Viscosity Compensation of Smith Meter® MV Series Helical Turbine Meters

Technical Paper

Issue/Rev. 0.0 (3/08) Bulletin TP02007

Introduction

***Smith Meter® MV Series Helical Turbine Meters** have significant performance advantages over conventional rotor turbine meters for crude oil service. The use of universal performance curve compensation allows the application range of helical turbine meters to be extended even further.*

Background

Normally, turbine meter performance curves are constructed with flow rate on the X axis and either K-Factor or Meter Factor on they Y axis. This is fine for viewing the meter's performance on a single set of product characteristics. However, because helical turbine meters are typically used in applications where the product characteristics vary, a different means of viewing the meter's performance is needed. Constructing the meter's performance curve using Reynolds Number on the X axis allows the graph to take into account both flow rate and viscosity.

This graph is typically constructed using flow test data from multiple sets of product characteristics and is called a universal performance curve because once constructed, it can be used to estimate the meter's performance on any set of product characteristics that fall within the range covered by the data.

To simulate each MVTM application as closely as possible at our Erie, PA testing facility, the temperature of multiple fluids is controlled in order to match the Reynolds number range of the customer's application. The Reynolds Number (Re) range is calculated using the following simplified equation and based on the worst-case conditions:

$$\mathrm{Re} = \frac{(2214^{*})\,(Q)}{(MS)\,(V)}$$

Where:

Q = Flow Rate (BPH)

MS = Meter Size (in)

V = Kinematic Viscosity (cSt)

*2214 is a constant which incorporates the unit conversions for flow rate, meter size and kinematic viscosity.

From the customer's data, the following information is determined:

- Minimum flow rate and maximum viscosity to yield the minimum Reynolds Number
- Maximum flow rate and minimum viscosity to yield the maximum Reynolds Number

A test plan is then constructed that will incorporate multiple tests on different viscosities to provide meter performance data covering this application range. The testing is carried out and the universal performance curve is generated. This universal performance curve is then programmed into the Smith Meter® Universal Performance Curve Compensator (UPCC), a microprocessor-based device mounted on the meter in lieu of a standard preamp.

The UPCC accepts a live viscometer frequency input to determine actual application viscosity. As a simplified explanation, based on this viscosity input and the frequency input from the turbine meter pickup coil, the UPCC determines the current point of operation on the universal performance curve and calculates a compensation factor which is applied to the pulse output. The result is a significant improvement in the linearity of the turbine meter which ultimately leads to an improved rangeability of the meter over varying viscosities.

If the application covers a single product with viscosity variations being produced as a result of temperature changes, the UPCC can also utilize a look-up table based on a temperature input to determine the current viscosity.

Another feature of the UPCC is that it can be used to increase the pulse resolution of the helical turbine meter to better fit the application. For example, if the customer already has a stationary ball prover in their installation, the pulse resolution of the turbine meter may need to be increased in order to provide the API recommended 10,000 pulses per proving run. This is accomplished, not by a simple pulse multiplier, but by pulse chronometry which is an accepted method of pulse interpolation. A separate technical paper (TP02006) covers this aspect of the UPCC and is available via our website at **www.fmctechnologies.com/measurementsolutions**.

Application

In order to show the effectiveness of viscosity compensation, an example of a past customer application will be highlighted.

This particular application was for a 12" helical turbine meter with a flow range of 1,900 BPH to 18,000 BPH and a viscosity range of 5.74 cSt to 253.7 cSt. Based on this information, the minimum and maximum Reynolds numbers are calculated:

Minimum Re = 1,381 (253.7 cSt @ 1,900 BPH)
Maximum Re = 607,129 (5.74 cSt @ 18,000 BPH)

Next, a series of flow tests are conducted that cover this Reynolds number application range. Raw results of the tests are shown in Figure 1.

