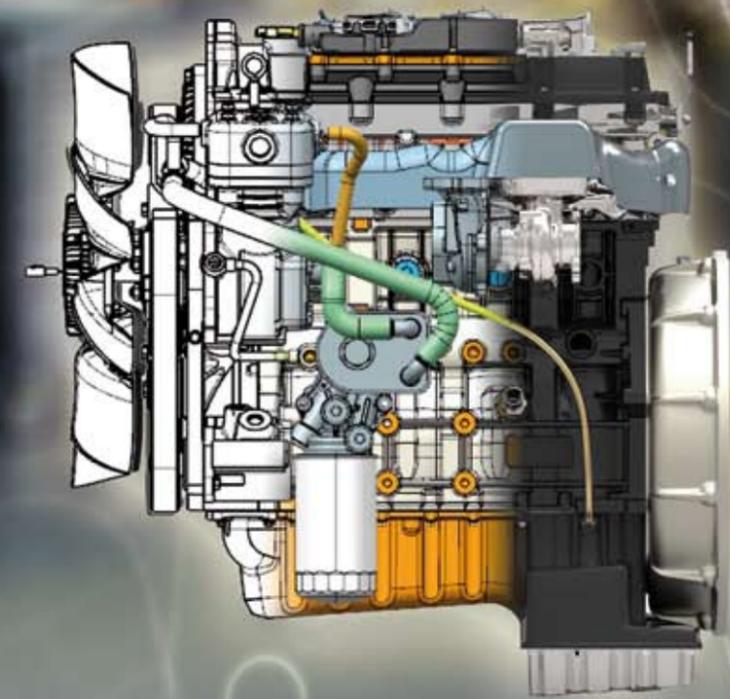
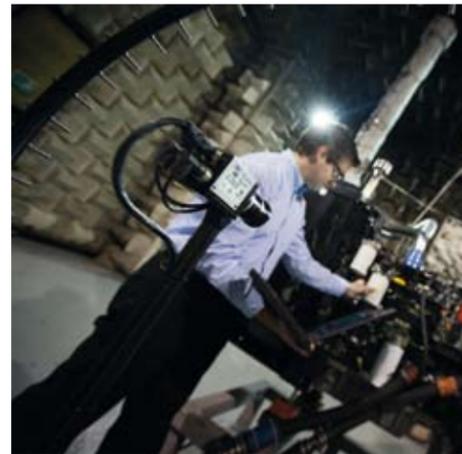
4000 series. The peak power of the Syncro series is fixed at 100 kW, a threshold that Peterborough (and not only Peterborough) needs to surpass since the Syncro family was born to explore new horizons, not curbing them. The formula to get into 2019 does not exclude recirculation, indeed it becomes a key factor to control diesel and technical urea consumption. Doc and dpf will be separated by scr

in all calibrations above 56 kW; in the starting segment (below 56 kW) scr canning is going to disappear. We finally took a look at the Syncro in the assembly line and it seemed dimensionally well calibrated, featuring all filters on one side and leaving the other side free. The search for power density disrupted the obsession for reliability at all costs. Regeneration relies on an automatic process without

triggering the filter heating by the operator and forcing unwanted machine stops. Perkins engineers have further boosted the overcharging, pushing bars into the combustion chamber, raising the tolerance of the rotation system during the stress test to improve wear resistance and adjusting the gaskets.

My Engine&SmartCap

Innovation at Perkins is now moving towards My Engine App and SmartCap. Regarding the first one, available in English, German and French (Spanish, Italian and Portuguese versions will be available by the end of the year) the software coordinates in the Perkins engine/machine integration process with SmartCup, introducing an innovation element combined with cost containment: a cap, available in three sizes, able to replace the existing caps of all Perkins engines from 3 cylinders, 0.7 liters to 6 cylinders, 7 liters, both mechanical and electronic. This feature makes it suitable as an economical retrofitting for older units, that are typically more in need of constant oil monitoring. The cap hosts a battery and a bluetooth chip which record level, impurities, abnormal emissions and leaks, updating the registry via cloud. At a price of 45 euros, it may become a successful and cheap substitute of complex diagnostic systems based on input and output sensors. We could call it a... cheap chip. The final curtain of the day dropped on the aftermarket. Perkins invests his nearly centennial roots in the four corners of the globe coining a medical metaphor: Doctor Aftermarket, featuring filters (engine breath) and original Perkins oil (the lifeblood) as a recipe for engine's health care. **Fabio Butturi**



A RELIABLE PARTNER TO THE POWERTRAIN INDUSTRY

DESIGN AND DEVELOPMENT

- Internal combustion engine design
- Hybrid powertrain design
- Simulation structural analysis



PROTOTYPING

- Internal combustion engine prototyping
- Hybrid powertrain prototyping
- Proto powertrain/vehicle assembly



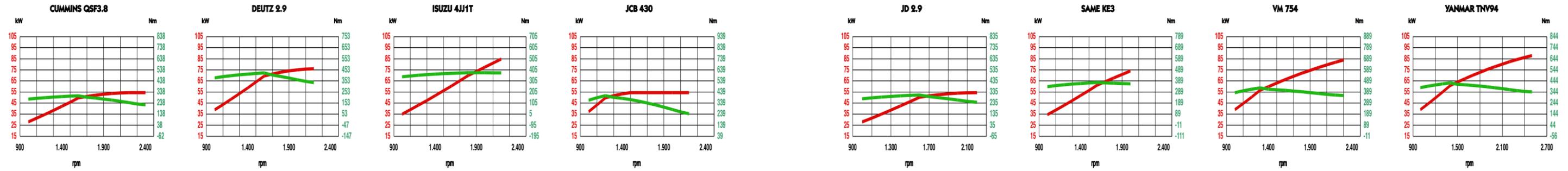
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Comparison 2.8 - 3 liters industrial engines

A SIGNIFICANT 'BORDER LINE'

A few cubic centimeters gap and a world of differences in terms of workloads, specific curves and power density. There are eight units packed in a range - besides the Cummins 2,770 cc - that starts from Same 2,888 cc and ends with Yanmar 3,050 cc. This is a displacement in the middle between the 2-liters/3-liters super-compact engines stopping at 50 kW and 3 to 3.8 liters featuring up to 100 kW peaks made by Deutz, Kohler, Same and soon by Perkins Syncro (Deutz announced a future raise up to 105 kW for Stage V). We have a new entry, introduced at ConExpo in

It's the one of three liters, where both powerful units and others that just stop below the 56 kW threshold live together. Waiting for Stage V... Among them the JCB J430 introduced at Las Vegas. Yanmar boasts the best responsiveness, Vm follows close



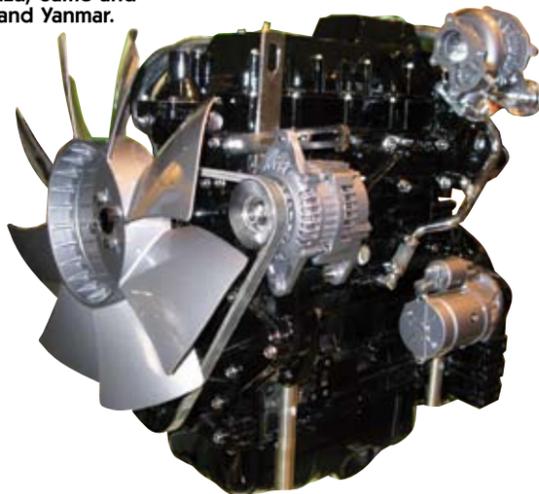
Las Vegas, his name is Jcb. Three liters round, which reaches 55 kW like Cummins and John Deere. One might argue that these are captive units tailor-made for in-house applications.

