



Figure 1. Refinery output blending.

Optimising blending operations

Julie Valentine, Emerson Process Management, USA, explains how the latest highly accurate flow measurement systems can improve blending operations and plant profitability in both refineries and oil blending operations.

Blending systems in the hydrocarbon industry have used the benefits of Coriolis flowmeters to improve plant output and overall blending performance. Experience has led to the adoption of online/inline blending systems, where Coriolis meters provide the accuracy and versatility needed to meet required specifications. Furthermore, Coriolis meters have shown that they do not require the frequent proving and maintenance attention that is required for mechanical flowmeters.

By using wide turndown and accurate flowmeters, such as the Micro Motion Coriolis meter from Emerson Process Management, increased versatility is available to meet the varied modern specification requirements. In addition, using the accuracy now available from Coriolis meters, $\pm 0.1\%$ of flow rate, advanced process control and information systems enable blend optimisation software to maximise plant performance while retaining the output blend within the required specification.

Flow based blending systems

The improvements possible in moving to a flow based blending system can be illustrated by the application of Micro Motion Coriolis meters at the UK blending plant operated by D A Stuart Ltd, a worldwide leader in the production of superbly engineered lubricants, additives and in-process and production cleaning products. Faced with the task of consolidating

the work of two UK blending facilities onto one site, the objective was to improve the efficiency of the delivery and blending operations in order to increase this single site output by 400%.

Previously, sequential measurement of blend components into a mixing tank was used, where the mixture was controlled by load cell measurement of each addition in the tank. By using flow measurement based systems, the possibility of



Figure 2. Measuring lubrication oil flows for in tank blending.



Figure 3. The Micro Motion ELITE family of flow sensors.

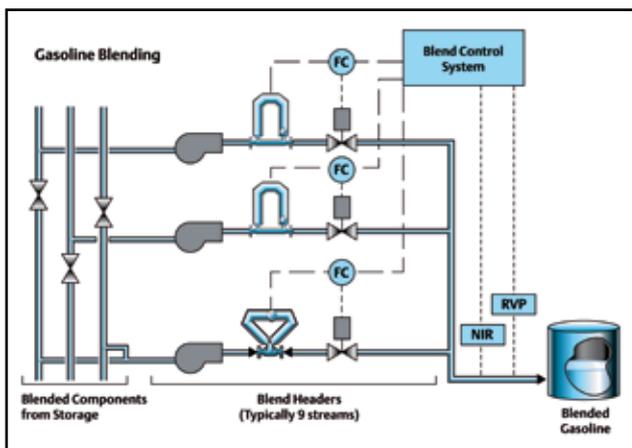


Figure 4. Schematic of a plant blending facility.



Figure 5. Dual stream blending skid for fuel oil loading.

simultaneous delivery of the components into the mixing or delivery tank improves efficiency.

The main area for efficiency and throughput improvement was in the handling and delivery of the various oils and additives to the blending tanks. The system adopted introduced 17 separate supply lines, each dedicated to one oil type, with the batch quantity required for each blend being called up via a PLC based system. Each line is equipped with a Micro Motion Coriolis mass flowmeter, which measures the correct mass of that oil required for the blend (Figure 2). Meter sizes range 0.75 - 2 in. depending on the capacity needed. For higher viscosity oils the lines are heat traced and lagged, which includes the flowmeter bodies.

The inline mass flow metering approach allows delivery of several streams simultaneously. The system increased the

production capacity available, but also improved the operator interface and provided increased flexibility. Using the Micro Motion Coriolis meters, the overall system accuracy and long term batch consistency has been measured to be within $\pm 0.5\%$.

Similar production capacity increases required at a refinery in the Southwestern USA had resulted in the company upgrading its reformulated gasoline blending facility from a sequential blender to an inline blender. The old sequential system of blending required a lot of time to complete the blend and required many adjustments before it would meet specification. It was especially difficult to blend the butane accurately.

The incentives behind the upgrade were to be able to blend more grades and double the blending rates without increasing tankage. With a more accurate system in place, the objective was that the blend would be on spec as it was filling the tank and could be moved out faster.

The refinery chose Micro Motion ELITE Coriolis meters over turbine meters for accuracy, turndown and low maintenance (Figure 3). These meters are exceptionally accurate, at $\pm 0.10\%$ of rate, and they maintain their accuracy throughout their life in these applications.

