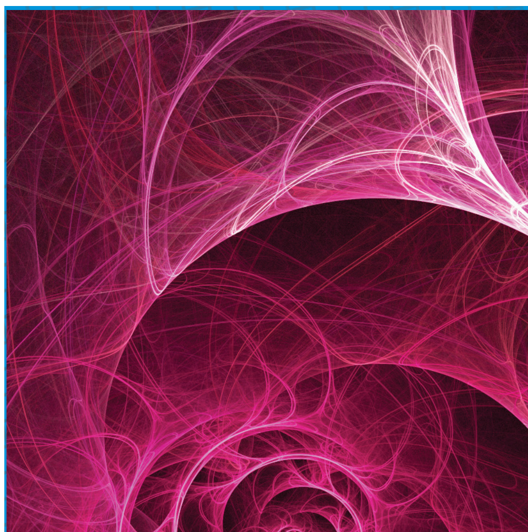

NextGen Derived Cetane Analysis Enables Refineries to Save on Maintenance & Operations Costs

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Fuels with better ignition quality allow more precise control of the ignition start. Therefore, higher cetane numbers, a measurement of the ignition quality of diesel fuel, are required for fuel efficiency. The major problem for refineries is that it is more difficult and more costly to obtain a higher cetane number. A typically way to increase cetane ratings utilised by refineries, is using cetane improving additives. Cetane improving additives readily decompose under diesel engine conditions, temperature, and pressure, to form free radicals, which increase the rate of chain initiation reactions, leading to improved fuel ignition characteristics.

The Cetane Index calculated using distillation data and density cannot differentiate between products with Cetane Improver and products without cetane improver. Therefore Cetane Index cannot be used to rate products which are blended with Cetane improver or Biodiesel.

To contain the costs associated with adding cetane improver, while meeting the specification, refineries must analyse the end product frequently and precisely. However, because the Cooperative Fuel Research (CFR) Engine technology, which is the reference method (ASTM D613/ISO 5165) to measure cetane number, has poor precision, refineries must set higher cetane numbers targets than required in order to ensure they meet the minimum cetane number specification. This of course requires adding more cetane improver than necessary and the cost adds up quickly. In addition, CFR Engine analysis does not provide accurate results for Biodiesel, which is increasing in demand. Therefore, refineries now need to perform accurate Derived Cetane Number (DCN) analysis on diesel and biodiesel fuel to maintain fuel consistency and quality. This article describes the traditional CFR Engine technology and why alternative technologies were developed. In addition, the alternative CVCC technologies that determine the DCN are described, along with the latest generation CVCC instrument that provides significant refinery savings through high precision. In addition, this latest technology is easy to use and requires low maintenance.

Traditional CFR Engine Technology

The CFR Engine was the first technology developed for measuring the cetane number of Diesel. It was standardised as ASTM D613 and ISO 5165, which are considered the referee test methods. The cetane number is determined by using a bracketing procedure that varies the compression ratio of the engine with a hand-wheel to obtain a specific ignition delay for the provided sample and for two reference fuels. This allows the fuel cetane number to be determined through interpolation of the hand-wheel readings between the two reference fuels. The cost of the two reference fuels, which need to be tested together with each sample and the total operator time to test the two reference fuels and the sample are the main cost drivers for the cetane number analysis with the CFR Engine.

The CFR Engine is a single cylinder engine so it has a moving piston which changes the combustion chamber volume. To run this engine, laboratories need an engine expert, which is not typically on staff. In addition, the CFR engine takes up very valuable lab space. Due to the high noise level when running and their large size, they typically have their own rooms. The CFR Engine can also be costly since its initial investment and ongoing maintenance expenses are high. With these drawbacks, the industry demanded an easier to use instrument that does not require extensive operator training.

