Improving Bottom Line Profits with Real-Time Viscosity Monitoring of Asphalts

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There are more than 700 refineries worldwide with a capacity for 82 million barrels of oil per day operating in almost every country in the world. Of these, 137 operate in the United States with an estimated capacity of 17 million barrels of crude oil per day.[1]Demand for energy continues to rise along with pressures on producers to streamline and speed production, increase yield, and operate more efficiently.

A typical barrel of crude yields 50% gasoline, 15% fuel oil, 12% jet fuel, and so on through diesel, asphalt, lubrication oil, and other refined products. However, actual output varies dramatically by refinery. Viscosity is one on the most critical measures of product quality for virtually every refinery product. New developments in viscosity measurement enable refineries to significantly improve production quality, cost, and output.

Quality control in modern asphalt production can be a challenging proposition. Refiners often produce products requiring varying grades and viscosity levels, and the quality of source material—crude oil—can vary vastly depending upon the supplier.

Asphalt

Asphalt is critical for road paving. Roads are subject to radically different environments throughout the world, and throughout the year. Asphalt must be suitable for those local conditions. All customers have asphalt pavement specs that are suitable for their region.

The raw material for making asphalt is basically what is left in the bottom of the barrel of crude oil when all higher value materials have been extracted and refined. That material can be very non-homogenous, and can vary radically in make-up from barrel to barrel depending on the source of the crude. Variations in refinery process conditions can also have an impact.

Refineries utilize in-line measurements to enhance production consistency. Three technologies are commonly used for in-line viscosity measurements: capillary, vibrational and oscillating piston. All require conditioning of the fluid being tested so that it is as consistent as the lab samples are in terms of temperature, flow, and particles. The oscillating-piston technology is preferred for its accuracy, reliability and ease of installation. Capillary systems require high precision pumps for accuracy, which need frequent and costly maintenance and recalibration. Vibrational-based viscometers can cause resonance frequencies in fluids which result in inaccurate measurements; they are also subject to process equipment vibrations which also can cause incorrect analysis.

Controlling viscosity is the key to producing consistent, high quality asphalt. However, lab sampling data often times does not correlate with product run results, making it difficult to accurately monitor viscosity and adjust for fluctuations. To address this issue, a Brazilian refinery implemented an in-line viscosity control system featuring the oscillating-piston technology to better measure asphalt viscosity and achieve higher product quality.

The Challenge

The viscosity and density of in-process asphalt can vary significantly during processing. This is due to fluctuations in raw material characteristics and manufacturing processes. Historically, engineers have controlled the process by periodically sampling the in-process material, testing the samples, and adjusting the process control factors to compensate for any variances.

This method would work fine if the characteristics of in-process material were consistent. Unfortunately, they are not, and as a result, periodic laboratory results are often not representative of the asphalt material being produced as a whole.

In the case of the Brazilian refinery, the company manufactures many different grades of asphalt, including AC-5 asphalt with a viscosity of 500 cP, so it is important for the refinery to produce asphalt as close to the targeted spec as possible. Each grade requires a different viscosity level and needs to be closely controlled.

The company was experiencing inconsistent results when measuring lab samples and comparing them to process samples. Lab samples hardly ever match up with process samples due to the variances in the fluids. When a sample is taken to the lab, it may not be fully representative of the line fluid; it loses volatiles, flow characteristics differ, and it needs to be heated again; thereby changing the characteristics of the fluid.

Asphalt Viscosity Control with Real-time Density

In order to better understand this problem, the refinery equipped an asphalt processing line with

