Exhaust Manifold Measurement

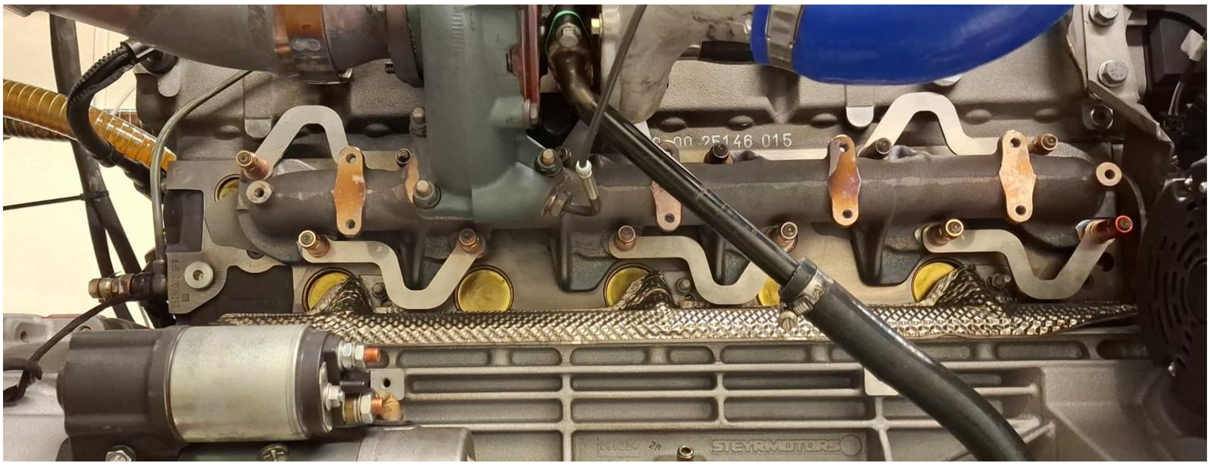
Automotive Component Testing via 3D DIC

Component testing is essential across all industries as it allows the companies to validate parts of a system before all the components are combined into a full assembly. **Understanding the behaviour** of individual components allows the product design to be optimized – effectively saving in costs. **Each component** must meet quality and performance standards before a vehicle is assembled as safety is the primary concern in automotive industry.

Objective

This case study aims to evaluate multiple values during **operational cycles of the engine**.

- Screwhead displacement at critical spots
- Surface temperature at full load
- Elongation of selected cylinders



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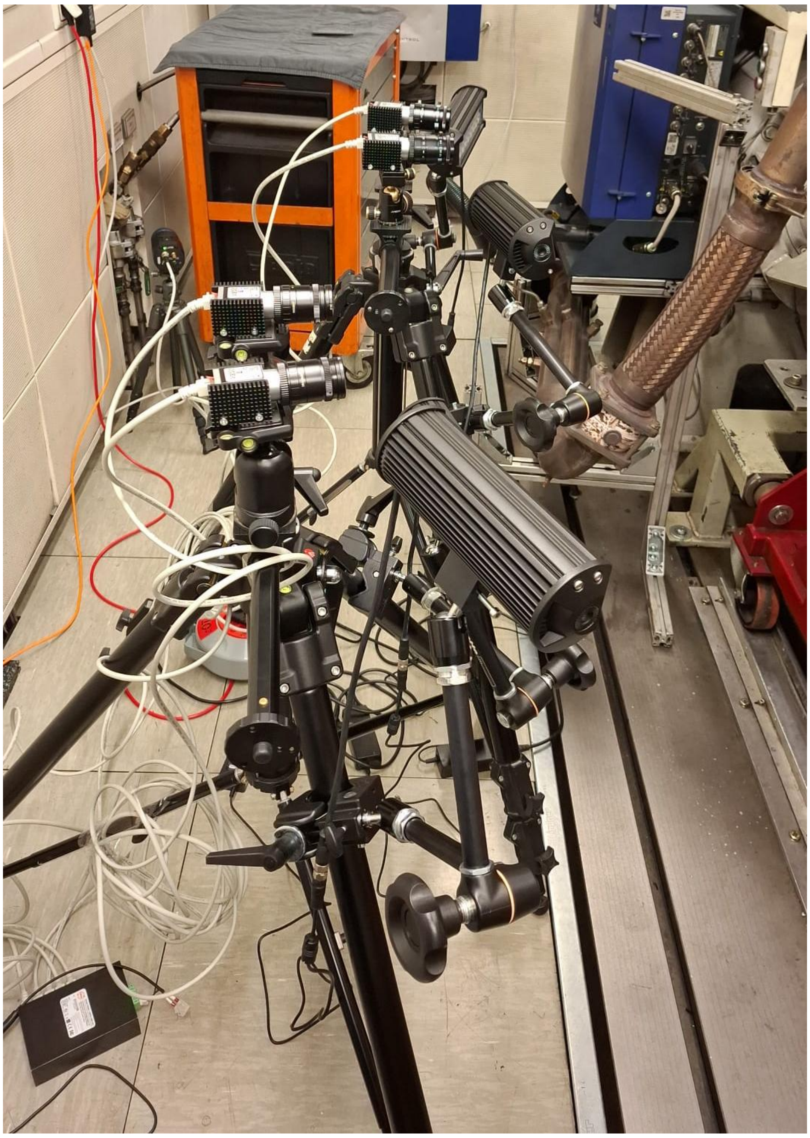
Description of the Case Study

The engine, starting at idle state, was slowly brought to full load, remained at full load for a short period and then remained in drag until next cycle.