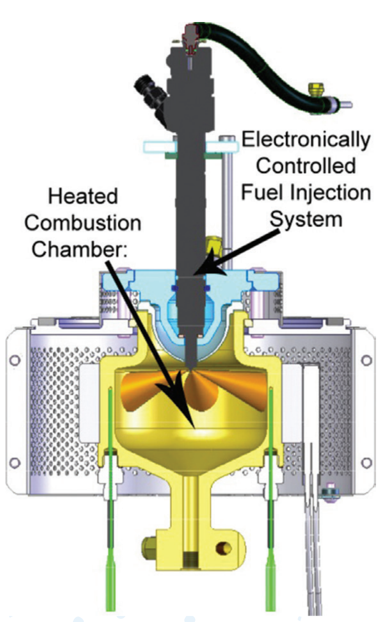


Figure 1: Combustion chamber with High Pressure Injection System

First Generation Derived Cetane Number Analysis

Since the CFR Engine technology is difficult to perform and costly, a new technology, Constant Volume Combustion Chamber (CVCC), was developed. A CVCC analyser is a bench top instrument which doesn't have a movable piston. The fuel is injected into a heated, temperature, and pressure controlled test chamber. The analyser measures the time period from fuel injection to the first pressure increase caused by the heat release during combustion, which is called the ignition delay. The ignition delay values are then converted into a derived cetane number using a correlation equation, which was developed by using ignition delay values of fuel samples with known cetane numbers.

With the first generation CVCC instruments, they improved CFR engine technology by:

- Not requiring engine experts to run the analysis
- Reducing maintenance because there is no movable piston
- Improving the ease of use by automating the measuring cycle

Even though the first generation CVCC technology has a smaller footprint and does not require a highly trained and experienced engine expert to operate, it still has some short comings. The DCN results acquired using the first generation CVCC instruments are not any more precise than the cetane number results acquired using the CFR Engine technology. While the maintenance efforts are reduced, the operators still need to perform manual calibration and cleaning. In addition, the injection technology used is still a low pressure injection system and pintle type injector, which requires mechanical adjustment for the opening pressure.

Highly Precise DCN Analysis - The Next Generation CVCC technology

By combining an electronically controlled high pressure injection system with fully automated measuring and calibration procedures, the CVCC technology reached the next level.

With the way the combustion chamber and the injector with 6 nozzles, which generates miniscule droplet size, were designed, it is possible to achieve faster evaporation of the fuel, with more efficient and sootless combustion. The electronically controlled high pressure injector guarantees precise injection volume for each combustion cycle (See figure 1). This enables an accurate simulation of a real-world diesel engine.

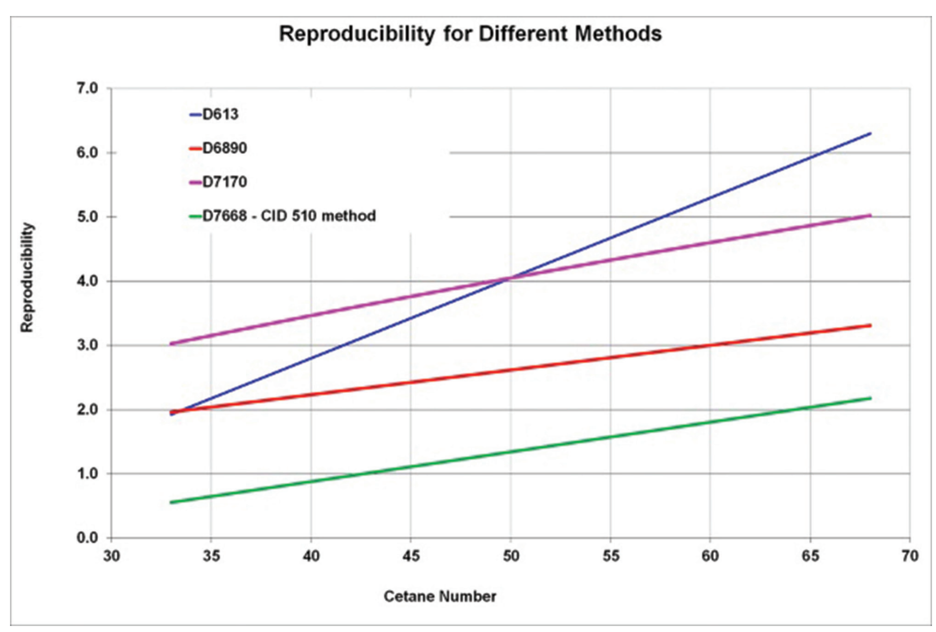


Figure 2: ILS Study Data showing Excellent Precision for ASTM D7668

In addition to the Ignition Delay (ID) measurement, this technology uses Combustion Delay (CD), which is the time from the fuel injection to the mid-point of the pressure increase during combustion. Only by considering ID and CD, it is possible to determine the correct cetane number for all fuels.

