White Paper

MEETING TIGHT QUALITY SPECIFICATIONS IN PRODUCT BLENDING WITH MICRO MOTION

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EMERSON
Process Management

Figure 1.

Introduction

The current blending business climate forces the refining industry to manage increasingly tighter specifications with more components to blend, making it challenging to meet blending production plans cost-effectively. Product blending has increased in complexity over the last several years as new specifications for sulfur levels, ethanol content, volatility, and additive requirements have all changed. Blend optimizers are increasingly complex as they must consider multiple objective functions of inventory and profitability, while managing multiple linear and non-linear properties including volatility, octane, sulfur and oxygen content. As a result, blending control performance, including flow measurement and control is increasingly critical to meet blend specifications in the most cost-effective and efficient manner.

The number of different grades of gasoline that a refiner can blend has increased exponentially. Regions at higher altitudes have different specifications than at sea level due to the effect on vapor pressure. Other parts of the world have additional requirements. There are regular, premium, and mid grades, conventional and reformulated. There are over 100 distinct recipes of gasoline produced in some refineries.

Meeting octane and volatility specifications are the first level of meeting blend objectives. Various reports show that typically 15% of the blends are off-spec and must be re-blended and that another 15% are in spec, but touched up to minimize quality giveaway. When the blend specification is met through touch up, it is highly likely that the final blend recipe is far different than the optimum recipe.

Meeting the new gasoline sulfur levels of 10 ppm in the final product exiting the refinery is challenging and there are a number of considerations in setting the target sulfur level at the blend header. Contamination from downstream piping needs to be budgeted for. Consideration should be taken as to where and how the blended product will be piped and stored before reaching the final point of sale at the terminals or refinery gate.

In many parts of the world, gasoline blending at the refinery is done to produce blendstocks for oxygen blending (BOB's). Ethanol and other oxygenates, as well as other additives, are then blended at the terminal. Everything that is blended at the terminal affects the final product volatility, octane, and sulfur levels. The addition of these components at the terminal then needs to be planned for in the optimizer at the refinery blender. Any deviations from the planned blend recipe will affect the allowable ethanol content, and again due to the non-linear nature of the octane and volatility specifications could impact the final product quality.

Additives to both gasoline and diesel are increasingly important and costly. Many of these additives are dosed on a mass basis, or in grams/liter. Chemicals such as anti-static, and corrosion and rust inhibitors for gasoline are critical to the performance and quality of the product. For diesel, the additives for cetane enhancement and pour point depressant are costly, so accurate injection and measurement systems are critical.

Effects of Measurement Uncertainty

Refiners have long recognized the importance of reducing the uncertainty in blend measurement, but now with increasing government regulations and tighter specifications, precision is more important than ever. Inaccurate flow and density measurement can result in products that don't meet specifications, so they need to be downgraded or require reblending which costs time and money.

Blending is done by ratio control of the components. When traditional volumetric measurement is used for this ratio control, temperature and density correction must be done to reduce the uncertainty. Target volumes for each component may not be met if flow meters lose their accuracy due to two-phase flow or entrained vapor in the line, or mechanical wear over time, often resulting in a missed specification.

Traditionally, refiners have used turbine meters to achieve this level of accuracy in gasoline blending; however, Coriolis flow meters have emerged as a better way to get accuracy and reliability. Figure 2 shows a schematic drawing of a typical blender utilizing Micro Motion Coriolis technology.

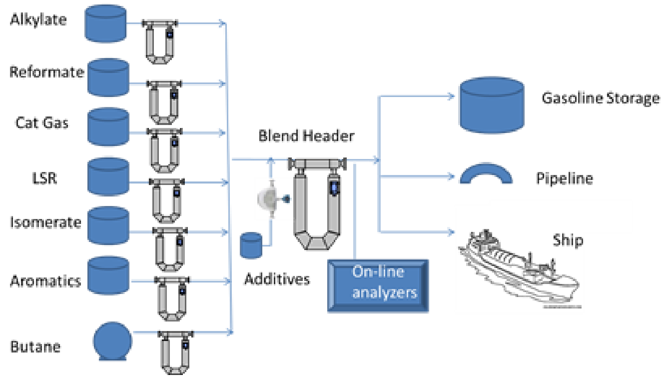

Figure 2. Typical Refinery Gasoline Blending System

Results of loop audits show that in many cases there are mechanical problems with the turbine flow meters. Turbine meters require regular maintenance and calibration to avoid uncertainty in the measurement. Turbine meters are very sensitive to two-phase flow caused by vapor in the line, which is a common problem, especially at the start of a batch. Two-phase flow can cause overspinning and damage to the turbine blades.

New advances in Micro Motion® Coriolis technology with respect to entrained gas help to increase the reliability of the measurement under these conditions. Micro Motion ELITE® Coriolis flowmeters perform with unparalleled accuracy in plant applications with two-phase flow. A new software feature aims to bring clear and concise information about the condition of the fluid being measured so that the appropriate action can be taken. The transmitter can give notification that the fluid is in single phase, has moderate entrainment (some loss of accuracy, but measurement is still repeatable), or severe entrainment, in which case the measurement is likely neither accurate nor repeatable. No matter what the conditions are with respect to gas entrainment though, the meter will not be damaged by two-phase flow.