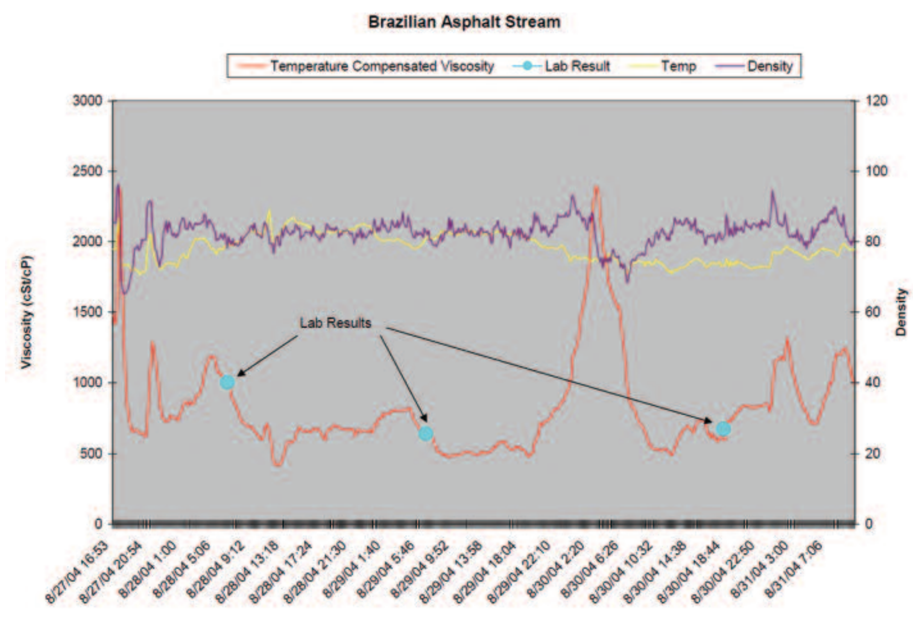

Figure 1: Comparison with traditional lab and in-line measurements

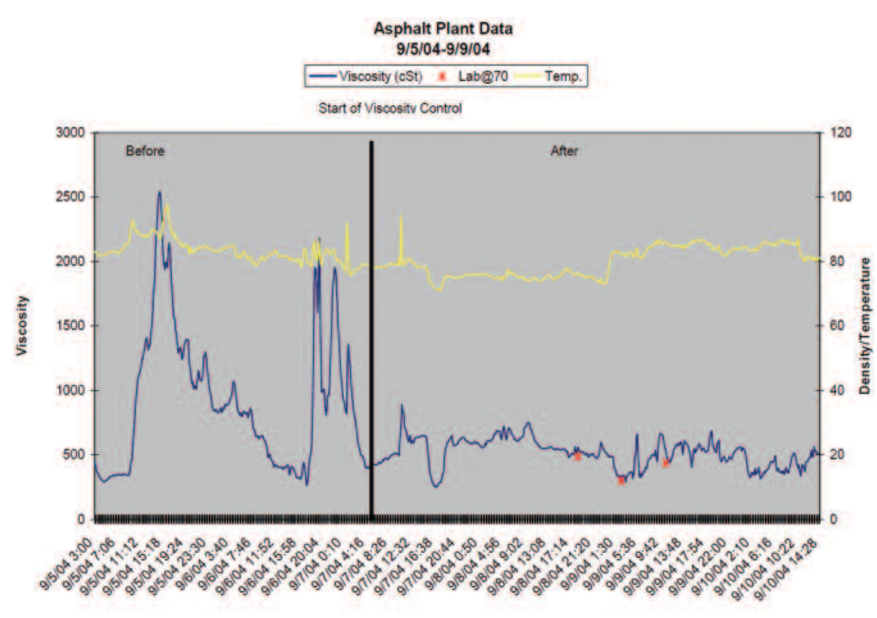

Figure 2: Fluctuations in Asphalt Viscosity before and after implementing In-Line Viscosity Control

a new in-line instrument from Cambridge Viscosity to measure viscosity and temperature in real time. They then compared the in-line measurements with periodic lab testing of process samples. Results from this effort are shown in Figure 1.

This figure shows precise agreement between the characteristics of the in-process material at the time the lab samples were taken, between the traditional off-line lab instruments and the new in-line viscometer. The continuous in-process measurements also showed that between the samples taken for the laboratory tests the in-process material showed significant variation. The plant engineers felt the variation shown in the continuous in-line measurements could explain the inconsistencies in the end product that the line was experiencing.

The plant engineers decided to test this concept by using the new in-line viscometer to automatically control the kinematic viscosity of the in-process material. The results are shown in Figure 2.

This figure displays process data for the two days prior to implementing in-line viscosity control with the Cambridge viscometer and three days afterward. Figure 2 illustrates that the viscosity results fluctuated a great deal prior to implementation of the in-line analyzer. The figure also shows that using the in-line viscometer enabled much tighter viscosity control in the process and a continuing close correlation between the results of the periodic laboratory tests with associated in-line results.

Consistent Data and Cost Savings

By using the new in-line viscosity management system, the refinery was able to achieve continuous sample measurement with no missed data points and spot-on correlation with lab results. While the control parameters for the Cambridge viscometer were not optimized for the characteristics of the specific plant process environment, the plant was able to:

• Reduce product variation by 90%

• Realize significant cost savings by reducing diluent use to achieve targeted specifications

• Reduce tankage requirements and associated capital and maintenance costs

• Increase throughput with less investment in inventory and capital equipment

By reducing product variation, it allowed the refinery to attain the targeted product specs with minimal post-process blending. Reducing product variation also limited the amount of "excess tankage," or extra material that previously was being inventoried in blending tanks. Less inventory in the blending tanks translated into less diluent that was required to be blended to achieve the targeted product specs; all of which ultimately results in a reduced operating cost and a higher throughput. "By producing the mixture to spec in the first batch, it prevents re-work, allowing a great cost and time savings by the refinery," explains Cambridge Viscosity Regional Sales Manager, Jonathan Cole.

