Automated Vision Based Particle Analysis

Thomas M. Canty, P.E. and Justin Hallbach, J.M. Canty Inc.

Abstract

Vision based particle analysis is becoming widely accepted as a preferred choice of tool when both particle size and shape are required for analysis. Extreme performance capabilities and novel handling techniques enable vision systems to overcome analysis problems that have plagued the drilling mud industry.

Introduction

Analysis of drilling mud has several associate challenges including sampling, size and shape analysis. In industries where size and shape are critical vision technology offers another dimension in analysis that not only assesses a particle shape, but more accurately assesses a particle size. Sampling and processing a sample are often difficult due to the weight of the particles in slurry. Stratification and drop out can prevent representative sampling and analysis. Vision capabilities and handling methods now enable the mud to be properly sampled at line in order for a representative sample of the pipe to be obtained and run in whole without further sample division. Further innovation in flowing the slurry, with dilution, into the instrument enables a complete sample to be run with no drop out, and thus representative data can be obtained.

Issues With Accuracy

Water

In well defined testing instruments of various types produce similar, but not precise, results with regard to particle size. This, however, does not include samples where water is present. Water appears to most instrumentation as another particle and can greatly skew size distribution results. Vision's innate capability enables the software to differentiate the water droplet from other particles in the flow. The data can be presented separately or eliminated, either way it does not interfere with the particle size analysis. Figure 1 shows an image of a water droplet in a dilute, oil based mud flow. Obviously this will create errors.
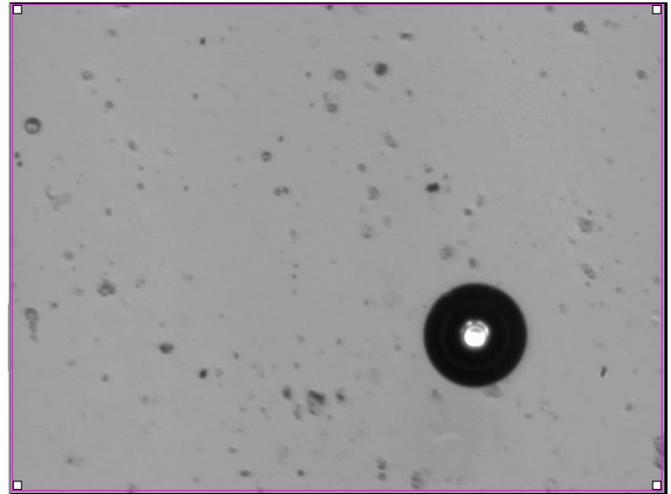
Figure 1. Image of Water Droplet in Oil Diluted Mud Flow

Shape

Vision analysis allows for the analysis of shape of the particle distribution. Through a ratio of area to perimeter of the particles, a dimensionless value, called circularity, can be computed for each particle. The distribution of circularity can advise on variations in the mud shape which is every bit as important as size. Circularity values for common particle shapes are defined below as an illustration of how the shapes are classified:

Circular Particle = $(4*Pi*.785 D^2 / (Pi * D)^2) = 1$; D – diameter

Square Particle = $(4*Pi*D^2 / (4D)^2) = .785$

Rod Shaped (L = 3W) Particle = $(4*Pi*L*W / (2L + 2W)^2) / W = (12*Pi*W^2 / (8W)^2) = .59$

Correlation

Mud is made of a combination of components which are manufactured and mixed to obtain a desired performance. These mixtures are dry when made. They are then combined with an oil or water based solute in the field where the analysis now shifts

