Optimizing Continuous Industrial Productivity with Modern Flow Metrology

Plática Invitada

George E. Mattingly

GEM & Associates
Bethesda, MD, Estados Unidos de América.
gemattingly@verizon.net

ABSTRACT

Flow measurement is arguably the most difficult of the five or six most prevalent industrial measurements if one considers temperature, pressure, time, length, force or mass, and flow rate as most prevalent. Therefore, assessing flow measurement and its current status, this presentation will include the types of steps that can now be feasibly taken in this measurement area to control and optimize industrial productivity.

In the distant past, industrial productivity was based on “batch” productivity. Such productivity had the obvious advantage of allowing each batch to be checked before shipment to the customer. “Batch” productivity also has the advantage that if a batch isn’t satisfactory, it can be set aside or re-done or the process adjusted so that subsequent batches are satisfactory.

However, while “batch” productivity has these advantages, it also has the (considerable) disadvantage of not being as efficient as “continuous” productivity in the manufacture of fluid products such as fuels, chemicals, food products, etc. Additionally, where the continuous process technology is not well controlled, significant losses can occur before the flaws in the process are detected.

Therefore, where it is desirable or critical to optimize continuous industrial productivity, this can only be done where there are appropriate controls on the process and this control can only be done where pertinent measurements are made. Consequently, the 3-step-sequence of measurement, control, and optimize starts with measurement.

In what follows, the example of “most difficult” flow measurement is considered and used to show what can be now feasible via modern metrology. By inference, other critical measurement areas can be treated analogously to this flow example with the end result being that very high levels of optimization are now feasible with modern metrology.

PURPOSE

Using a specific type of flow meter for liquids, namely a turbine-type flow meter, the evolution of this product is described with respect to its rangeability (i.e., its “turn-down”, or the ratio of maximum-to-minimum flowrates over which the meter factor is satisfactorily characterized) and the nature of the characterization of its meter factor. Early turbine meters had turndown ratios of 10-15 to 1, and over this range its linearity (i. e., the “constancy” of the meter factor) was typically between 0.25 % and 0.5 %. However, these ranges were soon found to be seriously reduced if the liquid viscosity changed from the values used in the meter’s calibration.

Furthermore, as software developments have advanced, it is now no longer required that meter factors be “constant” over turn-down ranges. As long as meter factors can be satisfactorily fitted using analytical equations, the parameter ranges over which these fits apply now determine “turn-down”. In what follows, it will be shown that previous 10-15 to 1 turndown ranges can now be increased to 100,000 to 1.

METHODS

Flow meter characterizations, using dimensionless parameters (via the Buckingham Pi Theorem) are described through which limited ranges of viscosity variations were satisfactorily handled, using a 2 parameter characterization for the meter, and turndown could be increased into the 100 to 200 to 1 range. Data sets are shown as examples. However, for very wide ranges of viscosity, as could be typically found in practice, meter performance was curtailed, until an extension to the Buckingham Pi Theorem was applied. This extension, using a new, third parameter to characterize flow meter performance, is generated and meter turndown is thereby increased to 100,000 to 1. Data is presented to show this increase.

DISCUSSION

Additionally, modern flow metrology can now further increase the results of flow meter calibrations through several techniques. Firstly, a "correlation" technique is described and sketched through which improved assessments of meter performance can be easily achieved. Secondly, data handling schemes- "correction schemes" can now be easily applied to typical calibration data, using "Excel" capabilities so that further metrological improvements are attained. Examples are given.

Yet further improvements are now feasible with enhanced assessments of flow meter calibration laboratories and better quantifications of "Measurement Traceability" i.e., the measurement pedigree that establishes and maintains lab credibility and validity relative to national standards and references. Using lab assessment procedures (NVLAP –the US National Voluntary Laboratory Accreditation Program or other assessing organizations), lab measurement uncertainties are not only better, but are also better understood.

Furthermore, National standards are also now being internationally compared so that "Technical Barriers to Trade" (TBTs) are eliminated or reduced through the CIPM Mutual Recognition Arrangement (MRA, see www.bipm.org) The metrology for the Key Comparisons (KCs) is sketched together with a graphical analysis of variance technique (Youden plots) that is useful in clarifying the equivalence of standards as maintained in National Metrology Institutes (NMIs).

CONCLUSIONS

Modern flow metrology now offers significant improvements for industrial metrologists to apply to their respective production schemes. These improvements, coupled with modern computation capabilities are now readily available, and only await being applied by modern industrial metrologists for the optimization of their industrial productivities.