

moehwald *inside*

INFORMATION FOR CUSTOMERS, SUPPLIERS AND EMPLOYEES OF THE MOEHWALD GMBH

2005 - AN EXCEPTIONAL YEAR

As a result of strong demand for testing technology for common rail injectors and pumps, our development and production capacity was utilised to the full during the whole of 2005.

Turnover rose from 27.6 million Euros in 2004 to 44 million in 2005 (+ 59 %). Consequently - and by a wide margin - 2005 was the year with the highest turnover in the history of Moehwald GmbH to date. In particular, this very positive development in business was based on investments in China.

At 36.8 million Euros, order input did not reach the previous year's exceptionally high level (43.9 million Euros). It was, nonetheless, significantly higher than called for in the business plan (27.5 million Euros).

In the business year 2005 we invested 500,000 Euros in installations and equipment. The largest single investments were the construction of a modular drive test bank and the extension of the employee car park.

On 31st December 2005 there were 137 employees on our books (last year 130), of which nine (last year 7) were part-time.

Our technical activities were accompanied by changes in the organisation of assembly and a re-vamp of our corporate design. To secure our future competitiveness we put intensive efforts into the enhancement of the injection quantity indicator EMI 21 and the series development of the HDA injection analysis system using the hydraulic pressure rise process.

For the business year 2006 we are forecasting a reduction in demand but at a continuing high level.

MOEHWALD SYMPOSIUM 2005: ONE BECOMES TWO

With by now customary success, the fifth staging of the Moehwald Diesel Symposium was held in Homburg at the end of November 2005. There was, however, a significant difference to earlier events. This time, the Diesel Symposium formed only half of the programme.

"Since our integration into the Bosch organisation, we are more and more involved with testing and measuring technology for injection systems and complete fuel management systems on gasoline engines," notes managing director Dr. Hermann Bolle. "Thus, it was a logical decision to found a Moehwald Gasoline Symposium and to stage it together with the Diesel Symposium."

Success vindicated Moehwald's decision. The participant lists of both Symposia read like a "Who's Who" of the respective branches of the engine industry. The programmes of both events comprised high quality papers given by leading developers of compression- and spark-ignition engines.

"Good symposia and conferences are important forums for both formal and informal exchanges of information," confirms Moehwald Sales Manager and Symposium organiser Peter Wommer. "This exchange takes place primarily via the papers and subsequent discussions. But at

Moehwald Symposia we have always attached great value to creating an overall framework that encourages lively communication among fellow experts in something like a family atmosphere."

In this vein, the first Moehwald Symposium in 1993 took place before the backdrop of a major tennis tournament.

And in 2005, in addition to loquacious coffee breaks and meals, there were evening entertainment and two works visits which were equally useful opportunities for "talking shop" in a relaxed atmosphere.

Not surprising, then, that any Moehwald Symposium will invariably attract the right audience and the right speakers. Moehwald symposia were and are absolutely in keeping with the times, as a leading engine developer and Symposium speaker explains. "With the first event in 1993, Moehwald recognised the spirit of the times.

That period represented the start of an irresistible process. Progressively tightening emissions legislation in Europe, the USA and Japan was either passed or in the planning stage.

Of vital importance to compliance with these regulations are ever more accurate fuel injection systems.

Their development, in turn, demands ever more accurate measuring methods and equipment. Moehwald is a supplier of an "enabling technology" of this progress in

many areas of the engine industry, and thus ideally positioned to organise this type of industry-wide gathering.



Intense discussions at the walkabout through Moehwald Plant



Presentation of the Test Benches at Moehwald plant



Symposium hall

Looking at the list of technical papers confirms that, taken as a whole, they represent both a comprehensive "snapshot" of the current state-of-the-art as well as a glimpse of the future of fuel management. "Not only was a Moehwald Symposium always a major source

of material for articles, they were also a vital barometer of industry trends," says Diesel Progress journalist Jonathan Walker, veteran of the first ever Symposium and a always willing return visitor. "As in 2005, a Moehwald Symposium always provided a preview of the technologies that would go on to significantly influence the future of the diesel engine. For example, at a Diesel Symposium I gained my first deeper understanding