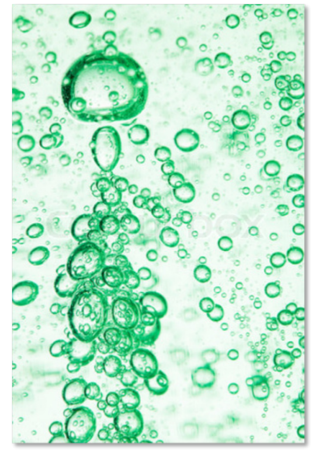

Figure 3. Example of Two-Phase Flow

Turndown

Because of the number of different recipes and the range of flows, good turndown is required of the flow meters. A Coriolis meter can achieve an accuracy as high as 0.10% even at 25: 1 turndown.

Additionally, some lines run more than one product, which requires meter flexibility. Ideally a turbine meter should be recalibrated when products are switched. This is not necessary when blending with Coriolis meters. A volumetric flow meter measures volume and requires different density, and temperature corrections for different components. A Coriolis meter measures mass directly, and requires neither recalibration nor compensation for temperature and density. A refiner should not be limited by a meter's turndown capability, or compensation for changing fluid properties.

Economics of Reducing the Uncertainty

In blending, a ratio control-based recipe is optimized to meet an objective function, which could be profit, or an inventory consideration. The blend stocks are ratioed to meet the quality specifications while satisfying the objective function in the most cost-effective manner. The optimum recipe set points are converted to flow set points, the blend is run and analyzed online, and the final product may also be analyzed in the lab. Any error in measurement tends to drive the actual blend recipe away from the optimum recipe, and this effect will be present whether the optimum recipe is determined with an off-line planning device or by an online optimizer.

Several years ago a study was performed using a commercially available blend optimizer to determine the effects of improved flow measurement on gasoline blending profitability. The optimizer determined the optimum recipe to maximize profitability and meet specifications. In this study, a simulation was run adding a 0.3% error to the limiting component. The result was that limiting a component to 99.7% of its optimum recipe causes the optimizer to seek a new optimum which is always less profitable than the original optimum. This is demonstrated in the graph in Figure 4. The reduction in profitability ranged from .02 cents per barrel to .65 cents per barrel. For a refinery that produces 50,000 BPD of gasoline, such improvements in profitability would result in increased profits of up to $200,000 per year.

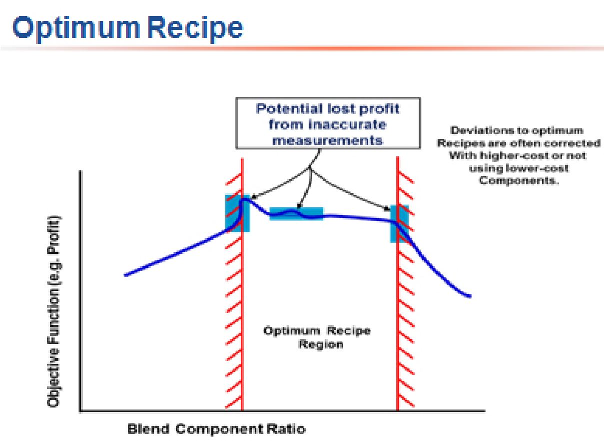

Figure 4.

In another study, using Monte Carlo simulation techniques, it was determined that a suboptimum blend which utilized more expensive blend stocks to meet product specifications due to uncertainties in measurement could cost between $1,000 and $6,000 for a single batch. If a refiner blends 300 batches of gasoline a year, this could cost between $300,000 and $1.8 million a year. The uncertainties in measurement were caused by the fact that there was no temperature compensation performed on the volumetric meters and there was no meter on the final blend header to check the ratio meters.

One way to look at the economic benefit of more accurate flow measurement is to look at the impact of accuracy on the blending optimizer, which is how the previous studies were performed. Another way to view the impact is through a reduction in variability. Understanding the impact of variability in the measurement and therefore the variability in the specifications has a very large impact on economic profitability. The graph shown below, Figure 5, plots the production cost vs. product sulfur level.

Production costs get progressively higher as lower sulfur levels are targeted. The objective then is to get as close to the target sulfur level as possible, in order to avoid giveaway, without the risk of exceeding the specification limit. The way to do this is to reduce the variability. To quantify the benefit of reduced variability and the resulting reduced sulfur giveaway, the increased margin from moving from a target of 7 ppm sulfur to 9 ppm sulfur can be evaluated. Using the safe assumption of 1 cent per gallon increased margin between 7 and 9 ppm target sulfur, the value would be $14.8 million a year for a refinery producing 100,000 BPD of gasoline.

