I-VIGILANT

Smart Meter Analytics

GLOBAL FLOW MEASUREMENT WORKSHOP

measuring for the energy transition

Ultrasys Footprinting - A New Method for Deriving Parametric Models

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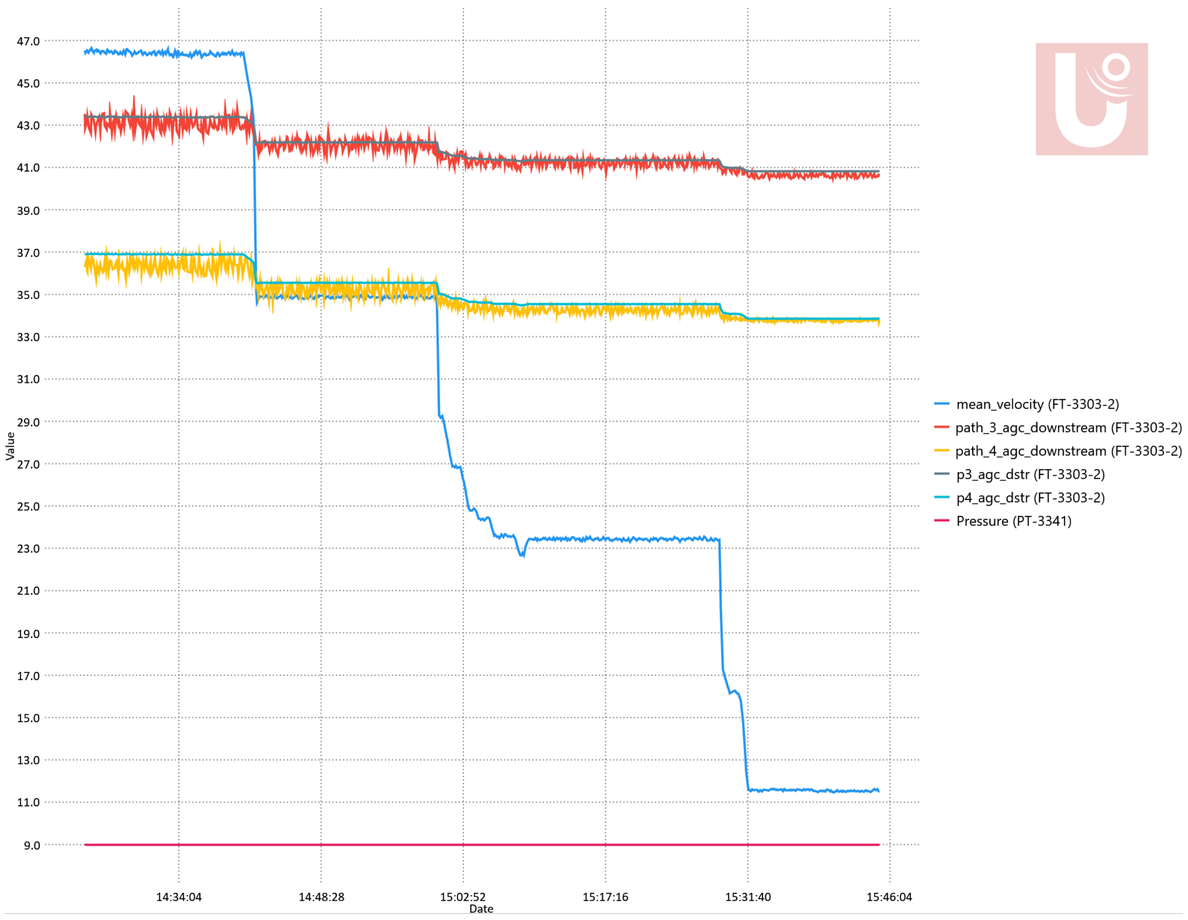

