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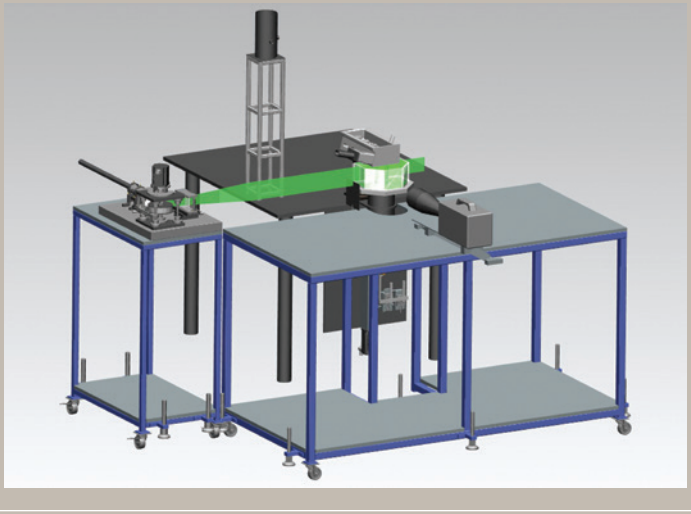
CASE STUDY



Increase Automobile Fuel Efficiency

CAD view of the experimental setup

Digital High-Speed Cameras Work to Increase Automobile Fuel Efficiency

When it comes to purchasing a new automobile today, the average consumer has never been so well informed. With the ever-rising price of gasoline being a major concern, the term "fuel efficient" has been touted and reused by every car manufacturer, whether it's for a high-performance vehicle or a commuter car. As environmentally conscious consumers, we expect low emissions, great gas mileage and high performance all at the same time. As a result, the need to create cleaner burning and more efficient engines year after year has engineers working at a pace that requires sophisticated technological solutions.

By using advanced digital high-speed imaging systems, engineers are able to refine their testing methods to a degree where they can inspect every last molecule of fuel running through a car engine. Such is the case for Prof. Christoph Brücker, an engineer and head of the Fluid Mechanics & Machines department at the nearly 250-year old University of Freiberg at the Institute of Mechanics and Fluid Dynamics in Freiberg, Germany. Along with a team of engineers, Prof. Brücker has embarked on an aggressive project to test the efficiency of internal combustion engines.

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"Our goal is to create better car engines that need less fuel to generate more power. In order to do this, we have to analyze the fluid motion inside the engines and pinpoint the velocity of the gases and liquids. That way, we can modify the way the air and fuel is being injected into the engine and possibly swap out some of the engine parts for ones that work better."

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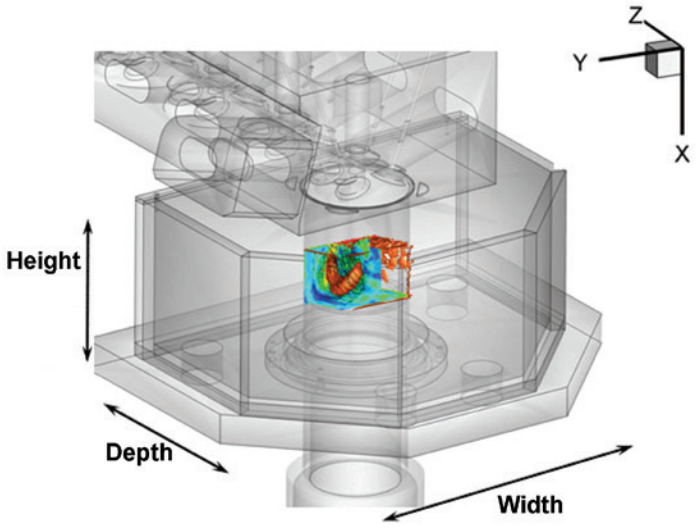
Start Your Engines

Brücker's experiment falls under the field of work referred to as fluid mechanics (or more specifically, fluid dynamics), which is the study of a mix of gases, liquids or plasmas. In engine flow, a good mixture of fuel and air is important for the efficiency and power generated in the combustion chamber. Therefore, detailed knowledge of the fluid motion in the cylinder is necessary.

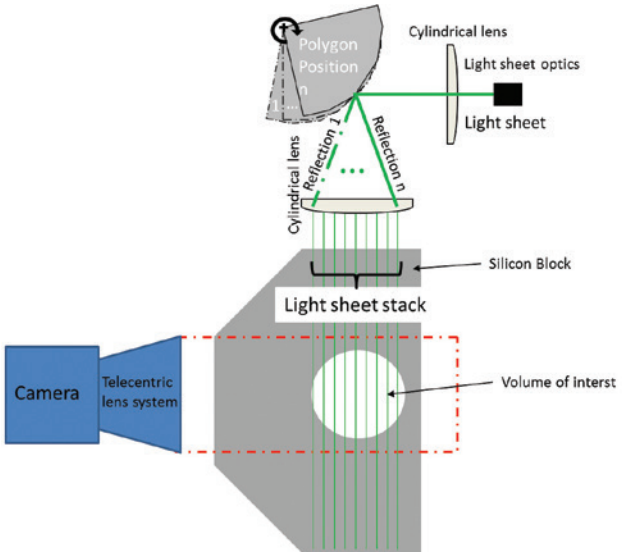


Simulated engine and cylinder internal view

The motion of a fluid refers to its velocity (speed and direction) at any point in the flow. There are several ways in which scientists and engineers measure velocity. Particle Image Velocimetry or PIV is when the fluids being studied are seeded with tracer particles. In this study, the speed and direction of the fluid elements are calculated by injecting those particles into the engine and lighting them with a laser sheet. A large amount of image planes are "scanned" by shifting the laser sheet rapidly. This technique is called Scanning PIV and allows the use of a single camera for 3D measurements, whereas normally 3 or more cameras are needed. "The idea behind PIV is to record an image sequence of the flow using this laser light technique and comparing successive images from the sequence. It's that mapping of images that illustrates the velocity of the fluids and in which direction they are moving over a certain period of time. We developed the PIV technology further, by rapidly shifting the laser light sheet to "scan" a volume (similar to X-ray computed tomography). This allows us to investigate the 3D volume and not only single planes in the flow. This Scanning-PIV technique makes a high frame rate mandatory," as explained by David Hess, an engineer in Prof. Brücker´s team.