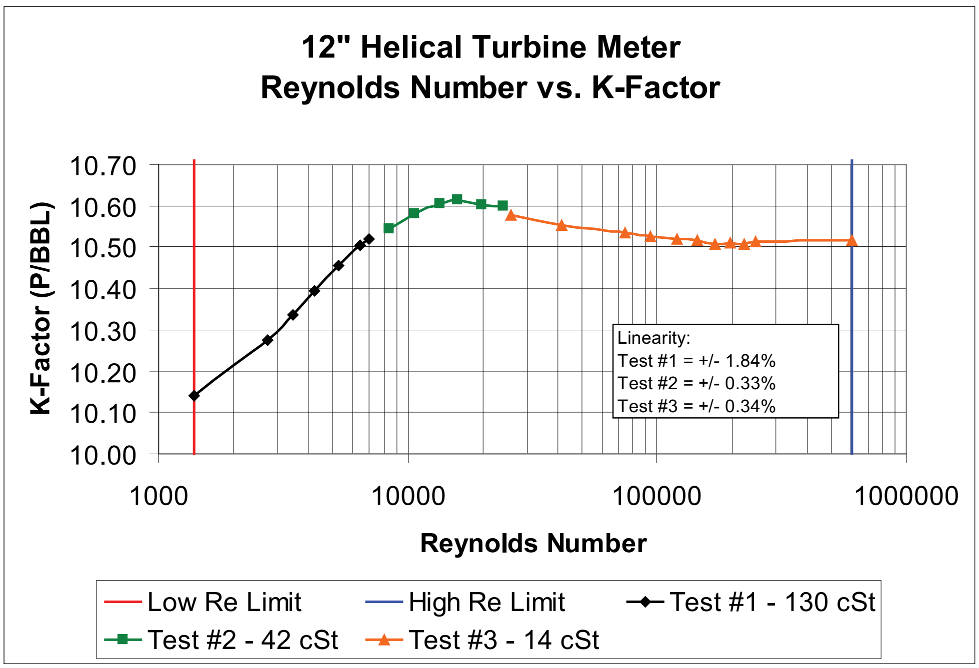

Figure 1. Raw Test Results

Next, these individual test results are combined to form a single composite curve, or universal performance curve as shown in Figure 2.

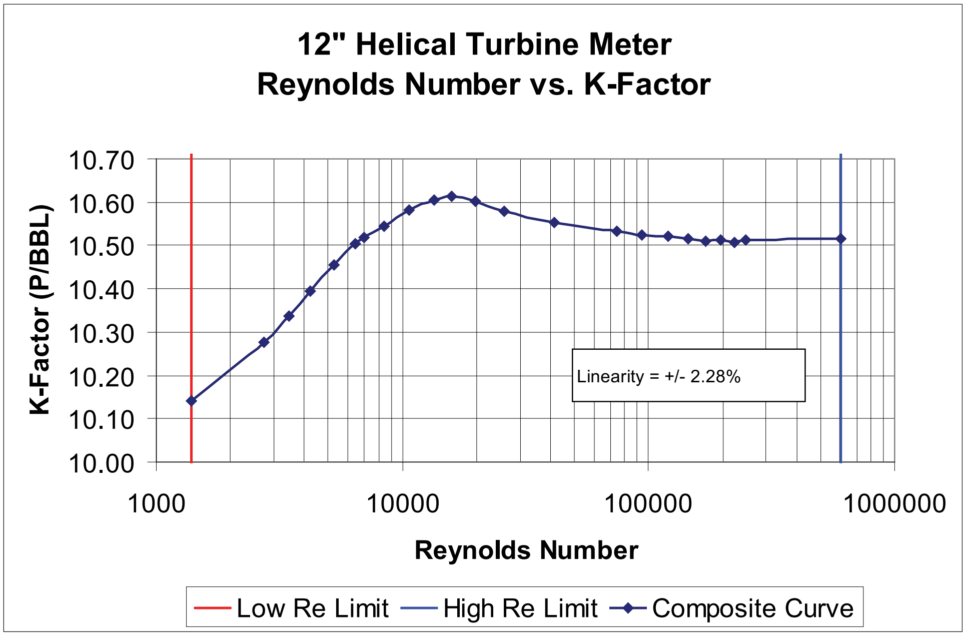

Figure 2. Universal Performance Curve

This Universal Performance Curve is then programmed into the UPCC and the testing is replicated utilizing a live viscometer input to verify proper operation of the UPCC. In this case, the customer also requested that the meter have a compensated pulse output resolution of 333 pulses / BBL in order to collect 10,000 pulses per proving run with their existing stationary prover.

