A NON-NUCLEAR DENSITY METER AND MASS FLOW SYSTEM MEASURING MINING SLURRIES WITH ENTRAINED GAS

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ABSTRACT

DuPont's Maxville Mine in Florida was chosen to evaluate comparative costs of a nuclear density meter and a new non-nuclear direct mass per unit volume type. Considerable ambiguity in cost of annual production implies a nuclear gauge accuracy of ± 2% at best, which together with its operational costs for a 16" pipe carrying zirconium slurry, amounts to over $1.2 million per year.

This paper describes this new density meter with optional gas entrainment compensation. It significantly reduces costs and overcomes the disadvantages of nuclear devices. A typical on-site accuracy of ± 0.285% can be shown. In the example above, this equates to an annual saving of over $880,000 per year.

ALTERNATIVE SENSING TECHNIQUES

The vast majority of continuous density measurement of mining slurries is done with nuclear sensors, whereby a gamma ray is emitted through a metal wall and across a thin diameter of a pipe, through which the media is flowing. The inside diameter of the pipe may be suitably lined to improve its service life. Diametrically opposite the gamma ray emitter is a scintillator devise, which converts the gamma ray to brief light flashes. The light flashes are sent to a photomultiplier, which amplifies and converts them to electronic pulses. The frequency of the pulses is a measure of radiation intensity.

A higher media density results in higher absorption of radiation, which means the frequency of the pulses is inversely proportional to the density of the media, and it is non-linear. Electronic signal conditioning provides a linear electrical output.

Such devises are relatively low in radiation levels, typically10 microSieverts/h, which is approximately the same as medical X-rays. Despite these relatively low levels, world-wide restrictions, security and safety standards are strictly imposed on such nuclear sensing techniques.

Special training must be given to handlers, special regular testing is necessary, and trained safety officers are employed by companies using them. When installed on a mobile skid or dredger, special permission must be sought in order to re-locate the unit. The basic high cost of nuclear sensing techniques, including the cost of safety measures, source transportation or disposal, storage security, and the potential health hazard, makes nuclear density sensing unpopular.

Until now there has not been a non-nuclear, practical alternative of adequate accuracy and insensitivity to vibration and temperature change. The high cost of mining requires a density sensor of good resolution and high accuracy, regardless of these external effects.

One form of density measurement embodies a vibrating tube or fork, the variation in frequency of which is proportional to the density of the contacting media. However, these are limited to relatively small pipe sizes and liquids. They are certainly impractical for use with mining slurries, due to the large pipe size requirements in the industry and the rapid erosion such media imposes on the vibrating parts.

Coriolis flow meters directly measure the mass flow of the media flowing through a thin wall bent pipe, which is caused to vibrate. By measuring the frequency phase shift at each end of the bent pipe, a proportional mass flow rate is obtained. These meters may have a separate density output. However, they are impractical for measuring mining slurries since the thin wall bent pipe would erode within weeks, or days.

Ultrasonic density sensing techniques have also been used, whereby ultrasonic waves are passed from an emitter to a receiver diametrically opposite in a spool piece installed in a pipeline. A strong echo is received with low percentage solids or density, but as the density increases the signal weakens. Accordingly, the density is a measurement of the strength of the ultrasonic echo, but above 15% solids the signal results in irregular noise. Any attempt at dampening is not the average of this irregular noise, resulting in unacceptable errors.

Other devices measure slurry density by sensing the phase difference of microwaves passing through the slurry compared to water as a reference. However, reliable microwave differential phase techniques are limited to media with reasonably consistent electrical relative permittivity (or dielectric constant) and high conductivity, such as waste water, paper slurry and a selection of foods. The natural characteristics of mining and inorganic slurry have such large variation in these electrical criteria that microwave techniques have very limited application.

It should be noted that inferential techniques, such as ultrasonic, microwave and nuclear density devices sense only a relatively small column across the pipe diameter and longitudinal length. In other words, their defined volume in the measurement of density is small. Most of the pipe cross section and length is ignored. Such techniques yield different results in the horizontal plane to when the meters are installed in the vertical plane, due to solids settlement and media stratification. Mining slurries are far from homogeneous as they flow along a pipe line. In consequence, the media density measured is often not representative of a larger volume of it, which can result in puzzling errors. See Figure 1.

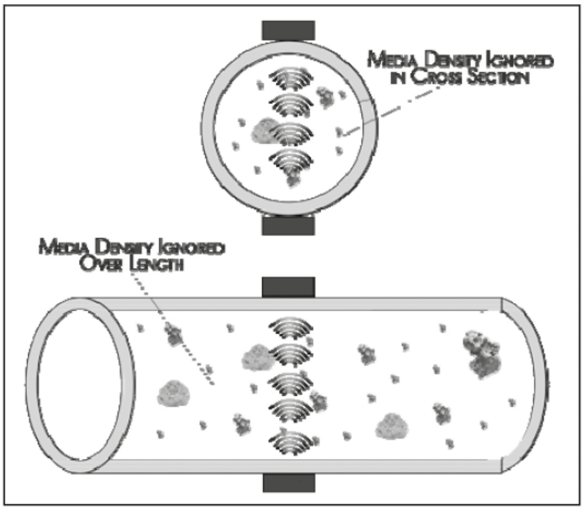

Figure 1. Errors result from not sensing adequate cross section and length.