Herzog by PAC pioneered this new technology in its CID 510 instrument, which is the only one of its kind on the market. With this unique technology, the CID 510 provides excellent precision in the complete DCN range from 15 to 100. A joint ASTM and Energy Institute inter-laboratory study with 20 samples including different diesel grades, biodiesel blends, biodiesel (B100) and samples with different cetane improver content was completed in March of 2013. In the ILS, 17 laboratories participated from the United States and Europe to compare the cetane number determined with the CFR Engine and the DCN determined with the CID 510. The high precision results for the DCN from the CID 510 achieved in the ILS are now published in a new ASTM method, D7668 “Standard Test Method for Determination of Derived Cetane Number (DCN) of Diesel Fuel Oils—Ignition Delay and Combustion Delay Using a Constant Volume Combustion Chamber Method”.

This new test method ASTM D7668 for our CID 510 is now officially approved by ASTM as alternative test method to the ASTM D613 / ISO 5165. It is listed in the following Diesel specifications: ASTM D975, ASTM D6751 and ASTM D7467.

The CID 510 can now officially be used as an alternative test method to the CFR Engine acc. to ASTM D613 to certify diesel fuel. These three new revisions of the diesel fuel specifications D975, D6751 and D7467 were recently published by ASTM. The ILS study (D7668) shown in Figure 3 confirms the precision of the CID 510 from is much better than traditional CFR Engine technology (D613), as well as other CVCC instruments (D7170 and D6890).

In addition, this unique technology is based on calibration with the same Primary Reference Fuels (PRFs) used to define the cetane number scale, which allows calibration completely independent from the CFR Engine. It provides excellent correlation to the mean value of the CFR Engine (see Figure 3) as demonstrated in the ILS described above and in the Energy Institute Correlation Scheme program as well.

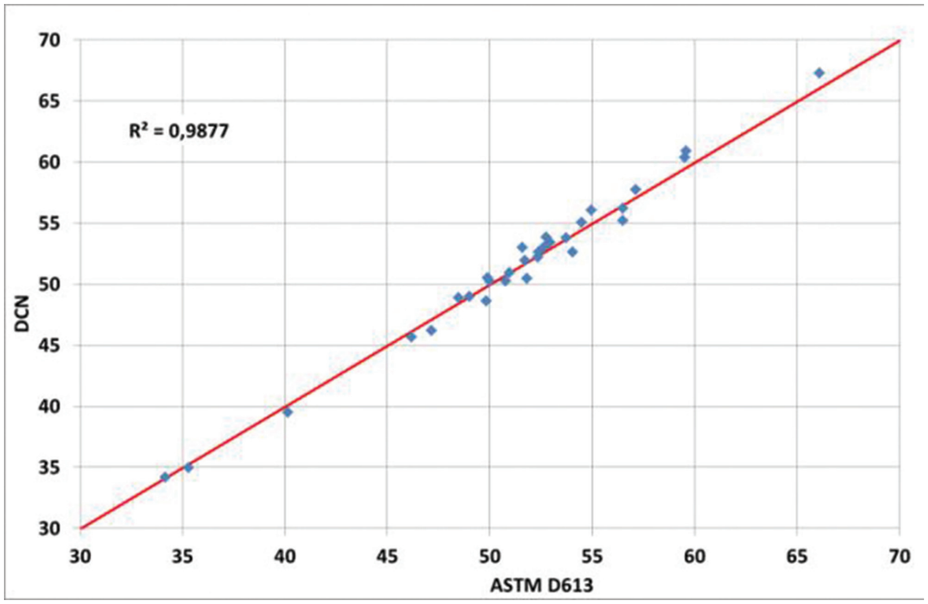


Figure 3: ILS Study Data showing excellent correlation to the mean value of the CFR Engine

Besides excellent precision and perfect correlation to the reference methods ASTM D613 and ISO 5165, the CID 510 provides numerous benefits, including:

• Improved ease of use – fully automated measurement and calibration with one button operation