Cummins thinks 'global'...
It is not clearly the case for Cummins who sets instead the calibration thinking as a global supplier after the eclipse of the A series made in Kukje, and destined the Qsf3.8 to oversee the 100 kW threshold (98 kW @ 2,800 rpm). John Deere, on the other hand, has surely conceived its odd engine for the

Brand Model	CUMMINS QSF2.8	DEUTZ TCD 2.9	ISUZU 4JJ1X	JCB JCB430	JOHN DEERE EWX 2.9	SAME KE 3	VM D754TE3	YANMAR TNV94HT-CR
I.D.								
B x S mm - S/B	94 x 100 - 1.06	92 x 110 - 1.20	95 x 105 - 1.11	92 x 112 - 1.22	106 x 110 - 1.04	103 x 115 - 1.12	94 x 107 - 1.14	94 x 110 - 1.17
N. cylinder - liter	4 - 2.77	4 - 2.92	4 - 2.97	4 - 2.97	3 - 2.91	3 - 2.88	4 - 2.97	4 - 3.05
Maximum power kW - rpm	55 - 2,400	77 - 2,200	86 - 2,200	55 - 2,200	55 - 2,200	75 - 2,000	85 - 2,300	88.4 - 2,500
Mep bar	10.1	14.6	16.1	10.3	10.5	15.9	15.2	14.2
Piston speed m/s	8	8.1	7.7	8.2	8.1	7.7	8.2	9.2
Maximum torque Nm - rpm	300 - 1,600	420 - 1,600	375 - 1,800	400 - 1,200	304 - 1,600	370 - 1,600	420 - 1,300	420 - 1,400
Mep at max torque bar	13.9	18.4	16.2	17.2	13.4	16.4	18.1	17.6
Torque rise %	44.4	42.6	33.6	62.6	45.1	39.3	39.2	37.6
Torque at max power Nm	216	333	372	235	235	363	353	333
% Power at max torque (kW)	91.5 (50)	91.50 (70)	82.20 (71)	91.50 (50)	92.70 (51)	82.70 (62)	67.30 (57)	69.70 (62)
DETAILS								
Specific power kW/dm ³	19.8	26.4	28.9	18.5	18.9	25.9	28.7	28.8
Specific torque Nm/dm ³	108	143.5	125.9	134.3	104.4	128.1	141.4	137.5
Areal specific power kW/dm ²	19.78	28.95	30.28	20.68	20.75	30	30.58	31.80
RULES AND BALANCE								
Dry weight kg	214	237	320	345	251	420	257	235
L x W x H mm	642x655x718	648x483x560	928x823x888	752x594x815	676x577x956	621x611x679	702x557x736	719x496x717
Volume m ³	0.30	0.18	0.68	0.36	0.37	0.26	0.29	0.26
Weight/power kg/kW	3.9	3.1	3.7	6.3	4.6	5.6	3	2.7
Weight/displacement kg/dm ³	77.1	81	107.5	115.8	86.2	145.5	86.5	76.9
Power density kW/m ³	183.3	427.8	126.5	152.8	148.7	288.5	293.1	340
Total density t/m ³	0.71	1.32	0.47	0.96	0.68	1.62	0.89	0.90
Displacement/volume dm ³ /m ³	9.25	16.25	4.38	8.27	7.87	11.1	10.24	11.75
INDEX								
TORQUE	10.1	17.9	6.2	12.3	8.1	6.3	12.2	13.2
PERFORMANCES	4.3	4.1	5	4.9	4.3	5.1	5.4	5.4
STRESS	7.3	7.9	8	8.5	7.2	8	8.8	8.9
LIGHTNESS	8.7	1.3	12.3	12.3	10.2	17	10.2	8.9
DENSITY	20.3	14	10.8	20.6	16.6	29.5	28.1	30.7
DIESEL	6.6	6.8	6.4	6.5	6.2	6	7.4	7.6



Opening: the Jcb 430. Top of this page: Cummins (first from left), followed by Deutz and John Deere.



Bottom: Vm Motori. Side, from left, Isuzu, Same and Yanmar.

green specialists and recovered it after a moment of oblivion by revamping the three cylinders strongpoints (currently sold by Agco Power, Doosan, Deutz, Fpt, Hatz, Isuzu, Kohler,

Kubota, Mitsubishi, Perkins, Vm, Yanmar). Let's go back to the newborn, the JCB 430. Featuring moderate power and generous torque, it looks like an innovator. In the years of Stage

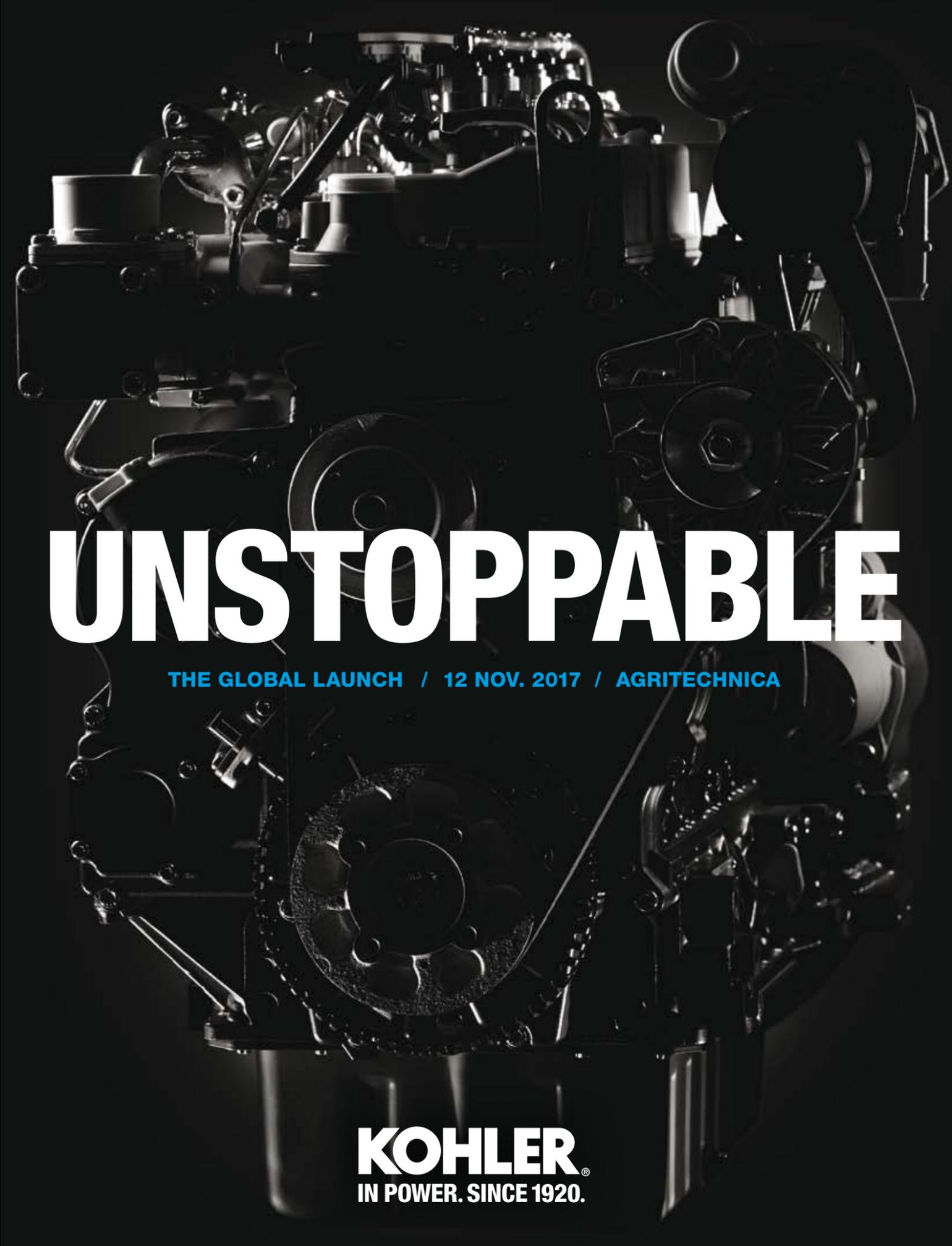
IIIB Rocester already earned the 2011 Diesel of the year prize for having gone through the particulate filter barrier. Now, favoured by the 56 kW threshold set by Stage IV/Tier

4 Final, JCB took one step forward eliminating both the egr and any other after-treatment device. The engine features an automatic valve regulator, spark plugs are integrated, carburetion is managed by the control unit, which can be mounted both on the motor or the chassis, tilting at 45 degrees.

We already talked about the smallest one, developed by Cummins along with Foton, which stands in line with the Qsf3.8. We've also mentioned John Deere. Now let's take a look at another captive unit, Farmotion, also available in four cylinders version, a purely agricultural engine featuring structural sump, slender profile (the classic 'narrow and high') to support the cylinder diameter. Single cylinder head, removable jackets, hydraulic tappets, 2,000 bar common rail, doc and scr to meet Stage Final.

3 for the captive Same

Same's three cylinders has been drawn to replace the 1000 series, keeping the same interface as its major brother and pushing on power and torque peaks (the four cylinders shows even better figures) in addition to attractive dimensions. Isuzu, who left the European trade shows after Intermat 2015, may now have his say climbing up to 85.6 kW with the supercharged version and waste gate valve, which wins the first position for specific power. The emission package features upstream - cooled Egr and downstream Doc and Scr. This engine - just like the six cylinders has a particular appeal for earthmoving machines between the two sides of the Pacific Ocean.