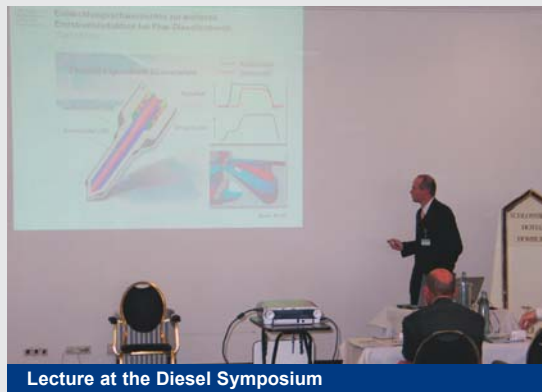
of Common Rail, the fuel injection system which more than any other will enable the powerful and clean diesels of the future. And, as we saw in 2005, a system in whose development Moehwald products have played, and continue to play, a valuable role."



Presentation of the newest measuring instruments

The feedback questionnaires distributed at the end of the two days showed that the events were very well received by their participants. In particular, the question asking whether they would come to the next Moehwald Symposium was answered with a resounding "Yes!" Copies of all the papers given at the Moehwald Gasoline Symposium and Moehwald Diesel Symposium can be viewed on our website.

www.moehwald.de



Lecture at the Diesel Symposium

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MOBA-B, THE NEW MODULAR BASIC BENCH: FAST SET-UP, FLEXIBILITY AND USER-FRIENDLINESS

"Our development objective with the MoBa-B was to create a universally applicable, basic test bench for development and laboratory purposes," notes head designer Franz Bründl

With its powerful drive, generously dimensioned test-oil supply and extensive test space, the MoBa-B represents an excellent base on which to build customer-specific testing solutions. Using a fast-exchange module with front-side insertion, the drive bench can be rapidly adapted to the testing task in hand, and just as readily converted to a subsequent task. In this area, customers can take advantage of a range of existing applications in both diesel and gasoline testing. These include modules for component testing on in-line, rotary and common rail pumps, modules with camboxes for unit injector and unit pump testing, modules closely emulating real cylinder head lay-outs and complete modules for common rail applications.

In addition, the basic bench can be equipped for test operations on associated peripherals. As well as customer-specific requirements MoBa-B could, for example, be equipped for a range of standard applications we have already produced, like the use of an additional lubricating oil supply, input-side temperature regulation and a broad range of well proven mechanical systems. The basic bench can also be equipped for explosion-prone test-pieces and thus offers a suitable test environment for gasoline applications.

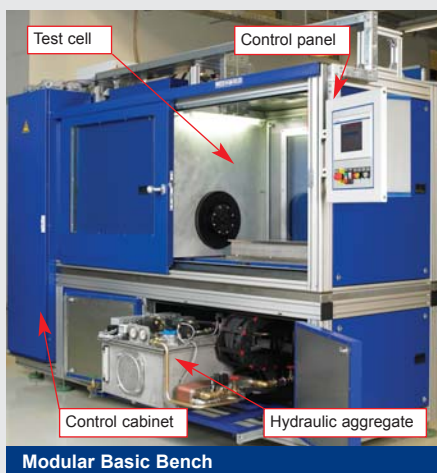
At the heart of the drive bench is a direct drive unit with scalable outputs from 28 kW and 41kW, and capable of delivering peak torques

of 450Nm or speeds up to 7000 r/min. according to version. High precision dynamic speed control forms a basis for sophisticated dynamic testing procedures. Completely scalable outputs and speeds allow the testing of all widely-used types of diesel and gasoline injection equipment for car, commercial vehicle or industrial engines. In-line, rotary or common rail pumps employ direct drive while unit injectors and unit pumps are driven via fast-exchange cam boxes. As well as the pumps mentioned, other components of the corresponding injection system can also be tested.

Further basic features of the test stand ensure both application flexibility and rapid conversion from one testing task to another. The MoBa-B possesses a large testing space for suited to maximum heights of 125 mm to 315 mm, with optional integral noise protection and removable media supply units in the sub-frame. The test space thus has sufficient reserves for the integration of application-dependent measuring components.