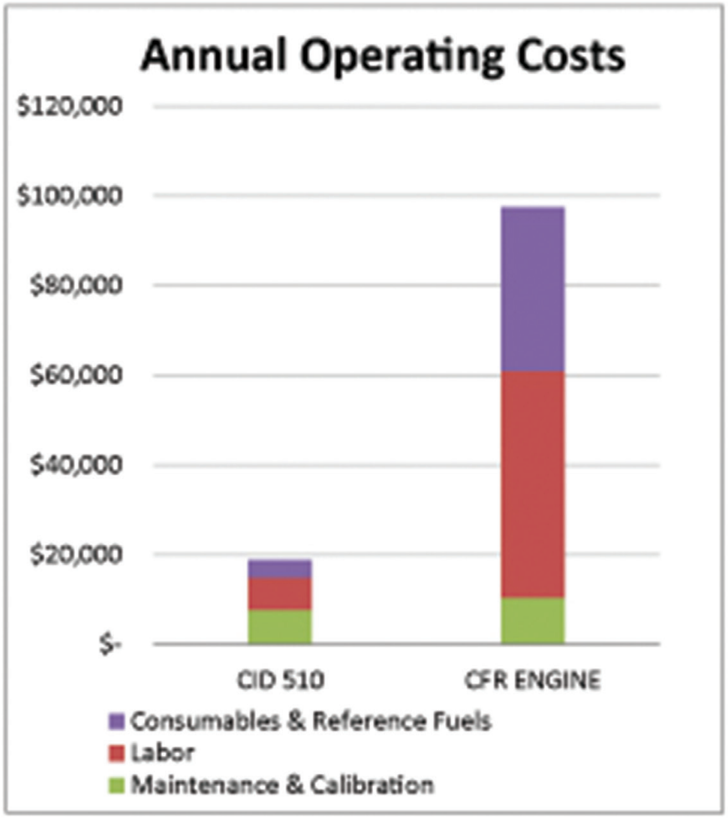
• High safety standards – the instrument is fully enclosed with over temperature and over pressure protection and includes a built in fire monitoring and extinguishing system

• Reduced maintenance – with soot less combustion, operators do not need to clean the test chamber; the very high calibration stability does not require operators to do weekly or daily calibration

• Reduced space – it is a bench-top model that is approximately 70% smaller than the CFR Engine

The PAC/Herzog CID 510 initial investment cost is less than half than the competition. With the CID 501 the cost for Reference Fuels, and the Operator and maintenance cost can be reduced by 80% The chart on the right shows a comparison that includes annual costs for maintenance, calibration, labor and consumables for sample testing.

Refineries are constantly trying to contain costs while meeting ever-increasing fuel regulations. With electronically controlled high pressure injection technology and measurement of ID and CD (ASTM D7668) from the Herzog CID 510, the cetane number results are much more precise. This allows refineries to operate closer to the specification limit while reducing the costs associated with cetane improvers, which ultimately increases a refinery’s profitability.



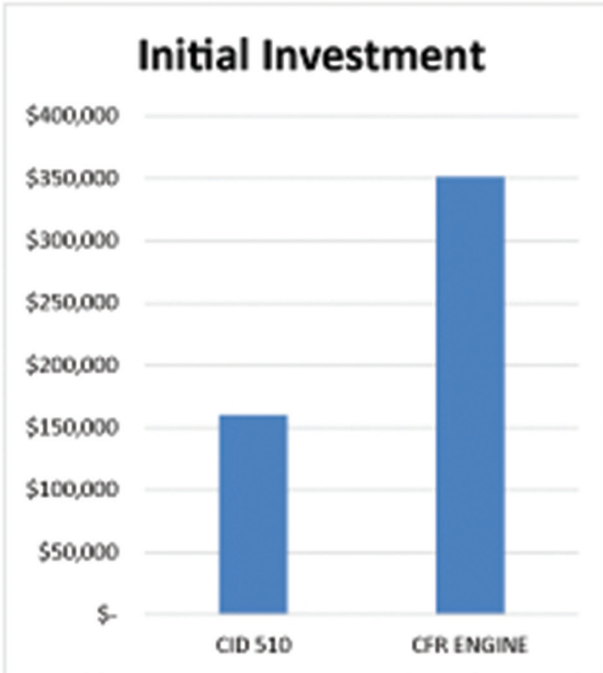


Figure 4: The CID Value Proposition shows its significant savings compared to the CFR Engine