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COMPARISON

Looking at downsizing, or rather power density main road, since Stage IIIB engineering focused on compact four cylinders engines, 600 to 800 cc per cylinder. With Tier 4 Final the landscape still keeps the four cylinders but focuses on a greatly increased cylinder displacement: we're talking of a classic four in-line cylinders, 1.2 and 1.3 liters per cylinders. This range is ruled by the German school, showing increased specific performances, sustained MEP to squeeze the best from the engine, rotation rate and stress of the piston inside the cylinder never surpassing critical threshold.

Deutz and Kubota

This range is enriched with illustrious brands. In the last year, starting from Bauma 2016, Deutz introduced his Tcd5.0 and Kubota his V5009. Both will start from Stage V basis and will be available from 2019 (Deutz) and 2020 (Kubota). Very little is known about the latter at the moment, apart from what is reported here in a specific box. Among the reviewed engines

Comparison - 5 liters off-road engines

GIVE ME FIVE!

Deutz introduced his 5 liters engine for the first time at Bauma in 2016. Kubota announced in Las Vegas the V5009 epiphany from 2020, featuring the same displacement and 157.3 kilowatts. This power range is going to be really strategic. Mtu's R4 is still unmatched



FIVE LITERS DANCE

Brand Model	DEUTZ TCD5.0	ISUZU 4HK1	JCB ECOMAX 4.8L	MTU R4 1000	SISU 49 CWA	VOLVO PENTA TAD572VE
I.D.						
B x S mm - S/B	109 x 134 - 1.23	115 x 125 - 0.81	106 x 135 - 1.27	110 x 135 - 1.23	108 x 134 - 1.24	110 x 135 - 1.23
N. cylinder - liter	4 - 5	4 - 5.19	4 - 4.76	4 - 5.13	4 - 4.91	4 - 5.13
Maximum power kW - rpm	150 - 2,300	145 - 2,100	129 - 2,200	170 - 2,200	147 - 2,200	160 - 2,200
Mep bar	16	9	15.1	18.4	16.7	17.3
Piston speed m/s	10.3	8.8	9.9	9.9	9.8	9.9
Maximum torque Nm - rpm	892 - 1,500	686 - 1,200	750 - 1,500	951 - 1,400	835 - 1,500	902 - 1,200
Mep at max torque bar	22.9	9.3	20.2	23.8	21.8	22.5
Torque rise %	49.5	37.4	48.3	2.9	3.1	3
Torque at max power Nm	627	657	559	735	637	696
% Power at max torque (kW)	93.5 (140)	59.50 (86)	91.40 (118)	82.10 (140)	89.30 (131)	70.90 (113)
DETAILS						
Specific power kW/dm ³	29.9	15.3	27	33.1	29.9	31.2
Specific torque Nm/dm ³	178.3	72.7	157.4	185.3	170	175.7
Areal specific power kW/dm ²	40.21	19.21	36.54	44.74	40.16	42.11
RULES AND BALANCE						
Dry weight kg	485	470	590	540	600	560
L x W x H mm	814x744x918	1.019x776x1.034	841x697x911	818x755x1.033	902x620x887	772x859x995
Volume m ³	0.56	0.82	0.53	0.64	0.50	0.66
Weight/power kg/kW	3.2	3.2	4.6	3.2	4.1	3.5
Weight/displacement kg/dm ³	97	49.8	123.8	105.2	122.2	109.1
Power density kW/m ³	267.9	176.8	243.4	265.6	294	242.4
Total density t/m ³	0.87	0.57	1.11	0.84	1.20	0.85
Displacement/volume dm ³ /m ³	8.93	11.51	8.99	8.02	9.82	7.78
INDEX						
	11	10.6	9.7	19.9	9.8	20.4
PERFORMANCES	6.6	3.6	6	2.9	2.4	2.6
STRESS	11.1	6	10	17.3	14.9	16.3
LIGHTNESS	12	7.3	14.6	1.2	1.1	1.2
DENSITY	19.3	6.6	17.9	2.9	3.3	2.8
DIESEL	7.5	6.2	6.8	7.8	6.5	5.5



Deutz is the only one specifically designed for Stage V along with the V5009, and it has currently been seen in fairs and under the bonnets as a demo unit. The anti-pollutants device chain confirms Deutz's vocation to full after-treatment, featuring doc, dpf and scr, being egr still under observation on this displacement. Cologne may in fact still opt for removing it. At the moment it is still adopted, according with German tradition of recirculation confirmed by Man (which is featured in a box, being the best performer in terms of specific curves but staying under the threshold target with its 4.58 liters) and Mtu, the leader of the comparison.

No compromise for the 5!

Bore and stroke show the original approach of the 5 liters in red and no compromises

From top, to left: Isuz and JCB. On the right, Agco Power and Volvo Penta.

for 4 and 6 liters in-line, the existing units that cope with the Tcd5.0 displacement. As stated by Michael Wellenzohn, Deutz Executive Vice President: «It is characterized by a number of reduced internal ducts, fewer components, a clear separation between hot and cold parts, reduced performance losses from oil and water circuits. The engine also features overhead camshaft, cross-flow cylinder head, maintenance-free hydraulic valve clearance compensations».

Mtu: natural born leader

The leader, as anticipated, is still Mtu, which is able to withstand the attack from Deutz and Kubota thanks to its 170 kW and 951 Nm which secure it from competitors. The R4 1000 is surely heavier, even though dimensions are competitive and power density is



MAN AND THE OTHERS (4 TO 4.7 LITERS)



D0834 was not included in this comparison due to a few cc. Man stands out for its figures under stress, so to speak. Nominal torque is 735 Nm, side by side with Mtu, but showing a significant 100 Nm gap in terms of maximum values, ie at the peak of the torque curve (951 vs 850 Nm). Staying at 1,750 rpm at maximum torque and 156 kW corresponds to a 96.2 per cent availability at 2,100 rpm, the maximum power ratio. This value means a lot in terms of elasticity

of torque and power curves and thermodynamic parameters of the 4.6 liters from Nuremberg. Man however is not the only unit excluded from the comparison. Comparisons in this range usually include 4 to 5 liters engines. In alphabetical order, Cummins Qsb4.5 (code name up to Tier 4 Final), Deutz Tcd4.1, Fpt Industrial N45, John Deere 4045 and Perkins 1204-Etta are included in the range from 4.03 and 4.48 liters, 115, 125 and 129 kW and 610 to 750 Nm torque.

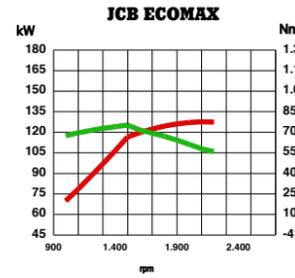
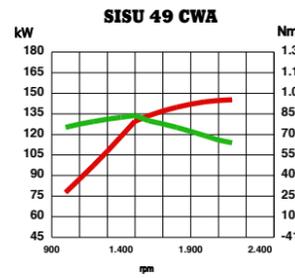
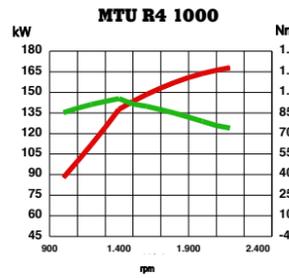
KUBOTA V5009

The oversized 4 cylinders is Osaka's top range and will fit right into this engine range. We talked about it in the Conexpo reportage. Leaked information is basic. We know it is a 4 cylinder featuring a 1.250 cc cylinder, delivering 157.3 kW. We also know that it will feature a complete after-treatment package including dpf and technical urea selective catalyst for Stage V approval. We would expect changes to the 100 millimeter bore (120 mm stroke) of 3.8 liter engine, coming back to the old 1 liter cylinder. Kubota instead designed a 5-liter barrel that raises expectations for the upcoming units, which will surely come between Agritechnica in November 2017 and Intermat in April 2018. Kubota is working on alternatives for some applications (in the case of Kubota, the dual fuel gasoline-LPG) without forgetting his diesel vocation. We were not surprised by dpf-scr duo. Let's take a step back to the aforementioned V3800 Tief4B. Kubota, in tune with the other major Osaka brand



Yanmar, crossed the line IIIB/IV alias Tier 4 Final through dpf. Diesel particulate filter, The device so many excluded in Stage IIIB e Tier 4 Final to avoid regeneration troubles, counterpressure inputs and control unit information overload. Kubota didn't, Kubota improved this technology. The control unit could be overloaded with sometimes contradictory inputs (fuel calibration by nozzles, load, regeneration and intake management, canbus protocol, etc). When regeneration is triggered by serpentine or post-injection complications even increase. Kubota mastered thermodynamic parameters to better integrate a 'lighter' version of the post-treatment module. This is at least our interpretation: we expect signals from Osaka about downstream management: integrated canning or separate modules? Scr approach or separate filtration? Catalyst coating working as a pre-filter or classic doc to raise the temperatures in order to process exhaust gases in dpf then in scr?

