Combustion Research Unit - CRU

The flexible CVCC solution
for advanced combustion research

The CRU instrument from Fueltech is an advanced tool for research on ignition- and combustion properties. The instrument is based on Constant Volume Combustion Chamber (CVCC), features an electronically controlled, high-pressure fuel injector and a broad range of sensors for measurement and control of the system during operation. Sophisticated electronics- and user-friendly software enables simple and cost-efficient operation of the equipment

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Brief description of the concept
A CVCC system consists of a combustion chamber and a nozzle to inject fuel into the chamber. When fuel is injected into the heated and pressurized combustion chamber, the fuel evaporates, ignites and combusts just like in an ordinary engine.

The CRU is a scientist's tool for analysis of fuel properties and the sensitivity of these properties to change in physical conditions.

The purpose of the system is to simulate the process that takes place in a reciprocating engine during combustion of fuel. The most important difference is the simplified approach, where the effects of engine dynamics (ie. pistion movement) are eliminated, making it easier to isolate and study the effects of the fuel.

All process parameters are measured and controlled in order to create reproducible conditions.
During the combustion phase, the chamber pressure is measured and transferred to the computer for further analysis and presentation.

Background
The CRU™ has been developed based on many years of experience from development and production of testing equipment based on Constant Volume Combustion Chamber - CVCC technology. This principle has become widely accepted as a cost-efficient alternative to full-scale testing on rotating engines. The CVCC – together with sophisticated data acquisition and analysis, also opens up for study of details of the combustion process that previously have been unavailable by use of traditional techniques.

- **The CRU instrument is a *cost-efficient alternative or supplement* to full-scale engine testing**
- **The CRU instrument features a standard *high-pressure common-rail injector* enabling exact control of injection timing and injected fuel volume.**
- **The CRU is a *sophisticated R&D tool* for oil companies and engine manufacturers.**
- ***Flexible solution* that can be implemented according to the users own specifications and requirements**

fueltech

Combustion Research Unit - CRU™
Product development and manufacturing
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CRU is a valuable research and development tool for ***Automotive Engine Manufacturers***, ***Ship Engine Builders***, ***Oil Companies, Universities*** and other ***Commercial Research Laboratories*** working in the field of engine technology and optimized combustion.

Fuel Research

The CRU concept is very well suited for both qualitative as well as quantitative study of fuel properties:

- Keep technical solution constant, and isolate the effects of varying fuel properties.
- Change process parameters (temperature, pressure, injected volume, injection pressure) and observe the effect of the combustion process.
- It is possible to charge the chamber with a mix of for instance air and CO_2, and analyse how different concentrations affect ignition/combustion properties.

Engine Research

The CRU can help to answer questions related to future requirements for efficient and low-emissions engines.

- The CRU can be equipped with different technical solutions and help determine operational limits on injection system, combustion chamber etc.
- Advanced software enables the user to operate under varying conditions

Solution

The Fueltech CRU™ has a modular design, and is built of components and sub-systems that can be adapted to the specific needs for the intended use of the solution.

The solution consists of the main subsystems/components as shown in Fig. 1

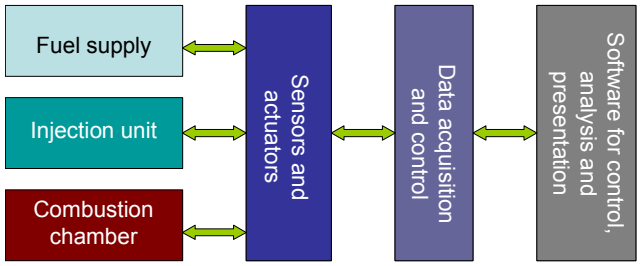


Fig 1: CRU modules

Injection system

The CRU is features an injection system based on industry-standard high-pressue common rail injector. Injection pressure can be varied from 300 bar to 1600 bar.

The injector can also be equipped with special sensors in order to monitor the nozzle movement.

Injection pressure and nozzle movement is logged and data are available for viewing and analysis in the user software.

Fig 2: High-pressure fuel Injection system

Combustion chamber

The design of the combustion chamber must be optimized according to the type of fuel and injection nozzle to be used (spray angle, longitudinal penetration etc.)

The chamber is heated with multiple individually controlled heater elements with separate temperature sensor for uniform temperature distribution.