Thanks to a BOSCH VEP30 industrial PC with touch panel, operation of the test stand is extremely simple. As well as manual operation via the control panel, the test stand can also be remote controlled via an optional measuring technology PC connected to the ethernet via a defined interface, and thus integrated into an automated test procedure.

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Modular Basic Bench

MOEHWALD - A PIONEER OF PIEZO INJECTION TECHNOLOGY

Modern diesel engines are required to meet ever lower exhaust emissions and fuel consumption values which, among other things, prescribes ever more accurate control of the fuel injection process. Recently Robert Bosch developed a system to series readiness that has the potential to fully satisfy all the demands of engine industry in the coming years - the Piezo injector.

Common rail injection systems injectors with Piezo actuation can cope with both higher injection pressures - currently up to 1600 bar- and achieve a previously unattainable level of precision in the vital area of injection rate shaping. In the milliseconds before a diesel engine's power stroke, Piezo actuators not only inject truly minuscule quantities of diesel fuel into the combustion chamber, they do it in several very well defined injection "events". This newly acquired precision has translated directly into tighter tolerances in the manufacture of fuel injection equipment. Likewise, it has called for pioneering work from Moehwald, triggering a parallel "quantum leap" in diesel test technology.

Symbolic of the progress achieved are Moehwald's so-called "Reference Test Stand" and "Warm Leak Test Stand", both aimed at a full range of diesel testing applications including fuel injection development, manufacturing and quality assurance.

Reference Test Stand

The Moehwald Reference Test Stand is a selection test stand used in Bosch works all around the world and featuring especially accurate measuring technology.

Using its high precision, the Reference Test Stand can attain very reliable measurements in random testing on new Piezo injectors. On the basis of networked comparisons, the measuring standard of all

series test locations in all Bosch works can be assured.

The key component on the reference test stand is the new Moehwald-produced injected quantity indicator EMI21. The EMI21 device uses the most modern measuring technology to acquire very accurate data on the quantity of fuel injected during the individual injection cycles of a Piezo injector.



Test Bench for Piezo-Injectors

A selection of the EMI21's main data underline its precision: it is capable of measuring injected quantities from 0.2 to 600 cubic millimetres (mm³) at frequency of 3000 injection cycles per minute, and at an accuracy of +/- 0.05mm³ (for quantities between 0.2 to 50mm³) and +/- 0.1% of the measured value (for quantities from 50 to 600mm³), at a resolution of 0.008 mm³. As a result, with the EMI21 device Moehwald is well equipped for future increases in the dynamics of Piezo injectors and of Common Rail systems with pressures above 2000 bar.

In the process of establishing limit values for production test stands, the injected quantities from selected Piezo injectors are measured and recorded at various operating points and under various boundary conditions. In the same way, operating

temperatures, rail pressures and leakage at the injector are recorded.

In addition, the Piezo Reference Test Stand can be used for the assessment of injectors returned from the field, for measuring specimen injectors and for quality assurance tasks.



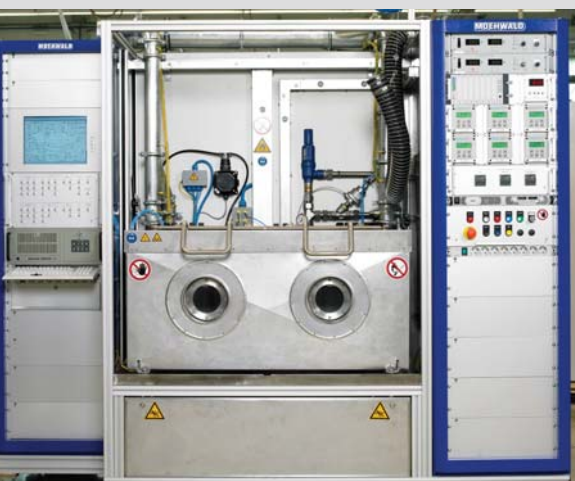
EMI 21

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REALISTIC SIMULATION: THE HOT GASOLINE TEST STAND

With this new Moehwald product, simulation takes centre stage - both as a tool in the design of prototypes and as a method of minimising expensive field testing. With the various versions of our "Hot Gasoline Test Stand" the central task is analysing the output of electric gasoline pumps and in-tank modules for cars under extreme ambient temperatures, very closely resembling those occurring in actual driving conditions.