4 cilindri - >175 kW



On the top, Deutz. Bottom, MTU.

the best of the lot. Volvo Penta follows close, featuring the same cylinder displacement of Friedrichshafen's base unit, without any synergies between the German and the Swedish unit, and made in India (just like the 7.7 liters Tad870-873-Ve). Volvo relies on scr - egr without catalyst and dpf. Supercharging features variable geometry for an homogeneous air intake without using double stage, a technique shared by Volvo and Jcb. The British come up with the Ecomax, Diesel of the Year 2011 that marked the transition to Stage IIIB without using dpf, which at that time seemed an irreversible choice. Engine mass here seems to favor the 4.8 liters (5 cubic meters, very close to the best in class, the Agco Power 49 Cwa), although its 590 kg make it the heaviest of the lot.

Despite its captive vocation the former Sisu is appreciated for its power/weight ratio and, as just anticipated, for its dimensions. Its compactness could open new doors besides agricultural applications of Agco Group.

Isuzu, a pure Japanese

Isuzu comes into this European monologue fits with his 5.2, being very conservative both in terms of stress and engine exploitation index and showing the typical family feeling of the Japanese engine school. Specific performance is far from the median. Its bright side is its very positive stress index.



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The re-appearance of the V20 in the range of 20 liters engines has not gone unnoticed. Specific curves fly high finding a fierce competitor in Mtu, the only manufacturer providing a double choice in this range, the 1600 Series 10 and 12 V cylinders. The comparison between the six contenders is inevitably heterogeneous, embracing a range from 18.1 to 21 liters, quite balanced and tight in terms of displacement but showing significant new entries and a couple of differences. One of these concerns the number of cylinders.

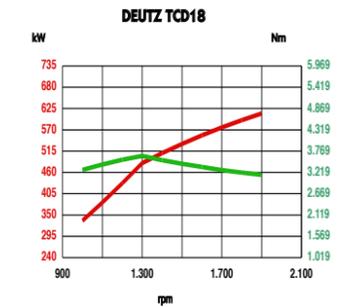
The fab '6 cylinder' four

Among the seven competitors there's a quartet featuring six cylinders, 3.1 liters per cylinder, one of the most popular displacements above 15 liters. FPT Industrial adds two cylinders, converting the V-eight configuration to a traditional 90 degrees tilt. Mtu 1600 moves up to 10 and 12 cylinders. Specific indicators concurring to determine the compactness index do not seem to favour the six cylinders, which obviously feature a different partition. Weight/

Comparison 18-21 liters

NEW ENTRIES AND UPGRADE

The V20 flies high after his successful launch at Conexpo, winning the Diesel Index. Cummins looks at mining and power generation, Perkins customizes his yellow twin looking at agricultural applications, Mtu stands at the side of the comparison. Deutz is also part of the game



Power ratio rewards the V20, while dimensions are Perkins strongpoint, which breaks on this range thanks to the upgrading of the top of the list by Caterpillar's descendants. Almost all volumetric indicators reward Peterborough and Caterpillar. As it happened to the 9-liter, the 1706J, the British modified the control unit and slimmed down after-treatment. This explains the remarkable differences between the American yellow twin in the 9-10 liters range - which features an almost double displacement is more sober showing similar nominal performances.

Diesel Index is for V20

The Diesel Index of the Anglo-American duo is the same, Fpt Industrial flies high with his 20 liters that is overpowered by Mtu 12 cylinders, while torque curves are just 3 percent different (124 Nm). Diesel Index rewards the engine from Turin designed in Arbon. There's huge buzz on the eve Stage V. Manufacturers are looking for a complete platform and Deutz is no

exception. After announcing the series developed together with Liebherr, reaching 13.5 liters, the 18-liter was introduced at Conexpo. The big brother from Koln stands at the top of the range and is part of the upgrading policy up to 700 kW announced by Michael Wellenzohn's interview published on the Italian edition of DIESEL. We know that the target will rise up to 620 kW, the power rate of the 6 cylinders, 3 liters per cylinder engine (the most popular among construction machines) featuring 3,600 Nm torque @1,300 rpm. Speaking of availability on the market in the coming months that will lead us to 2020 (including prebuy) the chosen solution is the reliable Eat package, consisting only of scr. Coming to Stage V, however, Deutz could leave behind egr and embrace the doc-scr package. Developed for railroad applications, the Qsk 19 has found fertile grounds in quarry and construction as well as on utility ships. The railway genesis has been sanctioned by the Toronto order which involved 18 Qsk19-R in pas-

senger transport services since June 2015, the first Tier - 4 Final approved for railroad applications to be operational in North America. The 18.9 liters in red is the tail lamp for power and torque, but stands up for mep, implying a conservative management of the potentialities of an engine designed for applications not draining constantly the maximum power. Mean effective pressure stays below the 20 bar threshold both at maximum power and torque.

5 cylinders displacements

Among the specifics of this comparison were the different splitting of the cylinders, divided into five classes, and the 'doubling' of Caterpillar 18.1-liter and his Perkins derivation that has been customized throughout the range above 9 liters to become a unique supplier. A synergy revealing a customization based on the agricultural vocation of Perkins units and the marine disposition of Cat. Mtu summarizes the double anomaly of unusual splitting and redundancy: featuring 17.5 and 21 liters displacements Mtu

From top to bottom: Caterpillar, Cummins and a former Agritechnica Deutz booth with the Liebherr writing behind. Side, a Fpt V20 detail.

LET'S START!

Brand Model	CATERPILLAR C18 ACERT	CUMMINS QSK19	DEUTZ TCD 18.0	FPT INDUSTRIAL V20	MTU 12V1600	MTU 10V1600	PERKINS 2806J-E18TTA
I.D.							
B x S mm - S/B	145 x 183 - 1.26	159 x 159 - 1	148 x 174 - 1.18	145 x 152 - 1.05	122 x 150 - 1.23	122 x 150 - 1.23	145 x 183 - 1.26
N. cylinder - liter	6 - 18.13	6 - 18.94	6 - 17.96	8 - 20.08	12 - 21.04	10 - 17.53	6 - 18.13
Maximum power kW - rpm	597 - 1,800	522 - 1,800	620 - 1,900	670 - 2,100	730 - 1,900	610 - 1,900	597 - 1,800
Mep bar	22.4	18.7	22.2	19.4	22.3	18.7	22.4
Piston speed m/s	11	9.5	11	10.6	9.5	9.5	11
Maximum torque Nm - rpm	3,655 - 1,300	2,852 - 1,400	3,600 - 1,300	4,100 - 1,500	4,224 - 1,300	3,518 - 1,300	3,665 - 1,300
Mep at max torque bar	25.9	19.3	25.7	26.2	25.7	21.4	25.9
Torque rise %	51.2	44.6	48.1	51.2	47.9	47.7	51.4
Torque at max power Nm	3,165	2,773	3,116	3,048	3,665	3,067	3,165
% Power at max torque (kW)	83.4 (498)	80.2 (418)	79.10 (490)	96.20 (644)	78.80 (575)	78.60 (479)	83.60 (499)
DETAILS							
Specific power kW/dm ³	32.9	27.5	34.5	33.3	34.7	29	32.9
Specific torque Nm/dm ³	201.5	150.5	200.4	204.1	200.7	167.1	202.1
Areal specific power kW/dm ²	60.24	43.83	60.08	50.72	52.03	43.48	60.24
RULES AND BALANCE							
Dry weight kg	1,542	1,928	1,950	1,600	2,200	1,940	1,542
LxWxH mm	1,438x969x1,132	1,679x872x1,616	1,554x985x1,215	1,625x1,190x1,340	1,873x1,258x1,200	1,707x1,258x1,200	1,438x969x1,248
Volume m ³	1.58	2.37	1.86	2.59	2.83	2.58	1.74
Weight/power kg/kW	2.6	3.7	3.1	2.4	3	3.2	2.6
Weight/displacement kg/dm ³	85	101.8	108.6	79.7	104.6	92.2	85
Power density kW/m ³	377.9	220.3	333.3	258.7	258	236.4	343.1
Total density t/m ³	0.98	0.81	1.05	0.62	0.78	0.75	0.89
Displacement/volume dm ³ /m ³	11.48	7.99	9.66	7.75	7.44	8.16	10.42
INDEX							
TORQUE	8.8	20.3	9.7	9.8	9.3	8.9	8.8
PERFORMANCES	7.6	6	7.6	7.4	7.3	6.4	7.6
STRESS	12.3	9.6	12.2	12.3	11.7	10.3	12.3
LIGHTNESS	12.5	15.8	16.9	11.1	13.8	12.1	12.6
DENSITY	9.5	5	8.2	5.6	4.6	4.2	8.7
DIESEL	7.5	6.6	7.4	7.9	7.6	7.2	7.5

