Cambridge Viscosity Supplies Ultra-High-Pressure ViscoLab PVT+ Viscometer Engineered for 100,000 psi Operating Conditions

APPLICATION

Measurement of lubricant mixtures used in ultra-high-pressure applications like compressors and engines

OVERVIEW

It's common knowledge that oil lubrication is one of the most critical components when it comes to equipment with rotating and moving parts. Lubricants reduce friction, maintain proper operating temperature, and minimize breakdown between internal parts. To meet these requirements, an understanding of how the lubricants behave under varying temperatures and pressures is needed.

Ultra High Pressure ViscoLab PVT+ System Overview

- **Viscosity Measurement:** 0.1cP to 5cP, 1cP to 50cP, 10cP to 500cP, 100-5000cP 200cP to 10,000cP, 400cP to 20,000cP
- **Operating Pressure:** 100,000 psi maximum
- **Maximum System Operating Temperature:** 190°C
- **Temperature Control:** ±0.2°C using a sample conditioning system

CHALLENGE

Lube oil is the life blood that keeps mechanical parts moving. Understanding how it performs under actual operating conditions eliminates unexpected premature failures resulting in untimely and costly equipment downtime. This applies to engines and compressors used in a number of industries, including power generation, automotive, refrigeration, and hydrocarbon production, just to name a few.

Many people don't realize the level of advanced technology that goes into the development of these lubricants. Viscosity is arguably the most important variable when considering its performance. A thicker lubricant is more effective in reducing friction between moving parts. However, a high-viscosity lubricant also means that a machine must work harder and use more energy—which will reduce its fuel efficiency. Conversely, a thinner lubricant may not provide sufficient protection from wear, resulting in premature failure, as it cannot apply enough lubrication between the moving parts.

Cambridge Viscosity's viscometers offer customers the competitive edge to ensure lubricants are precisely the right viscosity when being used under extreme conditions in critical applications.

The automotive industry is always trying to use lower viscosity lube oils to achieve their goals of higher fuel efficiencies while providing optimum lubricity to ensure long engine life for the vehicle. These applications can be severe—high-pressure and friction applications which are typically found in high-performance engines.

To meet these needs, lubricating oil manufacturers need to prove how their product performs under these extreme operating conditions. This requires PVT data—pressure, viscosity, temperature—to completely understand how the viscosity of the lubricant performs under these varying operating conditions.

Engine manufacturers globally are striving to reduce carbon emissions by increasing fuel efficiency. Today's car engines often use lower viscosity engine oils to help with this. Research is conducted to identify friction modifiers in nanoscale gaps between solid surfaces at the molecular level to reduce contact between metals. New formulations are tested to create higher performing lubricating oils that improve functionality, add value, and support carbon-neutral initiatives. Good examples of these high-pressure applications include diesel and turbo-charged engines.

THE SOLUTION—DEVELOPING AN ULTRA-HIGH-PRESSURE VISCOMETER

Cambridge Viscosity's innovative ViscoLab PVT+ system is the industry standard for obtaining this data in a variety of industries, including lubricants, upstream petroleum, and specialty chemicals. CVI was approached by a global leader specializing in advanced lubricants for a project requiring measurements exceeding our standard high-pressure system rated to 20,000 psi. This customer contracted CVI to develop a viscometer that would measure up to 100,000 psi to understand how their specialty lubricants would perform under these pressures for engine bearing analysis. This innovation would allow them to characterize their lubrication performance under high-performance conditions up to 100,000 psi, more than five times our standard system capability.

The ViscoLab PVT+ helps the end user understand how lubricants will perform under extremely high pressures.

Our engineering team partnered with expertise from Harwood Engineering, High-Pressure Equipment Company (HiP), and Omega Engineering to provide a solution to our customer. The entire team worked together on this project for more than a year, working to perfect the system.

THE SYSTEM

CVI's relationship with this customer began more than a decade ago, when they asked us to build a system to 43,000 psi. At the time, we hadn't built a system beyond our normal specification of 20,000 psi, so we built two sensors, even though the customer only needed one. Because the first one worked so well, we ended up keeping the second. When the customer came back with the request for a system that could perform at 100,000 psi, we used that second sensor as a starting point for engineering their latest request.

Cambridge Viscosity's ultra-high-pressure ViscoLab PVT+ system mounted on a customer's benchtop

Building a viscometer to withstand 100,000 psi required specialized engineering. Our first consideration was material construction. Our standard sensor needed to be re-engineered in order for it to handle the 100,000 psi rating. We needed physically different dimensions to make the wall thickness bigger, allowing it to handle higher pressure. The pistons were made to be much smaller, and we re-designed the inlet tube, which is the interface between the sensor and other system components. We solution annealed and had to heat treat the entire sensor through a special process to make the metal much stronger and increase the burst strength. The inlet tube was also heat treated to handle the extra pressure. The material as-is had a burst strength of 128,000 psi. After the heat treatment, it had a burst strength of 192,000 psi.

Safety was our primary concern. During the engineering process, the Cambridge engineering team worked with our partners to initiate several rounds of quality testing. They underwent several rounds of improvements, until we were easily able to achieve 125,000 psi testing without any deformation of the measurement chamber.

The end user required both analog and digital gauges to ensure safety.

We also incorporated a burst disk from HiP. A burst disk is thin metal in the shape of a cone that is set to hold pressure to 95,000 psi (+/- 5%). If the system becomes over-pressurized, the burst disk will let the pressure out in a safe manner. In addition to the burst disk, HiP also supplied CVI with the pressure generator, all the tubing, custom valves, fittings, and a 100,000 psi analog gauge. We normally don't use both an analog and digital gauge, but the customer requested both to further support safe practices.

The system also included a sample conditioning system to introduce a sample into the viscometer, control its temperature, and monitor the sample's pressure.

CONCLUSION

CVI delivered the system to our client and, with the help of our distributor, Japan Controls Company (JCC), conducted startup services and training to their R&D development engineers. Our solution has provided them with an understanding of their lube oil performance under extreme conditions to qualify their lubricants operation under these high pressures, giving them a real competition edge to provide superior products with higher specifications to their customers.