Fig. 1 – Regression dataset: Calibration data

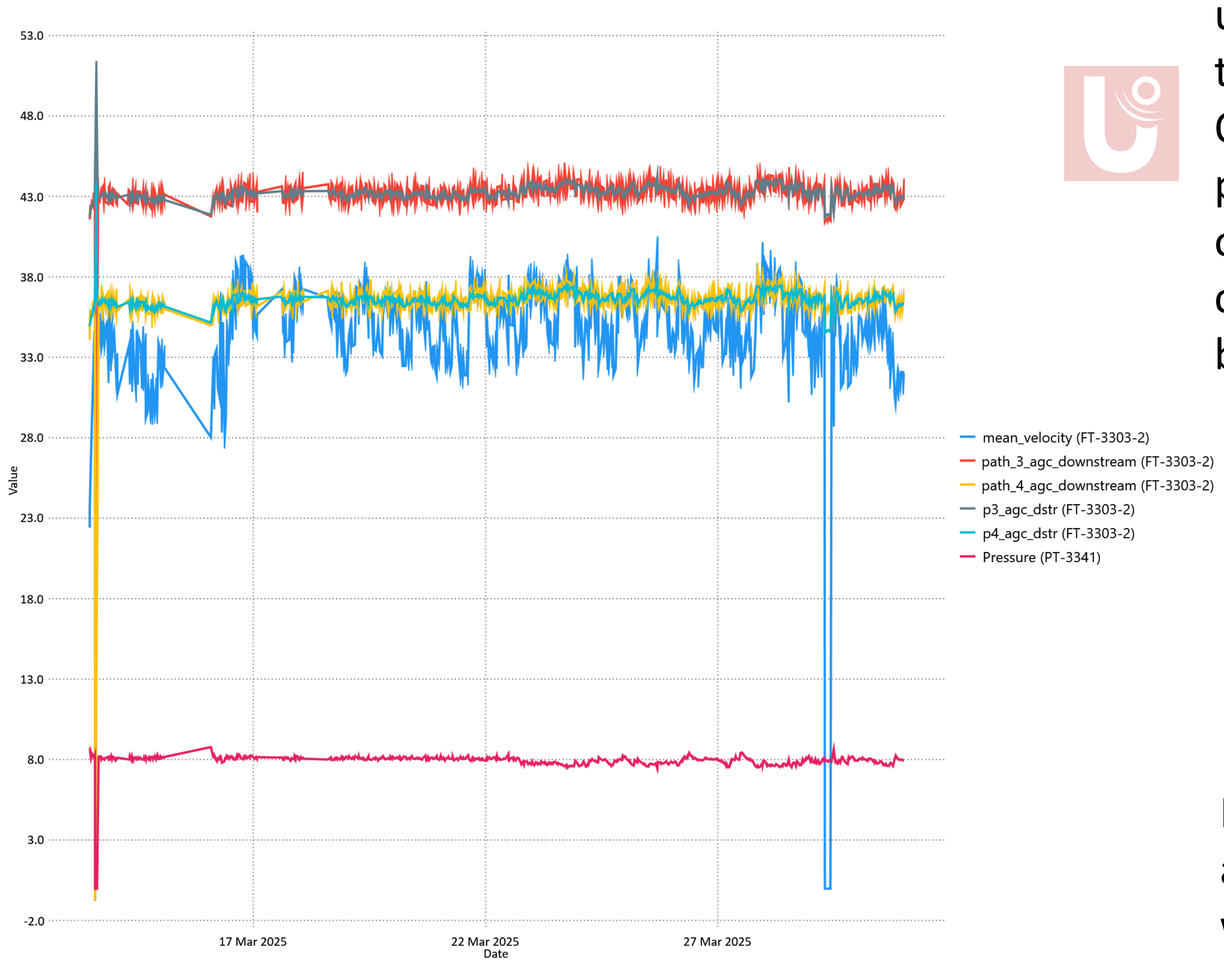

Fig. 2 – Regression dataset: Process data

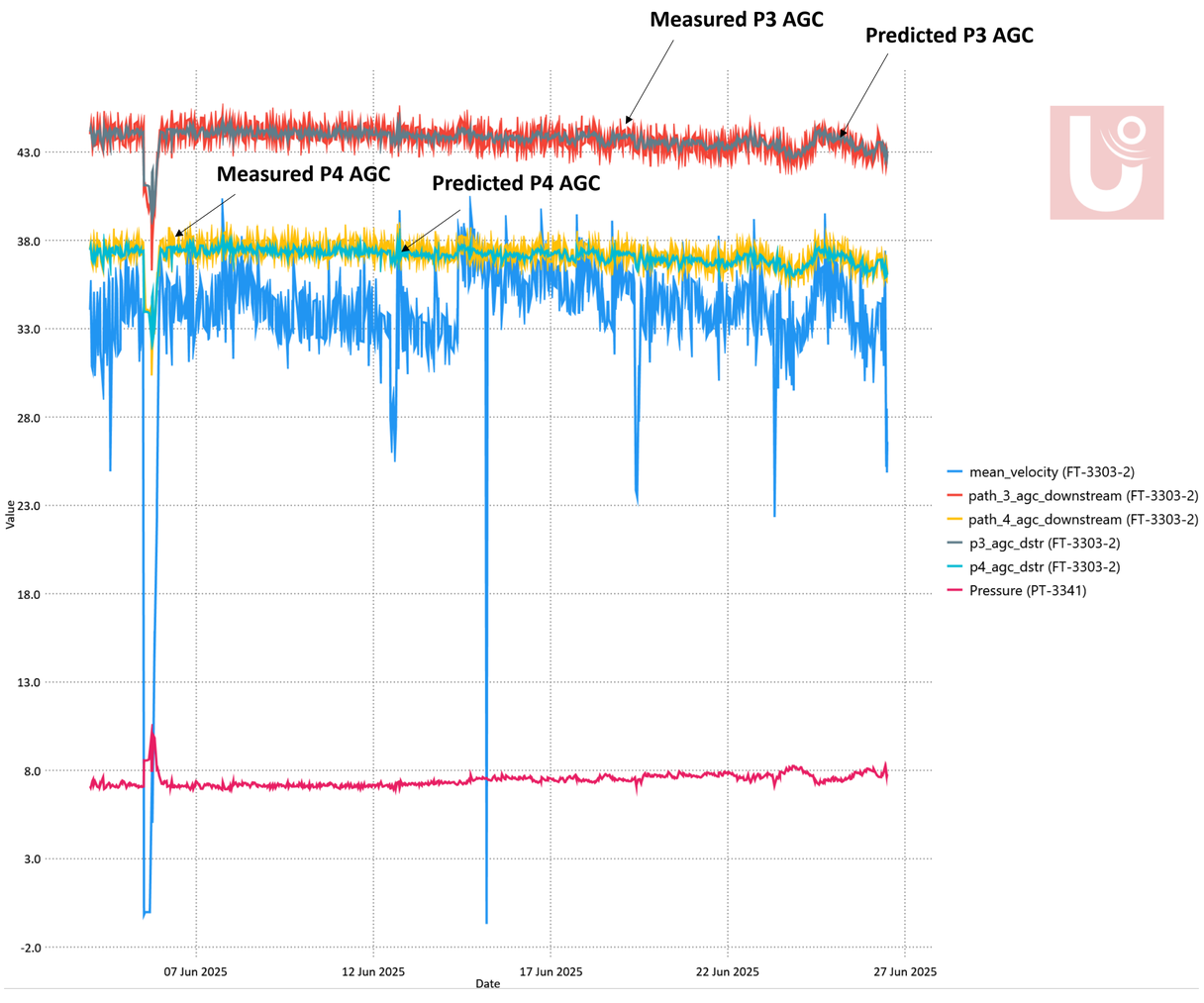

Fig. 3 – Regression result: Enhanced Diagnostic Model

Smart Meter Analytics (SMA) is a new condition-based monitoring (CBM) package for flowmeters. Ultrasys refers to the functionality within SMA which is designed for ultrasonic flowmeters (USM). Ultrasys uses parametric models (also known as footprints or fingerprints) to predict diagnostics. These provide a predicted value of a diagnostic to compare with the measured value. When measured and predicted values deviate this highlights an issue. Combining such models with measured vs calculated speed of sound comparison and various USM diagnostics allows creation of a system which can be used to reduce costly maintenance activities whilst providing evidence to stakeholders that USM performance remains acceptable.

Our parametric models are derived using OLS regression based on a patent pending approach of combining calibration data at one set of operating conditions, with process data at a different set of operating conditions to better predict how the diagnostic changes in service based on two (or more) regressors.

$\widehat{\beta}$
A
B
..

$$\widehat{\boldsymbol{\beta}} = \left(\boldsymbol{X}^{\boldsymbol{T}}\boldsymbol{X}\right)^{-1}\boldsymbol{X}^{\boldsymbol{T}}\boldsymbol{Y}$$

Example – model order can be changed!

$$AGC = A + Bp + Cv + Dv^2$$

$\boldsymbol{X}$				$\boldsymbol{Y}$
1	p	v	v^2	AGC
..	..	..	..	..