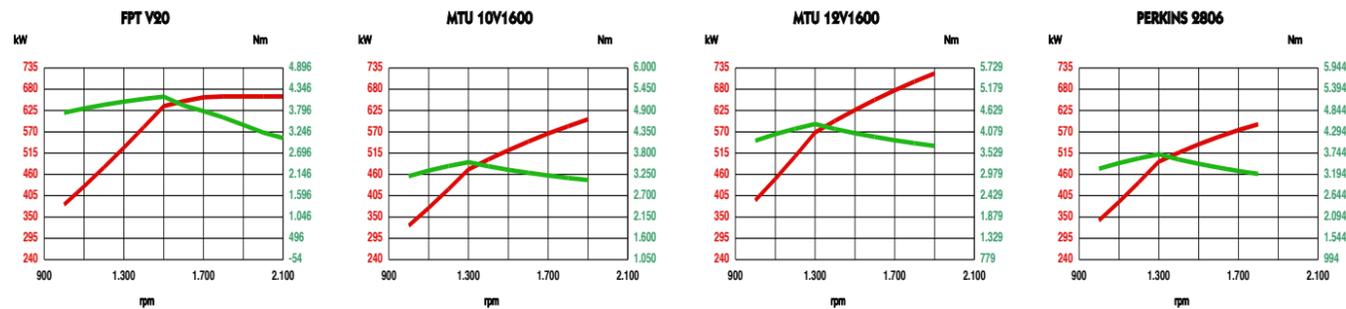
MAN D28

While Mtu is positioned on the sides of the comparison, let's stay in Germany just a few miles north to look at the radicalization of the concept by Man. Here comes the Nuremberg lion with his D28 series, D2862 identifying the 8 cylinders and D2862 the 12 cylinders. The elasticity of curves is a Man features also in this case, with the 16.4 liters showing figures that would stand the challenge, delivering up to 570 kW. The 24,2 liters tested in power generation starts from 588 and reaches up to 816 kW. Man top of the range is capable of delivering a torque curve from 3,750 to 5,000 Nm @1,300/1,400 rpm. Man has developed an air filtration and oil sumps protection system for the most demanding applications to favor steering radius and layout in large harvesting machines, in order to stand the test of wear and tear, impurities, soil and dust particles.



COMPARISON

6-8-10-12 cylinders between 18 e 21 liters



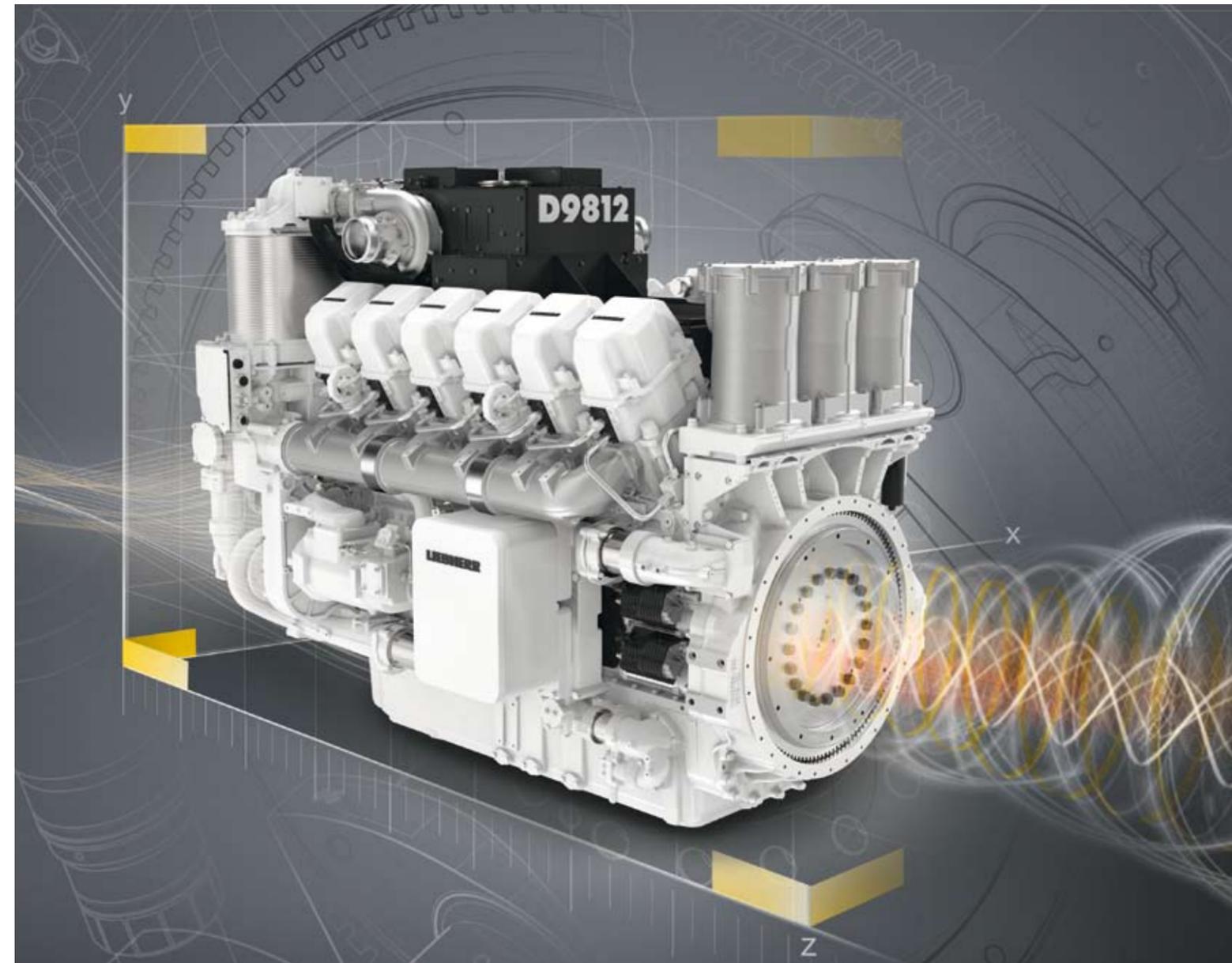
occupies the sides of the comparison, showing better curves in the 12 cylinders declination and substantially even densities. Let's not forget that we are above the 560 kW threshold, except for Cummins which in Tier 4 Final are still a free port. Still, scr is peeping as the definitive solution for exhaust gas treatment.

Cummins

The Qsk19 relies on a unique module processing gases from the upper nozzles and features a warning light indicating the minimum level of urea. V20 fits into the nouvelle vague of Fpt Industrial, which banned egr on Nef and Cursor engines as extensively described in the previous article. After-treatment with technical urea appears in any case an inevitable complication in terms of size.



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Liebherr is pleased to unveil its brand new D98 large diesel engine series. It extends the current portfolio with the most powerful engines ever built by Liebherr.

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Components

Visual control using a tablet. Technology comes to support technology. Below, pictures taken in Saran. Right, the 13.6 liters.



John Deere, industrial engines and Saran is an efficient synergy that reached half a century of lifetime. In 1963 the echo of WWII was fading and post-war France was sitting at the table of the great Powers. Today, the factory numbers tell a story of about a thousand employees, eighty-one dedicated to maintenance, organized on three shifts, half of the production destined to the free market, about 600,000 components handled annually, 1,543 assistance centers in Europe (4,000 worldwide), more than 40 million investment for Tier 4 Final production line.