For reasons of safety, such pumps deliver quantities of gasoline (ca. 150 litres per minute) which exceed the normal requirements of the fuel injection system by a wide margin. The gasoline not required for injection is returned to the tank, so that relatively large quantities of fuel are constantly in circulation. The variable temperatures of the engine, variable ambient temperatures (variable head winds etc.) lead to temperature fluctuations in the gasoline. In the process, temperatures of up to 70° C can build up in the tank and resulting pressures up to 25 kPa.



Hot Gasoline Test Bench

During journeys over mountain passes, vacuum conditions can occur in the fuel tank, promoting evaporation of the gasoline. Under certain pressure relief scenarios, bubbles can form in the fuel, leading to brief interruptions of fuel supply to the injection system.

These effects underline the importance of close-to-reality testing of gasoline pumps under variable tank pressures and gasoline temperatures using the Moehwald Hot Gasoline Test Stand. With appropriate conditioning of the test medium, our Hot Gasoline Test Stands can create the temperatures and pressures that would occur in the gasoline tank of a vehicle in the Sahara desert or on a pass in the Andes.

The central element of the test stand is an hermetically sealed gasoline tank with positive and negative pressure regulation, a gasoline heating line and pressure and deli-

vered quantity measuring lines. The gasoline pump to be measured is built into the tank, which can accept all widely available types of gasoline. The pump is activated and tested according to a pre-defined, automated test programme at various temperatures and tank pressures. A major element of the test programme is the so-called "mountain test curve", a pre-defined curve plotting gasoline temperature and tank pressure.

In this way, extreme but everyday situations can be examined.

The test stand is capable of simulating how a pump responds to "thermo-shock" as, for example, when a tank is filled on a summer's day and rapidly cooled by gasoline from the cold underground tank at the filling station. Similarly, using two separate tank compartments, modern "saddle tanks" can be tested. In many vehicles, the fuel is stored in tanks generously distributed under the rear axle, with the gasoline pumped to the main tank using a non-powered venturi pump.

The conception of the Hot Gasoline Test Stand was a major challenge, since it required the use of new technologies to realise these tests. Under intense time constraints, a testing system was developed which can to a great extent replace vehicle testing. To match the wide spectrum of test conditions that the Hot Gasoline Test Stand can simulate, a vehicle manufacturer would need to go to great expense, testing its cars on hot and cold days and at many different locations around the Earth.

A second generation of the Hot Gasoline Test Stand allows further measurements to be made and is also suited to the development of new fuel pumps. Among the additional testing options that have been implemented are:

- Measurement of the pump's electrical current consumption to test its function and establish its power loss - in these tests the pump and motor elements can be separated and evaluated individually.
- Measurement of pressure pulsations or pressure fluctuations on the complete pump and evaluation of structure-borne noise and vibration behaviour.

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HIGHLIGHTS...

General:

...re-modelled Homepage
www.moehwald.de with enhanced,
more comprehensive information.

...new Corporate Design

moehwald
Bosch group

...over 1000 test stands supplied
since foundation of the Company

...almost 200 new generation EMI
21 injected quantity indicators
already delivered to the market.

From the development depart-
ments:

...injector and pump testing at high-
er pressures (> 2000 bar) -
the testing technology challenge
for 2006

...testing technology for Common
Rail Pump Type CP4 under devel-
opment

..."Pre-development" Department
aims to increase the future orienta-
tion of Moehwald

From the Production Department:

...production re-structured to redu-
ce interfaces and optimise
throughput times

...extension of small device pro-
duction (e.g. EMI21 etc)

Personnel Changes:

- Uwe Jansen to Manager
Production
- Matthias Andes to Group Leader
Service
- Gerd Wagner to Group Leader
Automation/Hardware
- Ylber Haliti takes over
Responsibility for Small Device
Production

New Employees:

- Michael Becker, Service
- Andreas Henne, Hardware
- Jochen Kunkel, Project
Management
- Gerd Scherer, Service
- Markus Schwender, Hardware
- Jens Theobald, Mechanical
Design
- Stefan Zähringer,
Assistant to the Managing
Director