Mass flowmetering

Coriolis mass flowmeters have been improving in sophistication and reducing in cost for at least 25 years. But now the race is on for successful multi-phase mass flowmetering. Brian Tinham reports

The Invensys design for Coriolis metering, currently being trialled with Oxford University

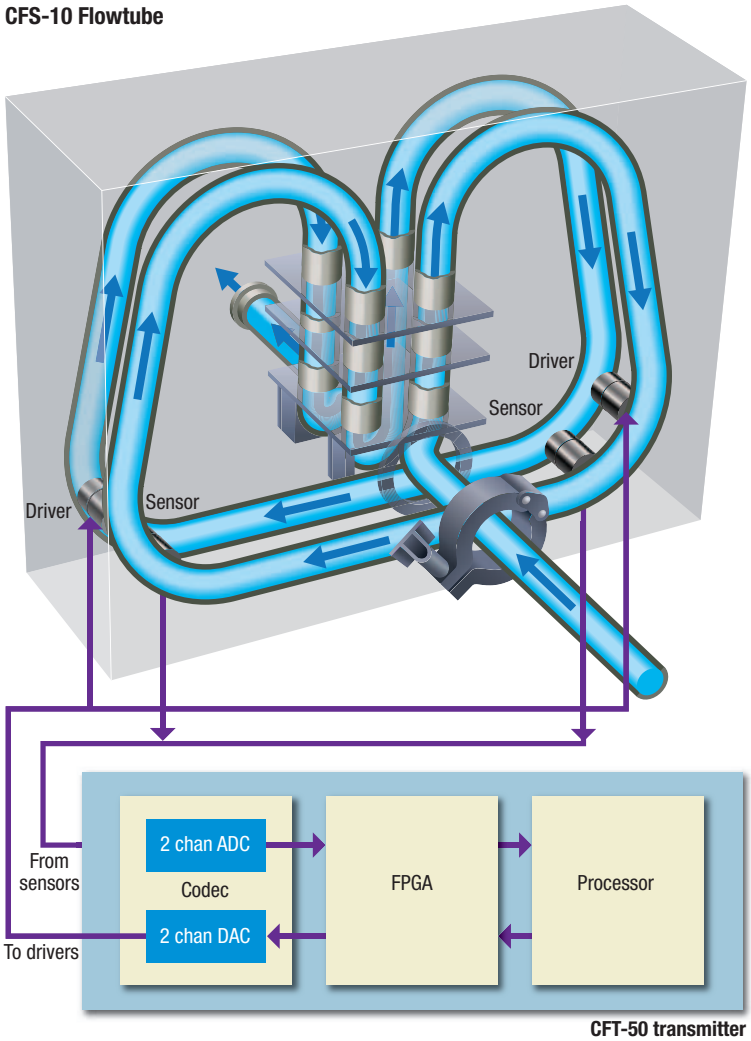
Over the past couple of decades, instrument engineers – even veterans with unshakeable faith in their favourite flowmeters – have been forced to concede that, when it comes to mass (rather than volumetric) flow, it's hard to beat Coriolis meters. Why? Quite simply, because they sense mass flow directly, instead of inferring the measurement indirectly from volume, as is the case for all other meters, with the exception of thermal mass gas flow devices.

Meanwhile, owing to the predictability of the Coriolis effect (essentially, the deflection of moving media in a rotating frame, achieved by vibrating flow tubes) and years of manufacturing improvements, Coriolis meters' accuracy, repeatability and stability can be extremely robust. And for many applications they are virtually maintenance free – most having long since been adapted for cleaning in place (where required) – while calibration is also rock solid.

Until recently, however, there was one problem and one limitation – the former price and the latter pressure drop (compared with vortex, magnetic and orifice plate meters). But that was then. Today, as Dr Manus Henry, director of the Invensys University Technology Centre for Advanced Engineering at Oxford University, explains, Coriolis meters' reputation for high cost is undeserved.

"Anything below, say, six inch OD is now at a competitive price point, compared to other flow technologies," he states. "It's only with the larger sizes, where material and engineering content are much greater, that the position worsens." And hence the growing number of applications for this apparently exotic flowmeter – ranging from large-scale oil and gas metering to disposable micro-machines for medical applications, where precise fluid mass dosing is critical.

CFS-10 Flowtube



CFT-50 transmitter

Multi-phase flow

For Henry, however, what's interesting now – given that the science, and the control and sensing electronics is a done deal – is taking Coriolis meters to the next level. And that entails turning these devices to solving the problem not only of dual-phase, but also multi-phase flow, particularly in the oil and gas sector, where metering oil, water and gas in combination is the challenge, and considerable sums ride on its solution.

Henry, who has spent more than two decades in this business, describes working on a sensor validation project in the late '80s. "We were examining faults that occurred on Coriolis meters in two-phase flow and decided to develop a transmitter that would not fail." Sounds simple? Not quite: the key issue with Coriolis meters is stability of the control system.

"The transmitter has to do two jobs: it extracts the measurement, but it also has to keep the tube vibrating at the right phase and its natural frequency. In single-phase flow, that's straightforward, but with two-phase it's much more difficult, because the damping effect of multi-phase mixtures on the flow tubes is up to three orders of magnitude higher than with pure liquids or gases, while the signal to noise ratio is much lower," he explains.

Part of the solution lay in developing a digital

drive, enabling the use of sophisticated algorithms, both for faithfully detecting signals and maintaining the all-important precision of tube motion. But the other aspect was dealing with potentially large measurement errors, as the device sees potentially widely varying media mixes. And for that, Henry and his team turned to neural networks (self-learning computers) for help. "They generate measurement corrections, but the accuracy is never going to be as good as single phase."

Getting round that has been central to Henry's research, and his latest and most promising development, with Invensys, has been a compact Coriolis instrument, integrated with a water cut meter, which is successfully delivering elusive three-phase measurements in the oil and gas industry.

"So far, we've applied this design to net oil testing and wet gas stream metering, with a view to enabling substantial cost reductions and operational improvements," he asserts. "For example, in Texas, we replaced a big three-phase separation tank and metering equipment, on an upstream well testing application, with one Coriolis-based net oil meter. We then achieved once per second measurements on each of three crude oil streams – a significant improvement on the traditional, overall, once-daily measure previously available."

And he claims similar achievements with wet gas on trials in Alberta, Canada, involving enhanced oil recovery, where the requirement is monitoring sour gas, water and oil flows out of the injected well. "Our technology successfully revealed the patterns of flow behaviour that operators need to know, in order to optimise gas injection rates."

Multi-phase Coriolis is only going to grow. Henry describes recently applying the principle to fuel bunkering in the marine sector, where the problem is financial losses, due to air entrainment in very viscous fuel oil.

"Now, Maersk and BP, for example, are accepting that Coriolis may be the solution to a 40 year-old problem, hitherto managed by tank dipping." PE