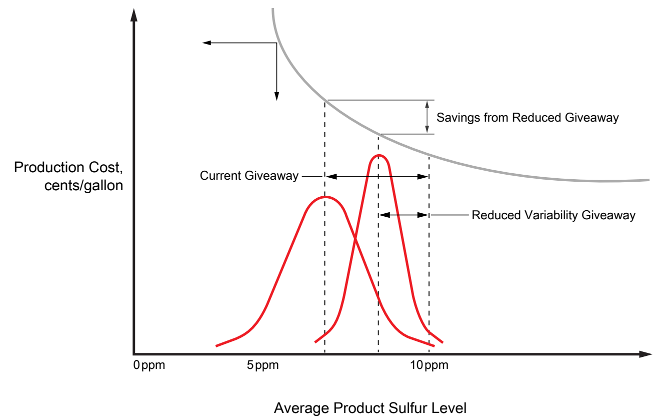

Figure 5: Impact of Variability on Refinery Margins

Another strong economic consideration for reducing the uncertainty in measurement systems is in avoiding penalties associated with non-compliance of government fuel quality requirements. Fines from government regulatory bodies for selling and distributing products that don't meet both product sulfur and volatility standards, can be imposed on refiners. In a recent court case in the U.S., a large refiner was forced to pay a $2.9 million civil penalty, and retire their sulfur credits, worth another $200,000. In addition to the fines they were required to spend, they spent $2.8 million on pollution controls to reduce emissions from volatile organic compounds.

Maintenance

Many refiners who use turbine meters in the blend area have had problems with both accuracy and maintenance. Operators compare flow totals with tank volume changes and adjust the meters' K-factors. Turbine meters can also occasionally lock up, to the detriment of blend control. During start-up, the turbine meter can be hit by a slug of air, damaging the turbine meter blades. Additionally, pieces of metal from flow straighteners have come loose and collided with turbines, damaging the blades. Turbine meter bearings cannot tolerate any small particles in the flow stream.

There is additional maintenance cost associated with replacing turbine meter parts. Any flow meter with no moving parts carries with it a significant maintenance cost reduction as compared to turbine meters. Turbine meter internal parts for a 4" meter are about $4,000. Added to that, are the labor to remove the spool piece from the line, and the labor to rebuild the meter.

Because a turbine meter has moving parts and requires lubrication, its meter factor tends to drift, and requires periodic proving or calibration. Coriolis meters have no internal moving parts, so the measurement should not drift over time.

Smart Meter Verification

Although Coriolis meters do not, in general, lose any accuracy with time, it is helpful to verify that it is, in fact the case. This is particularly true if the meters will be used to calculate GHG, doing inline blend certification, or adding biofuels at the terminal. Micro Motion meters include an optional feature which has the capability to verify the reliability of the measurement, using Smart Meter Verification. For Coriolis sensors, flow tube stiffness is a critical parameter and any changes in tube stiffness due to corrosion, erosion or damage will affect both the flow and density measurement. Using Smart Meter Verification, Micro Motion Coriolis sensors can include an advanced diagnostic to enable in-situ meter verification for tube stiffness using the process fluid under flowing or zero flow conditions. Data is compared to baseline values stored in the electronics and a positive indication means nothing has changed the physical integrity of the tubes nor the calibration of the sensor. This process takes just a few minutes, and will insure that these critical flow measurements are within the specified accuracy tolerance, as shown in Figure 6.

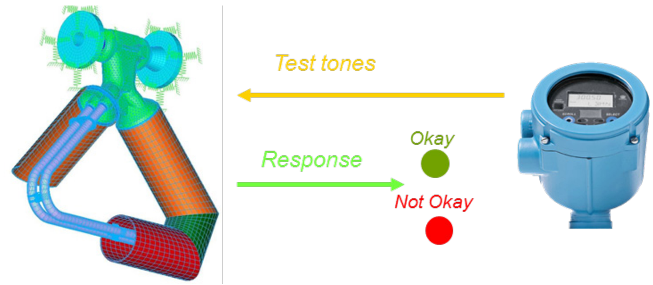

Figure 6.

Density

Simultaneous flow and online density measurement from Coriolis meters provide indication of changing fluid properties. A refiner can set tight gravity ranges in the DCS for each component with an alarm to notify the operator of any deviation. The density alarm may indicate cross contamination, or stratification in the tanks.

Conclusion

Stricter demands on blending from increased government regulations for volatility, ethanol content, and reduced sulfur specifications will require improved measurement and control. Uncertainties in measurement can lead to quality giveaway, or the necessity for reblending and touch-up. In cases where products are blended directly into a pipeline or ship, products would be shipped off-spec. All of these scenarios have significant financial implications.

To avoid these problems, and blend products in the most cost-effective and efficient manner, the trend in flow measurement is away from turbine meters, and towards the use of Coriolis flow meters. Because Coriolis mass flow meters provide the accuracy and reliability needed in the blend area, they should be considered as part of a blend system upgrade.

About Micro Motion

For over 35 years, Emerson's Micro Motion has been a technology leader delivering the most precise flow, density and concentration measurement devices for fiscal applications, process control and process monitoring. Our passion for solving flow and density measurement challenges is proven through the highly accurate and unbeatable performance of our devices.

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