Fig. 1 - Fig. 3 shows the method applied to the prediction of USM automatic gain control (AGC). This is a potentially useful diagnostic which is affected by pressure, velocity, contaminants, noise, signal detection and transducer faults [1], [2]. However, historically this is typically monitored using wide limits due to the variance in process in conditions [3]. In one case it was modelled based on velocity, but comparisons had to be made at similar pressures [4]. The wide limits typically used may result in potentially useful information in the form of smaller changes being missed.

The matrix of regressors $\boldsymbol{X}$ is comprised of calibration data & process data using regressors of velocity v and pressure p. $\boldsymbol{Y}$ describes the measurements of AGC corresponding to the regressors $\boldsymbol{X}$. $\widehat{\boldsymbol{\beta}}$ contains the polynomial coefficients. Calibration data (Fig. 1) is at one fixed pressure but with large variation in velocity. Process data (Fig. 2) includes realistic pressure but less variation in velocity. This data produced the example in Fig. 3 which provides a model of AGC with average error < 0.3% and 2σ of the error < 3% which was less than the noise in the AGC measurement. We look forward to gathering more data with USMs in fault conditions to further test the efficacy of the method.

REFERENCES

[1] LINDSAY, G., 2019. Review of NEL's internal knowledge in the field of flow meter diagnostics.

[2] DANIEL MEASUREMENT & CONTROL INC., 2015. Reynolds number based verification for ultrasonic flow metering systems. US9134155.

[3] KNEISLEY. G. et al., 2009. Ultrasonic meter condition based monitoring – a fully automated solution.

[4] PETERSON, S. et al., 2008. On line condition based monitoring of gas usm's.