Figure 3 shows the final testing results with the viscosity compensation and pulse resolution enhancement active:

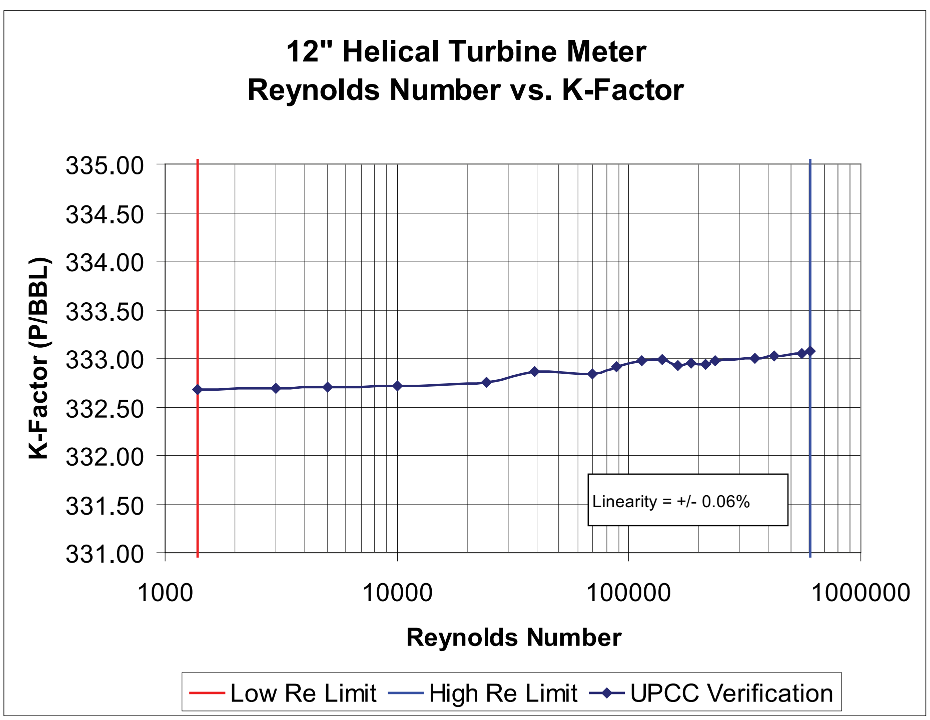

Figure 3. UPCC Verification Test

Conclusion

As evidenced by the application example shown, viscosity compensation utilizing the Smith Meter® UPCC and a live viscometer input can significantly improve the linearity of a Smith Meter® MV series helical turbine meter when used over a varying viscosity range. In this particular case, linearity over a 440:1 Reynolds number turndown range was improved from +/- 2.28% to +/- 0.06%, thus extending the rangeability of the helical turbine meter far beyond the traditional capabilities of turbine meter measurement.

Headquarters:
500 North Sam Houston Parkway West, Suite 100, Houston, TX 77067 USA, Phone: +1 (281) 260-2190, Fax: +1 (281) 260-2191

Gas Measurement Products:
Houston, TX USA +1 (281) 260-2190
Thetford, England +44 (1842) 82-2900
Kongsberg, Norway +47 (32) 286-700
Buenos Aires, Argentina +54 (11) 4312-4736

Integrated Measurement Systems:
Corpus Christi, TX USA +1 (361) 289-3400
Kongsberg, Norway +47 (32) 286-700
San Juan, Puerto Rico +1809 (787) 274-3760
United Arab Emirates, Dubai +971 (4) 331-3646

Liquid Measurement Products:
Erie, PA USA +1 (814) 898-5000
Los Angeles, CA USA +1 (310) 328-1236
Slough, England +44 (1753) 57-1515
Ellerbek, Germany +49 (4101) 304-0
Barcelona, Spain +34 (93) 201-0989
Moscow, Russia +7 (495) 564-8705
Melbourne, Australia +61(3) 9807-2818

Beijing, China +86 (10) 6500-2251
Singapore +65 6861-3011
Chennai, India +91 (44) 450-4400

Visit our website at www.fmctechnologies.com/measurementsolutions