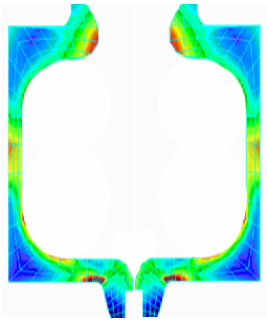
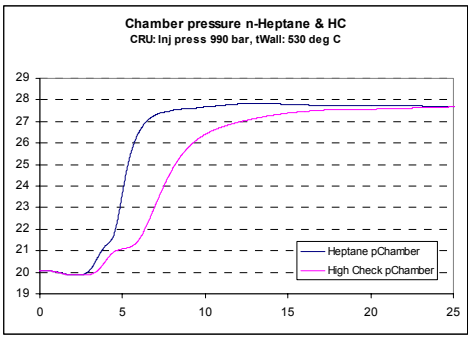


Fig 4: Chamber temperature distribution



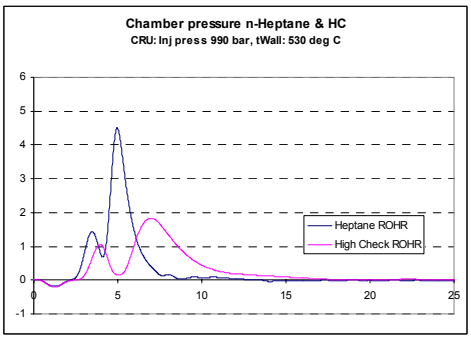


Fig 3: Comparison of combustion pressure and ROHR for 2 fuels

Sensors and actuators

For process control, CRU is equipped with sensors for monitoring of all relevant process parameters. Chamber pressure is measured by separate sensors for static and dynamic pressure.

Process control and data acquisition

The CRU features a sophisticated software control system, and in combination with sensors and actuators this makes the instrument near fully automated. Controller set points parameters like chamber pressure, chamber temperature, injection pressure, injection period is fully adjustable from user software.

All process parameters are continuously logged and monitored by the on-board computer during operation. During the test sequence, data series from the injection unit (injection pressure and nozzle movement) as well as traces for chamber pressure, fuel pressure and needle movement are collected by a separate Data Acquisition card using 16 bit AD converter. The on-board computer performs on-line diagnostic of critical electric and mechanical components.

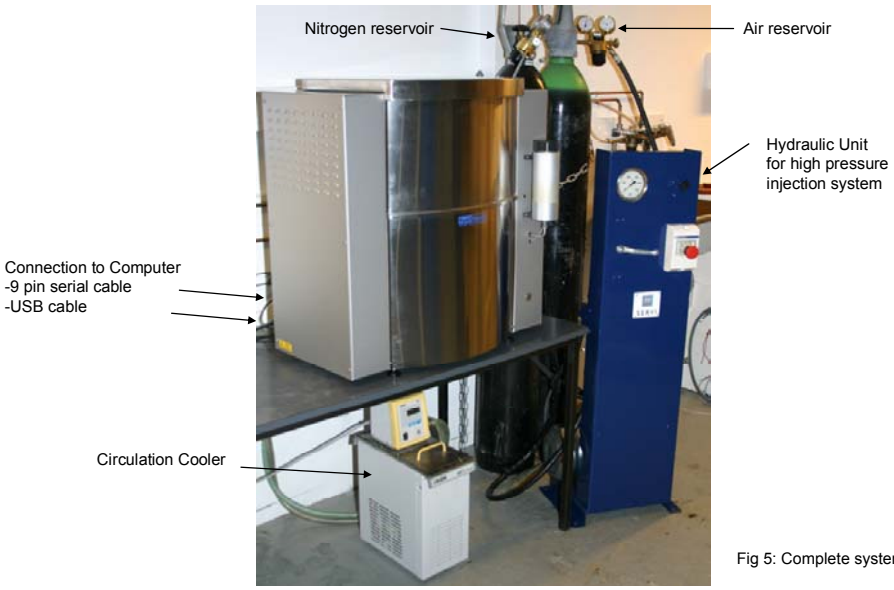


Fig 5: Complete system configuration

Test results and output

The most important output from the CRU system is the pressure trace generated during the combustion phase. From this set of data, a number of important parameters related to ignition and combustion can be derived.

Software control:
The CRU is connected via serial interface and USB cable to an external computer running the user control program. The user controls all operations of the unit from the main panel:

Different types of engines and operating conditions can be simulated by varying the most important process parameters:

- Chamber pressure
- Chamber temperature
- Injection pressure
- Injection period and timing