Research is development

The research and development at this site carry out a dual task: the first is a multipurpose one, supporting the Waterloo, Iowa facility, where the main R&D Center is located, the second one is focused on Oem applications in the Emea area. John Deere concentrates in Saran most of its 'customer oriented' activities, outside the boundaries of Deere machines. Within this perimeter, a production line is dedicated to power generation units customization, redefining the blower and pump layout, cabling, capacity and placement of sump, air compressor alternator and

John Deere Power Systems and the Exagon

THE DEER'S NEST

In the heart of France, near Orleans, John Deere supplies both Oems and its own machinery. Within this perimeter every engine paradigm is represented, from stationary to marine applications, from tractors and other to agricultural applications



radiators. John Deere plays heavy trump cards in power generation such as Kohler-Sdmo. Moving from Orleans to sketch John Deere's production cartography we need to start from Waterloo, the 9 and 13.5 liters manufacturing site, and cross the Mexican border to Torreon, where 4.5 and 6.8 liters are manufactured. Jumping to Argentina we come to Rosario, where 2.9 to 9 liters engines are assembled. Next step is Asia, featuring two factories focused on their respective reference markets: Pune in the Indian subcontinent for 2.9 liters engines, and Tiangjin in China for 4.5 and 6.8 liters. The assembly line revolution was mentioned speaking about Tier 4 Final adaptation. The progressive upgrading of production lines and procedures involved four areas: the cylinders block, the 2-valve head line, the 4-valves head line, the crankshaft.

Fabio Butturi

Smart&human automation

The automation process and the dialogue between operator and software coexist in Saran. The badge is an example able to verify the compliance of each step to reduce human error to zero. Overall, there will be over 150 component verification procedures. It is possible to adjust the inclination of the belt during a couple of assembly steps to facilitate ergonomics and operating modes. Alerts also intervene to detect any non-conformity, for example when handling valve

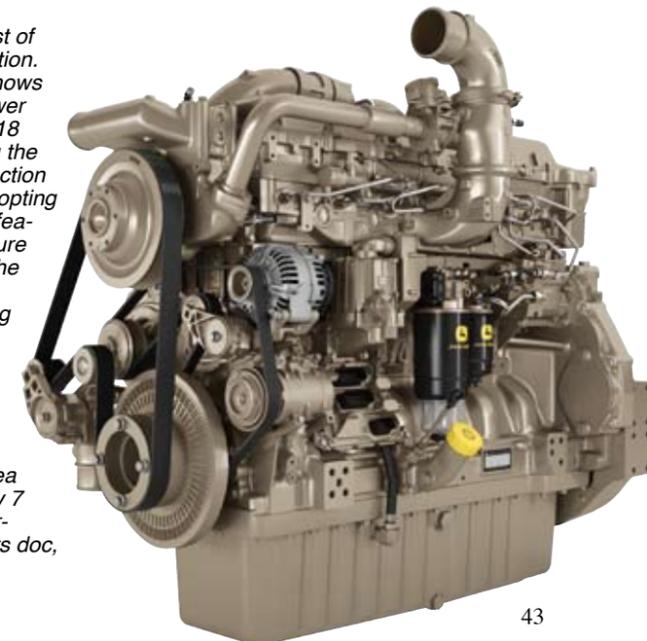


IN THE COUNTRYSIDE...

John Deere Power Systems (JDPS), has solid relationships with farm equipment OEMs around the world, enabling them to design and build compact, productive and reliable machines and benefit from the support of 4,000 expert service points worldwide. «Working closely with OEM engineers, our teams ensure the best possible integration —and performance — of the engine and drivetrain components» says Martin Ryley, manager, marketing services and sales engineering Europe, Africa, and Middle East. «Plus, preconfigured plug-and-play solutions save hours of engineering and help get machines to market faster». As an example, French company Kuhn Audureau S.A. used a 126-kW (170-hp) PowerTech E 4.5L engine on its self-propelled mixer wagon, which won the company the

«most innovative concept» prize at SIMA 2017. Other success stories includes Bag Budissa Agroservice in Germany, that uses the PowerTech PVX 6.8L Interim Tier 4/Stage III B engine on its RM 8100 bagger, capable of processing 10,000 tons of crop per year, Strautmann with its heavy-duty 6-cylinder Verti-Mix SF Fodder Mixing Wagon powered by a PowerTech PVX 6.8L Interim Tier 4/Stage III B engine, and Italmix, that switched to an Interim Tier 4/Stage III B engine in its Formula 18 mixer feeder. «We had to redraw the back end of the machine to create more space for the new block design. John Deere engine distributor Rama Motori's support in configuring the engine and attending field trials helped save us valuable time and money» says Sergio Lanzanova, sales manager of the company.

The 13.6 liter is the first of a new engines generation. Compared to 13.5 it shows a 10 percent more power and torque. Its size is 18 percent less, matching the 9 liters dimension. Injection has been modified adopting a Denso common rail featuring upgraded pressure and diesel dosage in the combustion chamber, as well as overcharging with dual turbo (fixed and waste gate) in the range from 410 to 500 kilowatts (fixed turbo and waste gate from 309 to 410 kilowatts). Fluid consumption (urea and diesel) dropped by 7 percent. A unique after-treatment module hosts doc, dpf and scr.



CAPTIVE VS FREE ENGINES AS USUAL

The number of third part engine manufacturers is as usual inversely proportional to the size of tractors. There's 6.8 liters engine John Deere among open field tractors, Fpt Industrial Nef 4.5 in utility tractors. Among specialized there are Vm R754 and a double Fpt F34

Tractor of the year, that is captive vs. free market engines. Among the fifteen finalists of the three prize sections we find a large number of engines designed and built in-house, which are represented in descending percentages starting from open field tractors to specialized. Among the tractors for tilling, plowing and road transport there's only one engine manufacturer acting as third part provider. The name

surely doesn't go unnoticed in agriculture: John Deere.

A couple of Deere

The 6-cylinder, 1,1 liter per cylinder engine makes its mark on both sides of the playfield: captive, on the John Deere 6250 R Commando Pro, and the genuine DIESEL target, the free market, under the bonnet of Claas Arion 660 Cmatic. The difference lies in V and S letters of Pss and Pvs. Where's the difference between? In

supercharging. 'S' stands for double stage, featuring a smaller low pressure turbo to sustain torque at low engine rates and a high pressure turbocharger with waste gate valve or vgt, ranging from from 168 to 224 kilowatts, without virtually overlapping the V version, which indicates a variable geometry turbine delivering from 104 to 187 kilowatts. The anti-emission package is the same, featuring an egr upstream of the combustion process, and a catalyst and

dpf anticipating the gas output through urea nebulization.

Let's take a look at the specialized. Here too there's only an engine manufacturer, Fpt Industrial, which supplies Argo Group to power the McCormick X6 Vt-Drive.

McCormick's strategy

McCormick's strategy for Tier 4 Final is well-known and is based on simplification: up to 100 kW threshold we find Deutz, above we find 4.4 and 6.7 liters NEF. In



					
Engine	Fpt Cursor 13	JD Powertech Pvs	JD Powertech Pss	Fpt Nef 4.5	Agco Power 74 Awf
Cilinders/cc	6/12,900	6/6,800	6/6,788	4/4,485	6/7,400
Power kW/rpm	399.2/2,100	128.7/2,200	183.8/2,100	106.6/2,200	172.8/2,100
Lenght mm	7,613	4,800	5,190	5,190	5,800
Wheelbase mm	3,912	2,820	2,900	2,684	2,995



					
Engine	JD Powertech Pwx	Agco Power 33 Eco	Fpt Nef 4.5	Fpt S8000	Agco Power 44 Wfc
Cilinders/cc	4/4,500	3/3,298	4/4,485	3/2,931	4/4,400
Power kW/rpm	91.9/2,200	66.2/2,200	103/2,200	55.1/2,300	80.9/2,200
Lenght mm	7,613	4,800	5,190	5,190	5,800
Wheelbase mm	3,912	2,820	2,900	2,684	2,995



					
Engine	Vm R754	Fpt F34	Agco Power 33 Awf	Kubota V3800	Fpt F34
Cilinders/cc	4/2,970	4/3,400	3/3,300	4/3,769	4/3,400
Power kW/rpm	80.1/2,600	72/2,300	74.3/2,100	85/2,600	76.5/2,300
Lenght mm	4,090	3,977	3,992	3,880	4,100
Wheelbase mm	2,300	2,148	2,185	2,130	2,124

this particular case, a 4 cylinders delivering 103 kW at 2,000 rpm and 578 Nm at 1,500. The utility tractors speak the same language, and that's rigorously Italian. Three out of five are free. Let's start with Aebi, a well known protagonist of Toty's audience for winning Best of Specialized in 2014 with its Viatrac Vt 450,

that is still under the spotlights with the 3 liters, 4 cylinder R754, delivering 80 kW at 2,600 rpm and 420 Nm. VM has the task to give a boost when the Swiss multi-function tractor is climbing on slopes, the natural playfield of these machines. The F34 by FPT Industrial is aboard the Claas Nexos 240 Ve

and the Massey Ferguson 3710 S, an engine which remained in the shade until the launch of Perkins Syncro family which in Stage V will replace the 854, the name used by Perkins to identify the FPT 3.4 liters. A slight change in the calibration (76 kW on the Ago, 72 on the German), a 373 Nm torque, under the bonnet of

Massey Ferguson and Claas in Tier 4 Interim. In this range the two Italians (Vm R754 and Fpt F34) are going to face Fendt's captives, the odd featuring 1.1 liters cylinder by Agco Power, and Kubota with its V3800, best seller ubiquitous on specialized, material handling and small construction machines.