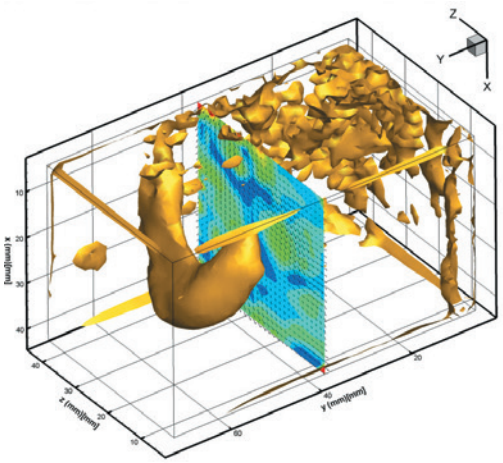
Unleashing The Phantom v1610

To begin his study of fluid dynamics, Brücker and his colleagues built internal combustion engines with special viewing windows. Then, using the Vision Research Phantom v1610 digital high-speed camera, the team was able to develop a map of images and view, record, and measure the velocity of the fluids inside the engine from that map. "A digital high-speed camera is absolutely necessary for this type of application, and it was a technology that we are very familiar with, since we had used the v12 in the past and was very impressed with its performance. So when we learned that the v1610 could acquire and save more than 16.3 gigapixels per second of data, together with exceptional light sensitivity, we immediately upgraded," Brücker said.



Schematics of the experimental setup

With the Phantom v1610, Vision Research has set an unmatched standard in the world of high-speed imaging. The camera, at the top of its class, can capture more than 16,000 frames-per-second (fps) at full resolution and up to 1,000,000 fps at reduced resolution. Thanks to these ultra-high frame rates, Brücker was able to scan the inside of the car engine by moving his laser light sheet back and forth in a quick manner, which essentially enabled him to "see" the 3D flow from the viewing windows. With the v1610 pointed perpendicular to the laser sheet, the team captured an impressive series of images that is comparable to combining 10,000 different images from a standard digital camera. "Frame rate is very important when studying the flow of fluids. There's no other way we would have been able to record this type of data, because it's impossible to actually 'see' the flow inside of an engine at such a high temporal and spatial resolution. The v1610 enabled us to map the 3D velocity field within one complete cylinder of a car engine. With the camera, we discovered the 3D nature of the flow structures and vortices. This helped us to understand the dynamics of what's happening inside the engine," Brücker explained.



3D view of processed velocity data

The powerful Phantom v1610 features a high definition and widescreen 1280 x 800 CMOS sensor, which is extremely useful when shooting an experiment with a preferred direction of movement, and is considerably faster than any other camera on the market today. Based on Vision Research's proprietary sensors,

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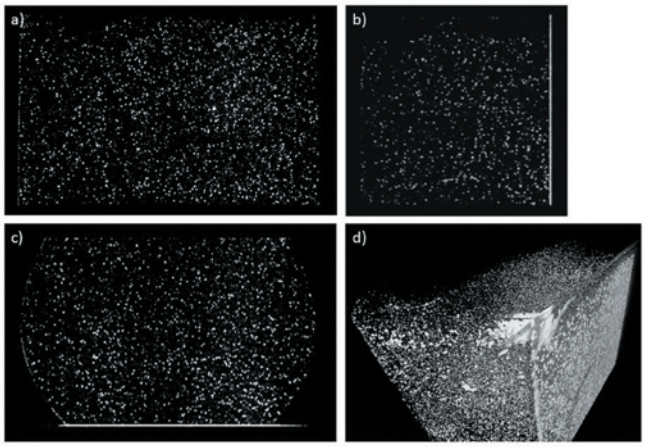

Particle images and reconstructed 3D view

the v1610 offers 28-micron pixels that allow for superior sensitivity when shooting in low light, which was an issue during Brücker's experiment. "We couldn't use a traditional lighting setup for this type of application because it would have hampered our results. The only lighting we had during testing was the light from the laser that was diffused over the sheet. But that proved to be enough, because the v1610 performed flawlessly," he said.

Additionally, the ability to store large amounts of data quickly was another key factor in Brücker's decision to use the v1610. "When you're shooting at such speeds with this high of a frame rate, you need a lot of memory and you need to be able to store your data quickly," he commented. The v1610 offers 96GB of memory that can be segmented into as many as 63 partitions and allows for continuous shooting of back-to-back shots. The camera comes equipped with Vision Research's breakthrough CineMag interface, which allowed Brücker to save his high-speed shots from camera memory to non-volatile storage in a matter of seconds.

Brücker's experiment at the Institute for Mechanics and Fluid Dynamics is ongoing, and one that he hopes will have significant impact on the fuel emissions of today's automobiles. "With the data captured with the v1610, our research team now better understands the dynamics of internal combustion engines. We hope the data we continue to capture will enable us to build cleaner, more efficient car engines that greatly benefit the environment," he said.

Phantom v1610

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