Versatility and benefits found onsite

Since Micro Motion meters have no moving parts, they are inherently reliable and maintenance free. The refiner mentioned that during startup of the new blending system, there were inadvertent slugs of air and water. Past experience with turbine flowmeters in this situation is that the blades would have been severely damaged during this startup, but the Micro Motion Coriolis meters came through unscathed.

Meter turndown is another issue where a comparison with turbine meters can be made. In the past, refiners had to create approximately 12 different gasoline blends. Now, with the implementation of new EPA regulations, this has been increased to approximately 24 different blends, and regulations are expected to change again. Flexibility is a key feature in terms of equipment and instrumentation, with equipment needed that is able to accommodate wide performance ranges. The refiner did not want to be limited by the metering system turndown capability. Turbine meters were capable of only a 10:1 turndown, whereas even at a turndown of 25:1, the Micro Motion ELITE meters still achieve accuracies of $\pm 0.1\%$ of rate.

Another feature that gives the Coriolis blending system additional flexibility is that several fluids can be measured through the same Micro Motion meter, without any meter recalibration. Since startup, the Micro Motion meters have not required calibration or maintenance of any kind, whereas it is important to have regular prover calibration of turbine meters to monitor changes to bearing performance in the fluids being monitored.

The high accuracy density measurement from the Coriolis meter was an extra feature that the refinery discovered to be of particular value. The density accuracy for all the meters used in this project is ± 0.0005 g/cc. The refiner has set up tight gravity ranges in the DCS for each component, with an alarm to notify operators of any deviations. This is valuable for several reasons. Many of the blend component pipe headers are cross-connected on the suction side of the blending pumps. The density reading is used as a good indication of any cross-contamination. The operator can also see when streams are changing, such as when stratification of the tanks occurs. In addition, some fluid properties can be inferred from the density.

A schematic of the system is shown in Figure 4. An NIR analyser is used for octane and composition analyses, and an

RVP analyser is used for vapour pressure to monitor the quality of the blends online. According to the refiner operations engineer, the blend is consistently and accurately conforming to the correct specifications.

Blending directly into a pipeline

Having established the benefits of flow measurement in controlling blending systems, the next step is to use the output from flowmeters to directly control the blending of hydrocarbon mixtures into the delivery pipeline. This eliminates the final product holding tank, where the QA systems can sample or monitor the mixtures intended for delivery, for a final check before dispatch.

Various simple dual stream blenders have been produced by Emerson Process Management, as skid mounted systems. One typical system (Figure 5) was developed for mixing and metering fuel oil loading to ships, for use at a bunkering facility in Turkey. In this system, separate streams of diesel oil and 70cS fuel oil are measured using Micro Motion ELITE Coriolis meters, which supply the measurements to a DeltaV control system. The ratio of the two flow rates is compared with that required, and adjustments made to two Fisher V150B control valves, 4 and 6 in. in size. The two streams are joined in a static mixer, just before delivery to the ship. In this system the DeltaV system monitors the whole delivery, and at the end of the batch delivers a 'Bill of Lading' to state the quantity of each type of oil delivered: the invoice is based on this document.

A more sophisticated system is in use at the LBC Tank Terminals facility in Antwerp, a major tank farm in Belgium where Micro Motion Coriolis meters have been used for many years for blending oils supplied to tankers for onward delivery. The tank farm can supply blends of various oils to ships and road/rail tankers, from the stock of different hydrocarbons, chemicals, mineral and vegetable oils and additives, using various sizes of Coriolis meter from Micro Motion. (Figure 6). ELITE meters are used, up to the CMF400 unit, which can deliver 545 000 kg/hr, and then for the largest flows a Micro Motion D600 unit delivers up to 1 578 000 kg/hr: this is used to measure bulk flows into 12 in. flexible hose delivery lines. A sophisticated control system uses the HART and RS485 digital communications available from the Micro Motion transmitters, to ensure fast and efficient communication and control.

Refinery output inline blending

A large US refinery had developed a system of using flowmeters to blend gasoline components directly into a pipeline. Their original system used turbine flowmeters to measure the different components: it was necessary to prove each meter every other month to keep the blends within specification. The cost of this was not inconsiderable: the standard rate for proving a flowmeter using either a compact or standard ball prover was approximately US\$ 500. Proving nine flowmeters every other month produced an annual spend for proving of approximately US\$ 27 000.