away from sieves to other types of instrumentation. Correlating results is a challenge because technologies are often measuring different particle features and characteristics. Measuring mud in-line or at-line requires a capability to correlate results from different technologies in many instances that are different or are measuring under different conditions.
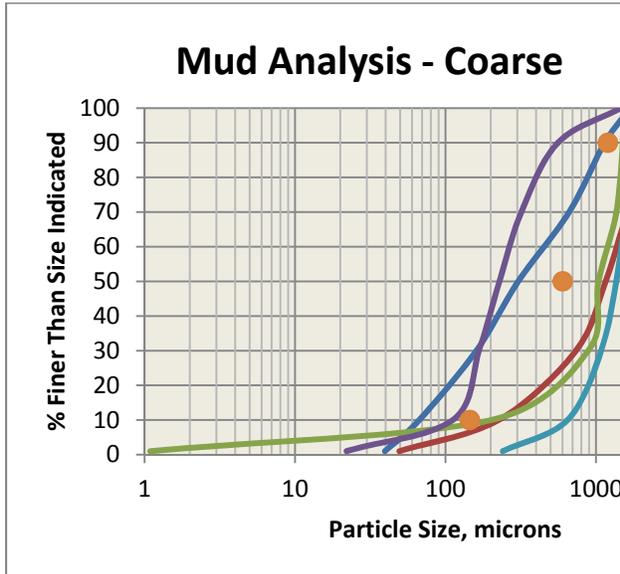

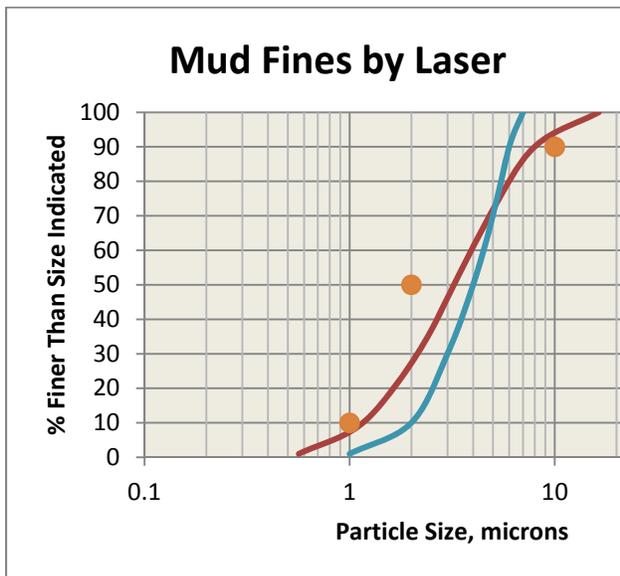**Figure 2. Various Instrument Types Measuring Coarse Mud Sample**

Figure 3. Fine Mud Sample.

Measuring via instrument, other than sieve, in most cases will allow measurement upstream in the manufacturing process which may provide better process control. Being able to interpret the results with respect to a downstream analyzer (sieve) is

critical is controlling the process. Vision technology is a non contact methodology and thus there is no product loss as there likely is with sieves (particles getting stuck). Vision is best suited to creating reliable correlations due to the optical component which enables the operator to see upset conditions and account for their occurrence.

In addition to the above, having instruments in several locations requires them to maintain a relative calibration. Sieves, in particular, tend to go out of correlation due to wear or shifting of wire positions changing the characteristic of what is passed through. Vision systems are calibrated to a reticule and do not experience calibration drift unless the system is physically changed by the operator. Keeping systems in calibration is straight forward and provides a basis for reliable measurement location to location.

Mud Dilution and Analysis
Sampling

When discussing any particle analysis technology one must start by discussing the sampling methodology. First, is a representative sample obtained from the larger population? This question always arises with heavy particulate in slurry which is what drilling mud is. The mud line likely has some stratification in it. To counteract this it is best to sample an entire section of the line.

Second question that arises, is the sample taken handled properly by the measurement device so that particle stratification or dropout does not affect the accuracy or reliability of the analysis. The best answer to this question is to present the entire sample to the measurement zone of the instrument. Further sampling while processing, or viewing only a portion of the flow past the measurement zone of the instrument can recreate the inaccuracies inherent with taking a bad primary sample.