Bonfiglioli in the words of Ceo Fausto Carboni

EXPANDING LIKE THE UNIVERSE

1,5 million units per year sold in about twenty application areas, a growth policy developing by “adjacent applications”, a leader in planetary gear units targeting sensors and predictive maintenance. This is Bonfiglioli in a nutshell

Planetary gear units - but not only - are its trademark. From Bologna to the four corners of the world, Bonfiglioli has become in more than sixty years a global brand crossing boundaries and applications. We met Fausto Carboni, Chief Executive Officer of Bonfiglioli.

Mr. Carboni, may you introduce us Bonfiglioli world?

Bonfiglioli has been working in the ‘mobile’ sector since the ‘70s. We started from a limited product range that we progressively expanded: the first was a concrete mixer, then we focused on tracks. From then on we fitted the gear units on several specific applications.

What technical-productive strategies is Bonfiglioli following?

When we find the need for a specific product the logic we rely on is based on ‘tailor made for application’ or ‘tailor made for oem’ concepts. This is where our ‘competence’ lies: adapting a technology to different applications.

What can you tell us about 2016 balance sheet and 2017 forecast?

In 2016 we reached a good growth ratio, about 8.1 percent (Group) and over 12 percent in the specific Mobile & Wind business unit. Coming to 2017, the turnover and orders trend remains very positive. Bonfiglioli distribution network is present all over the world. Europe, China, USA and India are our main markets, even though we think all markets are equally important. In the Indian subcontinent,

mobile market is growing significantly. Our Chennai factory is a ‘full fledged Indian company’.

Can you explain the reasons for O&K acquisition and the meaning of the incorporation of a Comer Industries branch?

The opportunity to acquire O&K came out in 2015 and enabled us to expand our offer upwards in Mining and Marine areas with a limited range overlap. The incorporation of Comer Industries branch is one of the several steps we took towards electric mobility. Track gearboxes, commonly known as motorwheels, have become one of the most important products in our portfolio. Through this operation we increased our market share in miniexcavators segment, becoming the only accredited European manufacturer in this area.

Who are your competitors?

In ‘mini’ applications we have a very strong Japanese competitor, a leader on the world market, Nachi, which also manufactures bearings and hydraulic motors. In crawler excavators with integrated hydraulic engine competition is almost entirely from Japan and Korea. Coming to tracks gearbox and wheels gearbox we have here in Italy Dana-Brevini, Reggiana Riduttori and Comer Industries, in Germany Bosch Rexroth, in USA Oerlikon Fairfield among others. In rotary gearbox market we find more or less the same competitors, especially Italians such as Dana-Brevini, Reggiana Riduttori and Comer Industries. Across the Alps we meet Bosch Rexroth and Liebherr on the market, plus Zf that acquired the Bosch Rexroth factory where large planetary gearboxes were manufactured and has become one of O&K competitors. Among the Italians we also find Pmp, which is particularly

specialized in concrete mixer gearboxes just as Zf. **Is Bonfiglioli interested in expanding its product range?**

We are strongly active in hydraulic motors area. We do not manufacture hydraulic motors in house, then we have strong partnerships with a couple of manufacturers including Kyb, Bosch Rexroth, Danfoss, Poclair, each focusing on specific applications. These synergies could of

course grow further. The topic of integrated units, hydraulics and mechanics, has still a long way to go. Electrification is another future relevant topic. About 7 years ago we created ‘cross team’ dedicated to ‘electromobility’ (sales, R&D, product engineering) featuring specific electronics and electromechanics skills. It is difficult to include such a team within a company that has a specific vocation for mechanics, but it’s necessary. We looked for an immediate ap-

plication area and we found it in material handling. This market is worth 20 millions, has a huge growth potential and is propedeutic to the future electrification of offroad machines.

Let’s talk about Stage V. Which is Bonfiglioli answer to engineers’ obsession with power density supporting at the same time fluidodynamic and thermodynamic inputs under the strict limits of regulation?

Bonfiglioli provides its support through the development and continuous optimization of hydraulic gearboxes efficiency and above all through investing in vehicle hybridization technologies. We are working in particular in agricultural and earthmoving industry, delivering high power density electric motors featuring a high level of protection against environmental pollutants and thus able to replace conventional hydrostatic applications. We have recently supported

the oems in Tier 4 transition. The integrated hydraulic gearmotor solution may improve overall transmission efficiency, which means less power request for oems.

Any ‘special’ applications or imminent product launches?

Our new developments are essentially focused on two fundamental issues: the making of highly integrated mechanical solutions, both hydraulic and electrical, and the increase in power density, in order to obtain compact and highly competitive products.

Which way will your products evolve?

Sensorization and predictive maintenance, of course within an IoT platform. For us, this is a transversal expertise. Industrial automation is ahead, for example in inverter programming using an app. We would like to transfer this and other skills in ‘mobile’ area. Oems know IoT and data features in the machines, but don’t see them in single components, while we believe they exist at least for predictive maintenance, that is able to reduce the Tco of the machine.

Fabio Butturi





Interpump Hydraulics. Interview with Paolo Cleopatra

A SUCCESSFUL CONSTELLATION

Interpump Hydraulics is the leading protagonist of Power take-off for commercial vehicle applications and in simple and double-effect cylinders. Interpump Group's structured expansion is rewarded by the market and the Stock Exchange

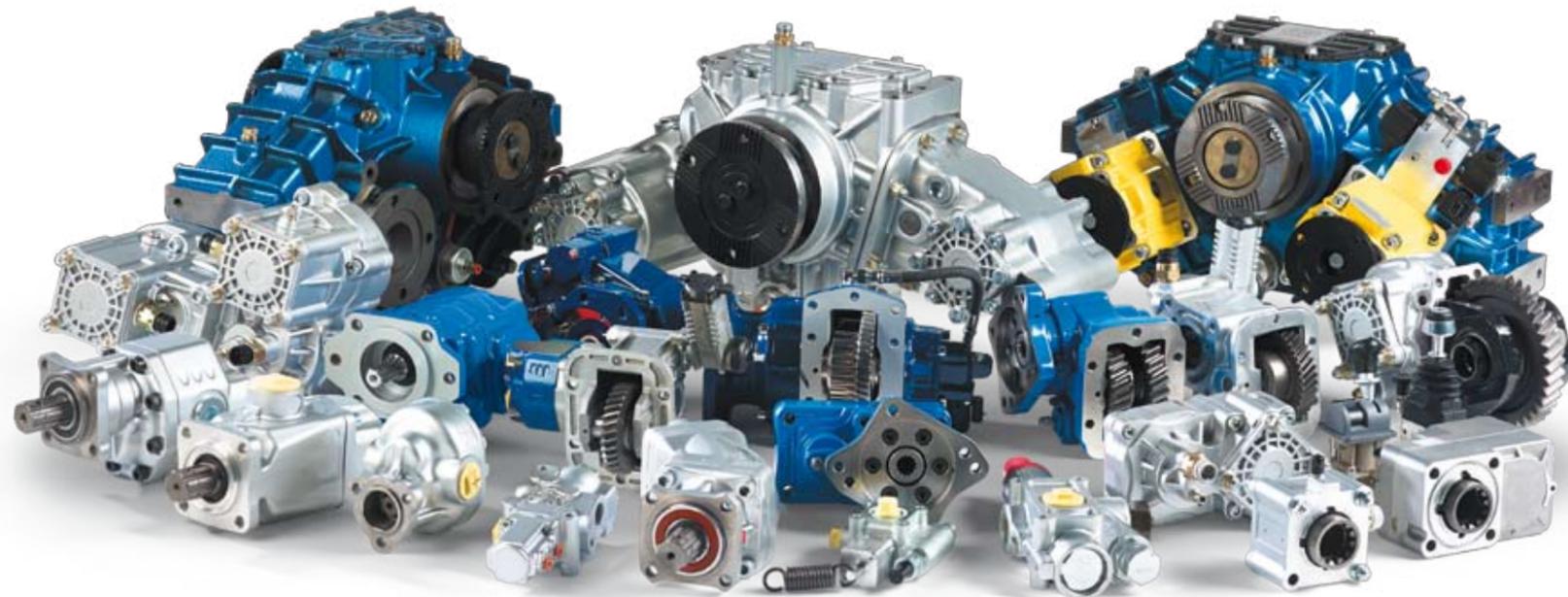
Interpump Hydraulics is a flywheel for the Emilian motorvalley. The leading company in PTO for truck applications (Light, Medium & Heavy Duty) is experiencing a commercial expansion within the Interpump Group.