Due to significant out-of-plane motion and size of the sample, the following 3D DIC setup was proposed:

- **3D system 1** – capturing images of the **last cylinder** of the exhaust manifold, **two 9 MP cameras** with low-distortion **35 mm lenses**
- **3D system 2** – capturing images of the **first two cylinders** of the exhaust manifold, two 9 MP cameras with low-distortion 35 mm lenses
- **2D system** – thermal camera focused on transition **between the turbocharger** and the exhaust **manifold**

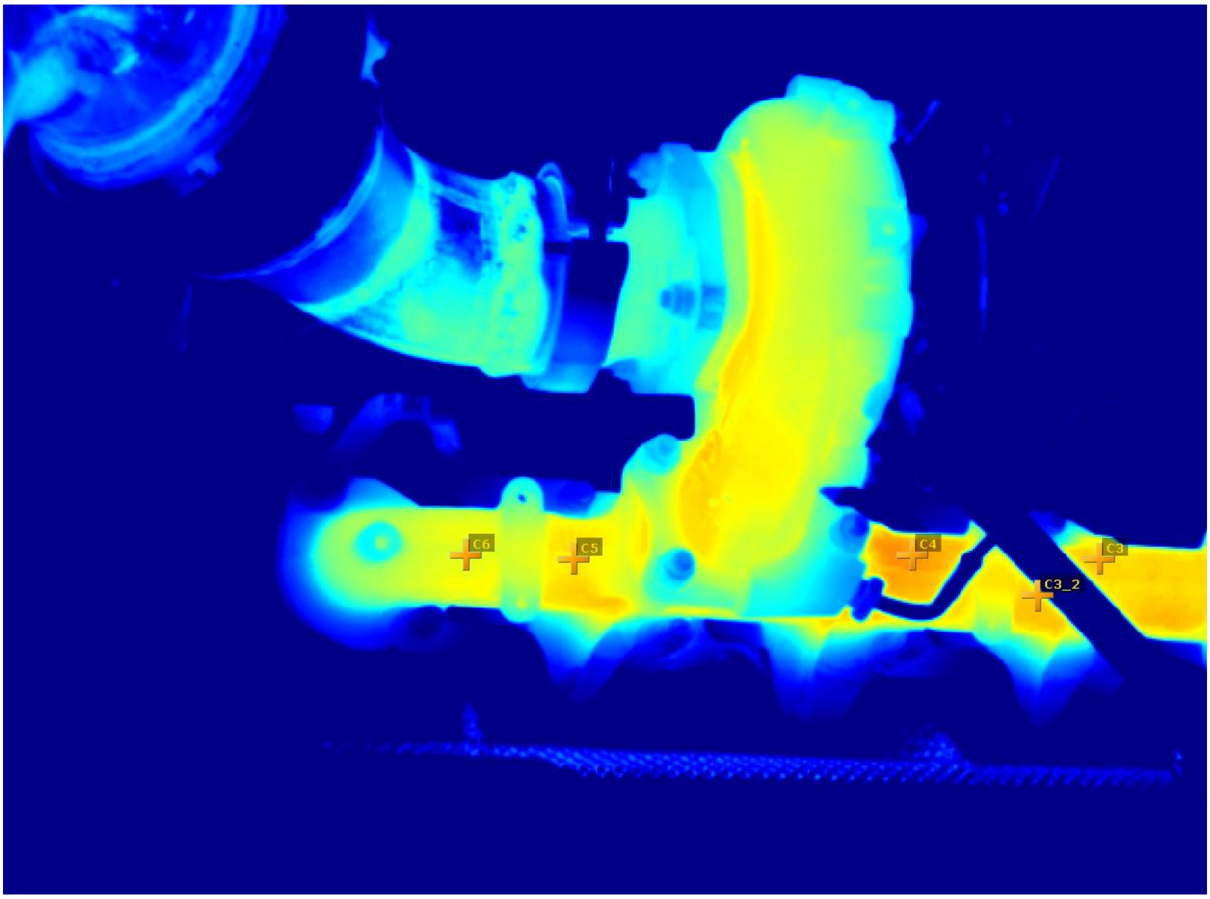


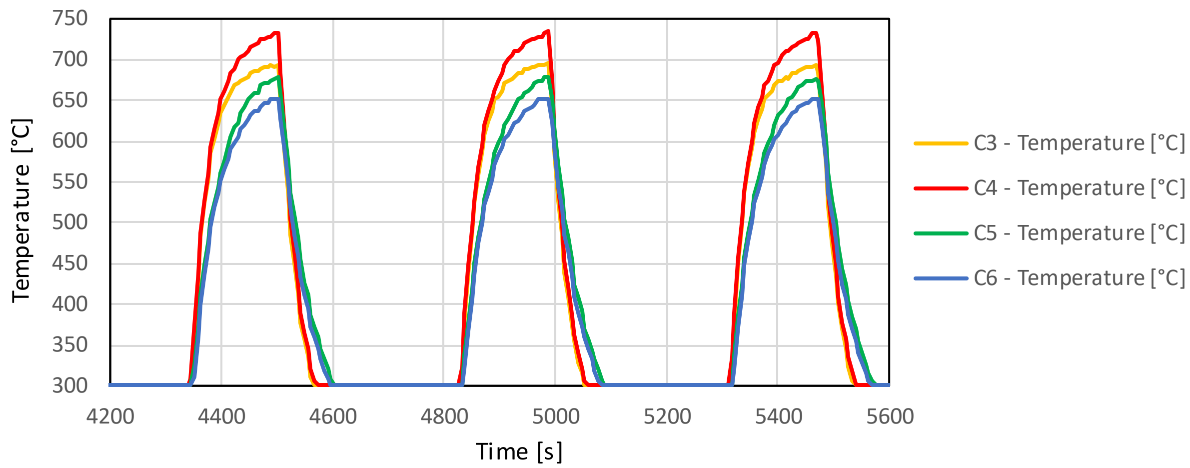
- **Hardware Synchronization –** All optical cameras were synchronized using an industrial switch and Basler's PTP technology.
- **Surface Preparation** - A speckle pattern was prepared on the exhaust manifold's surface by applying a heat-resistant white spray as the background colour and a heat-resistant black spray for the speckles.

Results

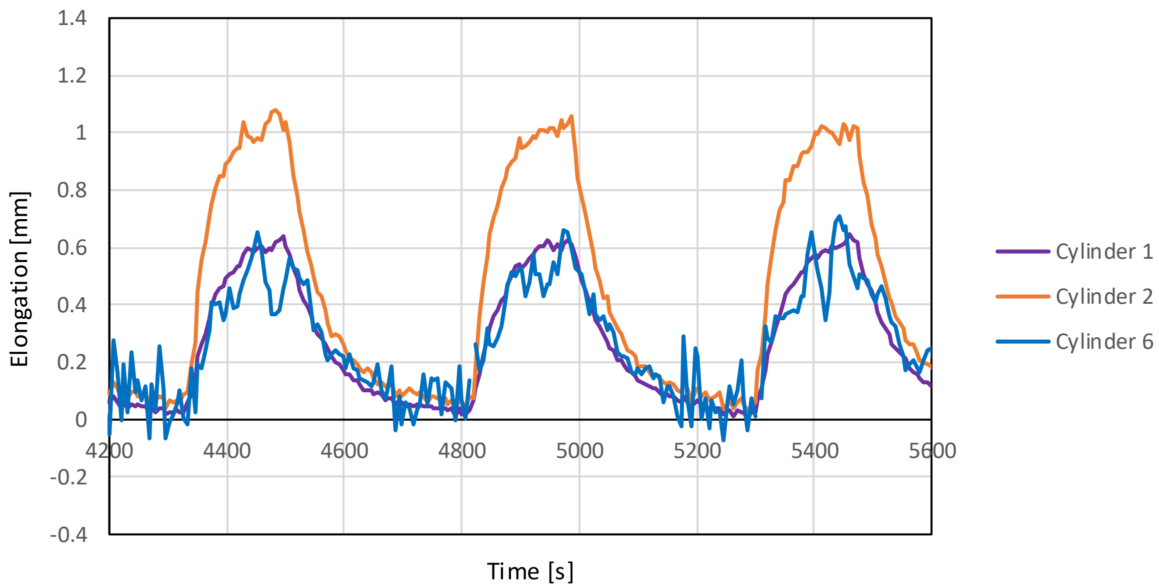
All the values were evaluated in real-time with post-processing available.

The thermal camera showed a peak temperature of about 735 °C at cylinder 4, the closest one to the turbocharger.





The elongation was evaluated for the critical cylinders.



The screwhead displacement in all axes (X, Y, Z) was evaluated. Following figure showcases displacement in X for screws captured by a single 3D system.

Advantages of Using 3D DIC in Engine Component Testing

- **Multi-System Integration:** Synchronizes optical structural data with thermal imaging cameras to track mechanical deformation and temperature simultaneously.
- **High-Temperature Resilience:** Utilizes heat-resistant surface preparation and non-contact sensors to deliver precise measurements under severe thermal stress up to 735 °C.

- **Real-Time Evaluation:** Computes displacement, strain, and thermal variations live during engine cycles, enabling immediate validation.

Conclusion

This case study showcases how Mercury RT was used to capture 3D displacement of screwheads during full-load engine cycles, temperature data and elongation all at the same time. A reliable, accurate tool for component testing is essential in automotive industry.