Sampling Apparatus

Technology has been developed that resolves both sampling issues. As mentioned previously it is best to sample the entire process line cross section. The device shown in Figure 4 sweeps out an entire cross section of the mud line and washes it into a feed reservoir for the instrument. By controlling the balance of water/oil addition to and flow through of the sample the material can be kept fluidized through the measurement zone. The details of the technology are pending patent approval and cannot be divulged, however figure 5 shows a diagram of the vision system.
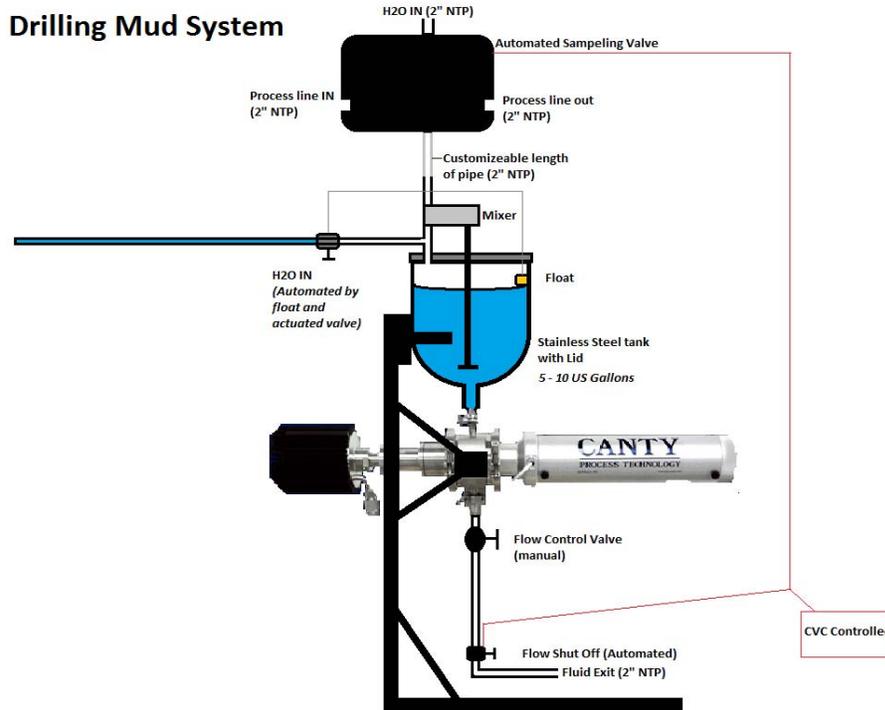
Figure 4. Sampling Manifold – Captures Entire Cross Section of Pipe.

Figure 6 shows some typical mud data run on a Canty vision system with the previously discussed sample handling methods. The data shows consistent results for multiple analyses.
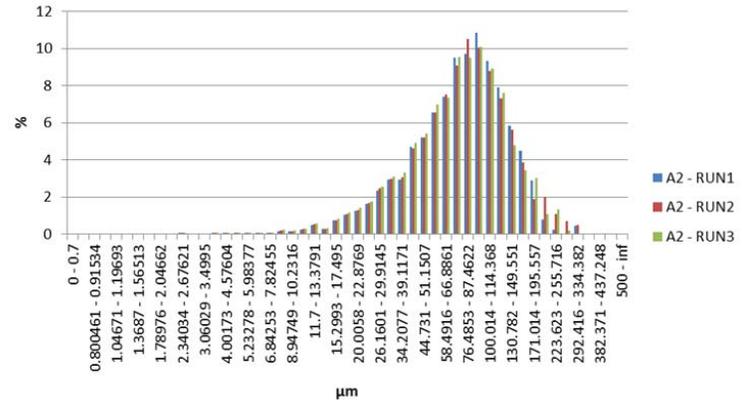
Figure 6. Typical Mud Analysis Showing Repeatability.

Figure 5. Vision Particle Analyzer w/ Slurry Handling System

This is a lab version of the instrument, however the at-line mechanism is identical with the differences relating to packaging for the process environment.

Correct sampling and handling is imperative in order to have a chance at properly analyzing any particle slurry.

LCM's

Lost Circulation Materials (LCM's) also deserve mention here. These materials range from small size cuts (US Sieve 60/200) to macro sizes illustrated in Figure 7 which shows crushed walnut shell cuts (US Sieve 4/6). Their preparation is as dry particles which

are mixed into the mud to prevent or stop leakage of the mud into the formation. The possibilities for LCM materials covers a wide range of sizes which are generally beyond an effective range for laser based particle analysis. Vision offers an unlimited range assuming the lens system can see the particles.

Figure 7. Crushed Walnut Shell LCM.

Conclusion

1. Vision analysis of particulate size and shape at line offers advantages over other types of instrument technology with regard to measurement of size and shape.
2. New technology has also been developed that enables a proper sampling and handling of mud slurries in order to obtain particle analyses that are accurate and repeatable.