We asked Paolo Cleopatra, Managing Director of Interpump Hydraulics, to take stock of the situation.

How is corporate aggregation going on and how is the business structure reorganizing?

Until 1997, Interpump Group only manufactured high-pressure piston pumps for water and, in some of its companies, cleaning machines. Since 1997, we progressively included Oleodinamica Pederzani & Zini and

then Hydrocar, that were two main players in PTO for trucks market. In this area, Interpump's critical mass strengthened towards the end of 1999 through the acquisition of Muncie in the USA. Later over the years a number of



companies specializing in simple and double effect cylinders were acquired to create a more consistent and organized product range. This growing range has been completed thanks to the latest acquisitions of some pipe fittings manufacturers. Meanwhile, to achieve greater integration, some manufacturers of directional valves - which are used both in industrial vehicles and in agricultural and earthmoving machines - have been acquired. Since about a couple of years Walvoil, one of the worldwide leaders in distribution trays, has joined the Interpump Group. At this point, in order to increase our effectiveness in the markets, we created some functional Divisions.

What these Divisions are?

First of all, the Pumps and PTOs Division, let's say the truck segment, which also includes cylinders and includes companies and

factories in North America, Brazil, India, China, Italy. Another Division is dedicated to pipes and fittings and includes factories in Romania and Italy. The Valve Division is autonomous. The structure also includes the historic Water Division.

Is your main philosophy still integration?

Interpump Group is, in fact, a small multinational, with an absolutely awarding success in terms of profitability. In some respects we have a unique profile: while being a company dealing with traditional mechanics and have a very high profitability, considering that we do not make hi-tech products and we really belong to the old economy, albeit pursuing innovation and accurate management.

What about your presence in different markets?

A premise on the nature and vision of Interpump is needed. The company has not relocated and has been dedicated to creating and acquiring successful companies in different areas of the world. Even in Brazil, India and China our goal was not to re-import cheap products but to create stable companies rooted in their respective areas.

What the missing dots to complete the Interpump mosaic can be?

We are an industrial group. Interpump has become a global player, a "one stop shop". When it comes to paradigms revolution it's difficult to guess the direction we're going to take... There are several solutions in the transport area (hydrogen, full electric, hybrid, etc.). Only the future will tell which direction will prevail over the others. But before facing the shift that

will dramatically change vehicle transmission there's a rapidly evolving aspect, which is dimensions. Vehicles no longer have space to meet regulatory parameters and support the rush to efficiency. The lack of space push us towards research and constant challenges.

And besides PTOs?

We have an interesting range of simple effect telescopic cylinders for dumpers and an excellent range of double effect telescopic cylinders for waste collectors.

What about off-road?

*Interpump Group is the owner of Oleodinamica Panni, which is a partner of companies such as Terex and Caterpillar ... There's an entire world of applications and capabilities to meet specific needs there. **Fabio Butturi***

THE PRODUCT POINT OF VIEW

The range of sandwich PTO (EFP series) introduced at Hannover Iaa in three sizes (SAE 1, 2 and 3) is capable to minimize the issues arising from the need for engine-dependent PTOs providing high torque transmission levels under continuous use (a typical issue for most common gearbox PTO). The versatility of EFP series makes it suitable for all types of engines and gearboxes, including robotized and automatic gearboxes (Allison 2000/3000 and 4000 Series). These applications are primarily - but not only - typical in



firefighting vehicles and wells drainage. The technological evolution of this PTO range is making obsolete previously used solutions (Split-shaft PTO), which also are part of Interpump range. PTO was previously placed halfway through the vehicle's transmission shaft, which was specially cut and suitably shortened, and operated through the gearbox in a stationary or moving vehicle without allowing gear shifting. Now it is usable when the vehicle is moving, and it is also possible to shift gears without any issue.





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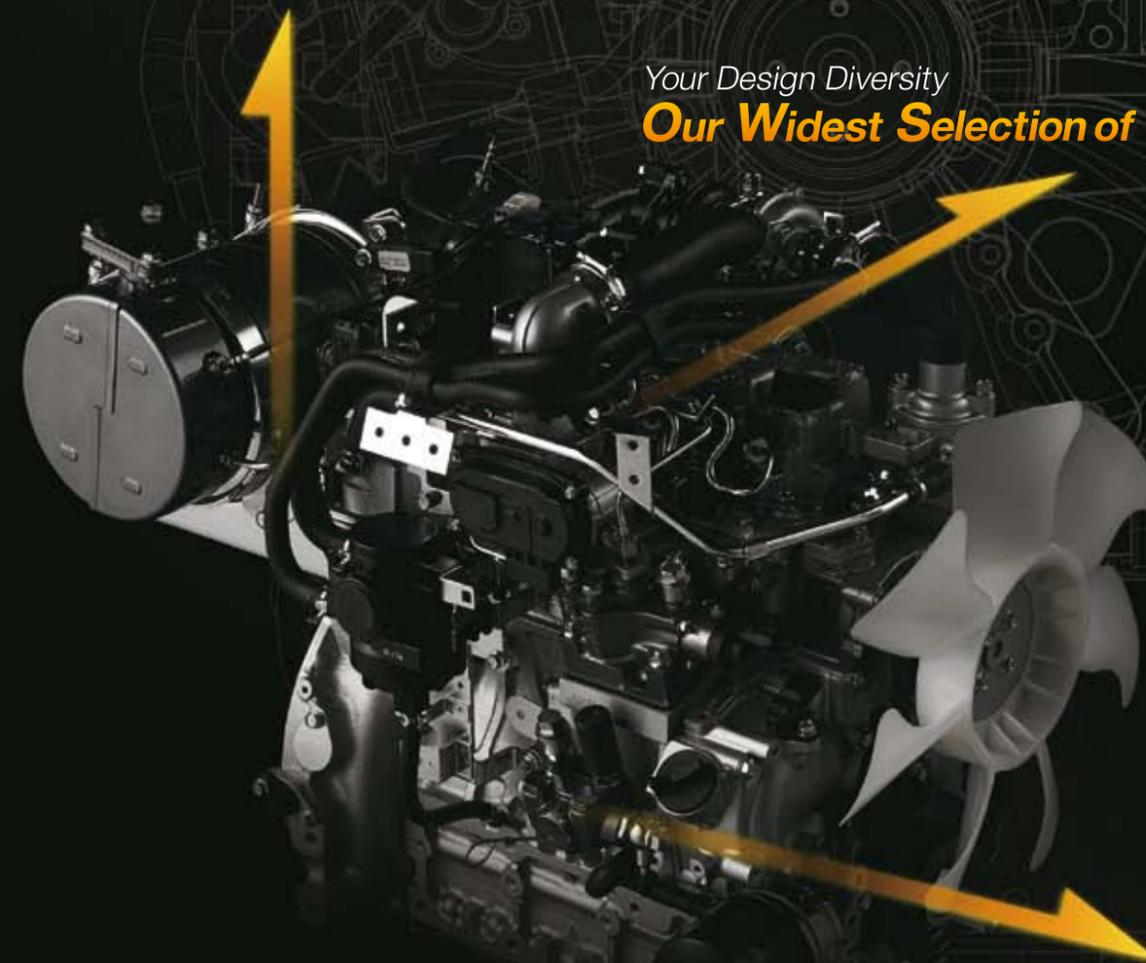
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