When a refinery delivers the final product to its end-user, the refinery supplies certified documentation proving that the asphalt meets proper specification. The documentation will state that the product has been tested, what the mixture breakdown is, what was used as a diluent (usually diesel), and ensure that the final product meets ASTM criteria.

"Customer specs are based on international standard test methods that utilize standard laboratory test equipment. These lab tests are done periodically throughout production, and the process is adjusted based on the test results. The material is then tested in the storage tank, and re-blended to meet the exact customer specifications. Unfortunately, the asphalt characteristics can vary significantly between lab tests. This can require significant post-process blending to meet customer specifications, "states Mr. Cole.

Figure 3: ViscoPro2000, an In-line Cambridge Viscometer

Sensor Technology

Cambridge viscometers are fundamentally simple, rugged, accurate and repeatable, even when used in operating environments with significant vibration (See Figure 3). A key to the company's technology is its use of a single, non-contact moving part both to clean and measure. The motion of the piston is controlled so that it monitors the fluid viscosity and keeps the sensor's measurement chamber clean, so that the sensor requires minimum operator attention. A temperature detector is also included in the measurement chamber so that both temperature and viscosity are known for every measurement. The company's patented self-cleaning and self-recovery characteristic enable the sensors to operate trouble-free in-line.

Cambridge viscometers use proprietary electromagnetic technology to analyze the piston's travel time to measure absolute viscosity and monitor temperature. With all wetted parts stainless steel, the constant motion of the piston keeps the measurement sample fresh while mechanically scrubbing the measurement chamber. Cambridge Viscosity, which is part of the PAC team, has more than 10,000 sensors installed worldwide in many applications where viscosity knowledge and management is critical. A schematic of the operating characteristics of a typical Cambridge viscometer sensor is shown in Figure 4.

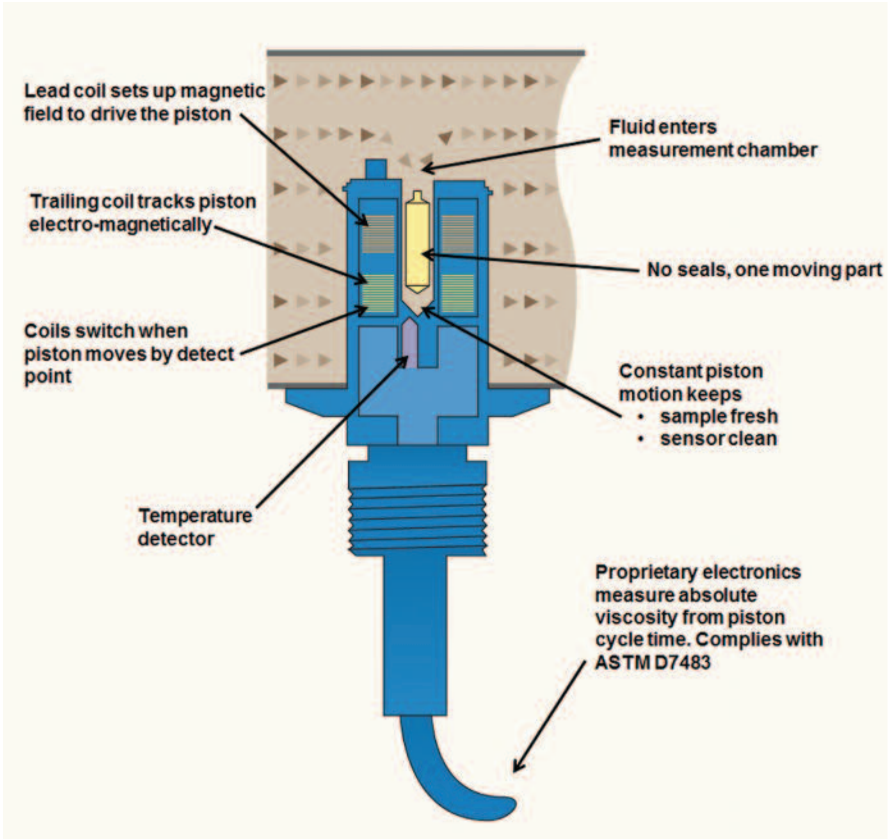

Figure 4: A Schematic of a Cambridge sensor operating in-line

Resources

1. International Petroleum Encyclopedia 2004 . Tulsa, OK: PennWell Corporation, p. 286., Oil and Gas Production - Oil Refining. International Labour Organization. http://www.ilo.org/public/english/dialogue/sector/sectors/oilgas.htm

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