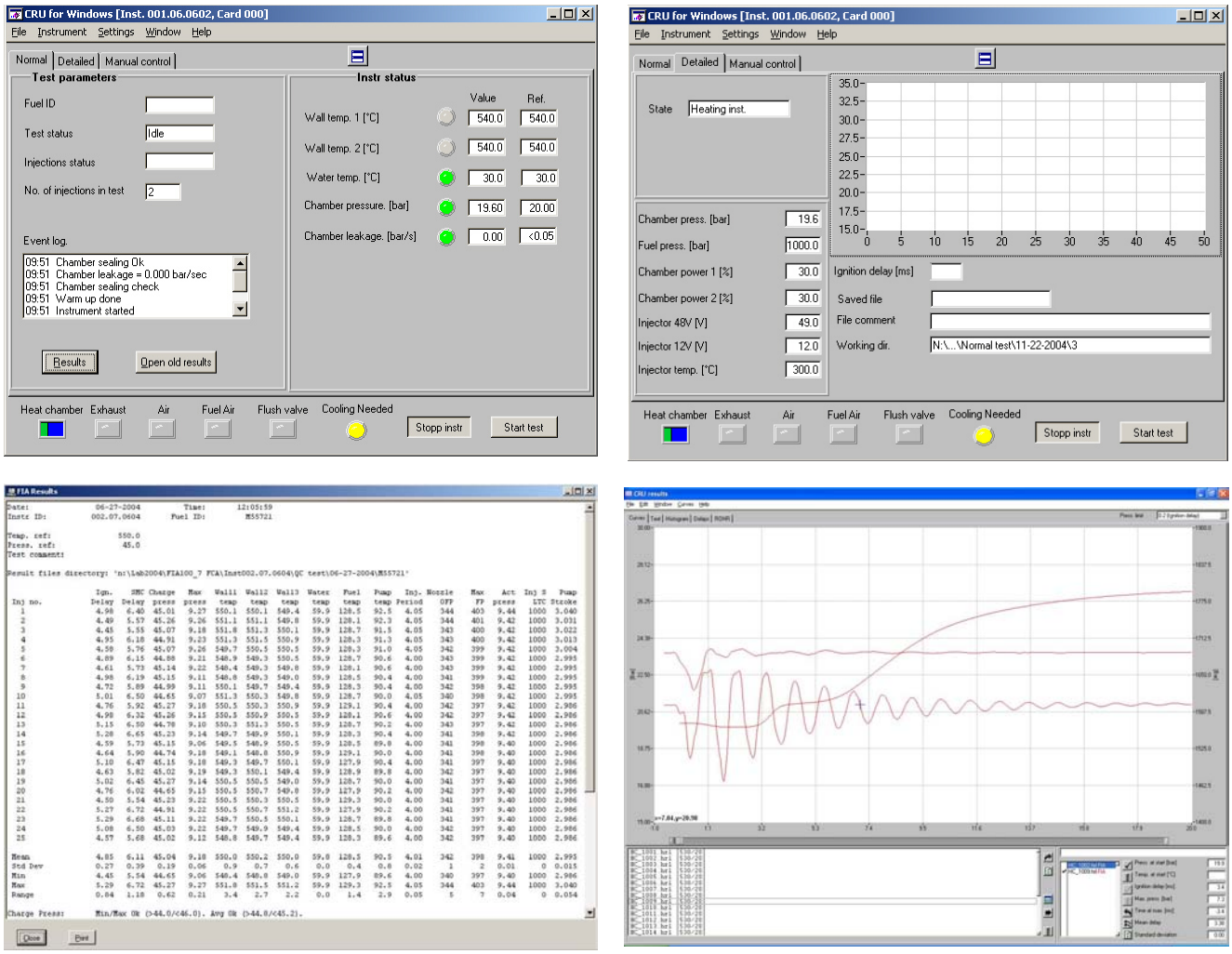


Fig 6: Sample screens from user software

CRU Standard solution - Specification overview

Chamber	
Fuel type	Diesel Fuel / Kerosene / Gasoline
Chamber temperature	Max 610 °C [1)]
Chamber pressure	10 - 75 bar initial pressure [1)]
Inner diameter:	100 mm
Inner length:	min 70 mm
Chamber volume	385 cm^3
Fuel Injection	
Fuel pump and injeciton nozzle	BOSCH CR injector Electronic control of timing, opening period, pressure
Injection pressure	400 – 1600 bars
Injected volume:	Approx. 0,05-0,12 ml
Instrumentation and control	
Chamber heating	2 heaters / 2 sensors
Chamber pressure	Air and exhaust valve / pressure sensor
Combustion pressure sensor	Piezoelectric pressure sensor
Fuel pressure	Piezoresitive pressure sensor
Nozzle sensor (optional)	Eddy current sensor
Injection volume control	Injector current on time
Fuel pressure control	Electronically adjusted
Test results	
Chamber pressure trace: resolution:	0,0006 bar/ 0,02 msec
Fuel pressure trace: resolution	0.03 bar / 0.02 msec
Software functions	Display of process parameters during testing Test results available in CRU user software Export of test results to Excel
Operational Requirements	
Test time 1 test	max 30 minutes on a “fit for use” instrument
Life-time	min 1000 tests with “normal” change of consumable parts
Connections to external systems	
Air supply	Compressed air in separate cylinder Air quality: ”Dry and Clean” Nitrogen for pressurizing fuel system
Cooling bath	Capacity 200 W @ 25° C
Computer	Standard Windows XP connect through 9 pin serial cable and USB cable
Power	220-240 V, 50 Hz
Power consumption	1800 Watt
Precision	
Repeatability and precision of measurements will depend on the type of configuration and may vary for each individual unit.	
[1)] Optional configurations	
Other options and configurations are possible based on specifications from user: - injection system - chamber layout: Can be individually adapted to the engine type in question - chamber temperature and pressure: up to 850 ° C, 100 bar - charge composition (ie. O_2 / CO_2 mixture) - spark plug for start of ignition	

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