The need for accurate flowmeters is critical in this case, because there is no opportunity to adjust the blends before shipment. During revamping of the blending unit and control system, it was decided to replace the turbine meters with Micro Motion Coriolis meters (Figure 7). The main incentive for this change was the reduction in the required calibration and maintenance costs. Micro Motion meters typically have no shift in calibration with time; there is nothing that wears in a Coriolis meter in this form of application. An initial onsite proving was requested by



Figure 6. Micro Motion Elite meters of various sizes in use at LBC Tank Terminals in Antwerp.



Figure 7. A gasoline blending system in California.

the pipeline company, but from then on the meters were in service for over a year without requiring a second proving.

With the historic use of turbine meters on this application, the customer had developed a system using the volumetric measurements, which were then corrected by pressure and temperature measurements on the streams. These used a mathematical relationship based on the assumed expansion coefficients of the various fractions, to enable production of a standard blend by volume, after compensation for environmental conditions. With the Micro Motion Coriolis flowmeters, while a volume flow measurement is available, the customer was aware that the mass flow readings would allow a simpler system for accurate blending, using mass, and saw this as a desirable route for the future. Currently, however, the commercial requirement for the product delivery is structured using a volume blend, so this is still in operation.

Blending optimisation

Using the advanced process control and information systems now available to the hydrocarbon processing industry allows refinery managers to adjust the blend used in gasoline (petrol) to make use of the fractions available from production and choose the blend which will produce the required specification at the lowest cost, while also managing inventory levels. For example, under certain cost conditions, by adjusting the relative proportions of reformate against alkylate, the resulting blend of standard unleaded gasoline/petrol can be reduced in cost. The Blend Optimiser calculates the optimum recipe to maximise profit and manage inventory levels for a particular grade of gasoline while satisfying all property specifications.

A study to evaluate the effects of improved flow measurement on the profitability of gasoline blending was performed in conjunction with one of the world leaders in such blend optimisation techniques. The study showed that any

error in measurement drives the actual blend recipe away from the proposed optimum recipe. The study also indicated that errors as small as 0.3% in the blend accuracy, caused by the flowmeter providing the blend information, can substantially decrease profitability. Micro Motion ELITE Coriolis flowmeters are typically accurate to 0.1% of reading, whereas turbine or mechanical type meters averaged performance might result in an averaged accuracy over lifetime of 0.4%, so that this 0.3% figure was chosen as a possible performance difference.

Using pricing for the components and finished products based on published Gulf Coast prices at the time (approximately US\$ 25/bbl), and with a 0.3% flow error from 'poor' flow measurement, it was established that the optimiser will seek a new 'optimum' setting that is always less profitable than the original optimum. The reduction in profitability from these small measurement errors ranged 0.02 - 0.65 ¢/bbl. For a blending operation that produces 100 000 bpd, this lack of accuracy would result in a reduction of plant profitability of US\$ 7000 - 200 000/yr.

Conclusion

The use of Micro Motion Coriolis meters in an oil or gasoline/petrol blending operation provides many benefits to the hydrocarbon processing and supply industry:

- The accuracy available from Coriolis flowmeters, especially maintained over time, prevents the need for rebends or adjustments to the blend, allowing the refiner to move products out of the plant faster. Plant

resources, such as mixing tanks, can be used more effectively because of the parallel addition of the required components. The mixing process can even be amended to blend the components directly into the delivery line to avoid the use of any mixing tanks.

- Maintenance costs with Coriolis flowmeters are significantly reduced compared with other flow measurement techniques: Coriolis meters eliminate the need for meter proving onsite, with associated costs and downtime, and avoid the cost and time to fit replacement parts into mechanical meters due to wear or damage.
- The flexibility of the blending systems that use Micro Motion meters is increased because of the wide turn-down available and the independence of the measurement from changes in fluid properties. This allows versatility in operation of the blending system, with a fast reaction possible to changes in market requirements or new product blend opportunities.
- The increased accuracy available from modern Coriolis meters can improve the performance of blend optimisation systems, allowing their more effective use in maximising profits from production.
- In terms of potential quality control benefits, with simultaneous flow and online density measurement available from a Coriolis meter, the plant operations management is provided with a separate indication of any change to the fluid component or blend properties that might warrant attention.

With all the new and continuously evolving regulations challenging refiners, all of these factors become important in maximising profitability. ■