"Coriolis": the new "black"?

Henry Ford is famously reported to have said "You can have any colour you like, so long as it is black."

The bunker industry has been "instrument free" for far too long. Signs of the inevitable change are evident in the announcement of one shipping company taking unilateral action on quantity issues by fitting coriolis meters on its vessels.

The news was not well received by the suppliers.

There are always dangers from unilateral action; one concern being that the vessels would challenge the supplier's figures only when it was in their interest to do so, perpetuating the mutual mistrust between suppliers and vessels.

What is better is an industry standard that delivers an equable system, properly administered, that favours neither supplier nor vessel, nor any one technology or manufacturer, and that deals with issues of different accounting methods reasonably.

In its February article, "Entering a new Era", World Bunkering reported on a welcome SPRING proposal to address quantity accounting, but the article implies that SPRING is likely to deliver an "any colour you like so long as it is black" type solution; coriolis meters. Sensitive regulation depends on supporting industry initiatives and in this case the supplier initiative is based on coriolis meters, but may we expect other options to be evaluated?

"70% of installed flowmeters are either the wrong technology or the wrong size"

This worrying comment is made in the Control Engineering article "Flowmeter selection: Right size, right design". This doesn't necessarily mean the technology chosen won't work, such as choosing a mag meter for a non-conductive fluid, but it does mean that the technology chosen may well be oversized and/or not the best technology for the application.

In an individual application this may not be too serious a problem, but if it affects an entire industry then the consequences could be far more serious.

Coriolis meters are indeed every bit as good as people say, but they are not a universal solution. The usual methods of deciding on the technology to use should not be neglected. Surely any new standard should be such that the industry is able to choose the most appropriate technology for the particular application? This may include coriolis but surely it should not exclude other choices?

If we are to review this selection then we must necessarily review a range of factors and evaluate each technology against them.

1: Fluid Viscosity:

This is an obvious and defining factor. We quickly reduce the range of possible technologies to just a few that are able to handle bunker fuel viscosities.

This includes Coriolis meters, PD meters and Ultrasonic meters.

2: Accuracy:

The industry needs an *equable* standard, i.e. one that is fair to both supplier and vessel, whatever that is determined to be.

There are many examples of cross boundary metering where different standards apply, but which is appropriate as a model?

Domestic water meters deliver *equable* metering. The accuracy requirement of 2% is consistent with a low value product and it is not based on a single transaction but on a sequence of transactions. It factors in the lifetime performance of the meters.

Forecourt metering (of petrol and diesel) measurement error must always be in the purchaser's favour and thus a very tight accuracy requirement is essential to minimise the give-away of high value dutied and taxed product.

Fiscal metering is intended to deliver performance suitable for high value, duty payable products with optimum single transaction accuracy.

But which concept best fits bunkering?

Conventionally, mass is determined from the volume measured by tank dipping, the density reported in the BDN and the temperature at which the fuel is delivered. In the marine industry the density readings are rounded up to the nearest 0.5kg/m^3.

Tank dipping is wide open to both inadvertent error and deliberate fraud but obviously, where well conducted, it has delivered an acceptable accuracy (till now?).

Taken together, the existing volume and density measurements suggest that the industry doesn't *need* a full blown fiscal standard. Bunker fuel is not petrol. So what accuracy is required?

The industry might consider that a good accuracy could lie somewhere between 2% and 0.1%. SPRING is apparently suggesting 0.5% accuracy. Is this based on the industry's needs or the capability of the chosen technology? Does it restrict choice under some conditions?

In fiscal applications we are not limited to a single technology: our possible technologies of coriolis, ultrasonic and PD are all capable of delivering 0.15% accuracy but the accuracy the industry chooses need not be the best accuracy of which the meters are capable, it may permit the use of less expensive meters designed for lower accuracy.

So is 0.5% too low or too high? What are the penalties of setting the wrong standard?

3: Operational Factors:

This involves a range of considerations. This may well be the source of most wrong choices where the supplier does not fully appreciate the application and the purchaser does not fully appreciate the pros and cons of each technology option.

In bunkering we might isolate two key factors:

3.1 Pressure drop:

Pressure drop is already an issue for bunkering but consider where the industry is going:

- Bigger vessels with larger stems and higher lifts
- Faster turnarounds (higher flowrates)
- Higher viscosities (500 cSt increasing in popularity because of cost)

All these trends have one common consequence: they each introduce higher pressure drops.

If we rank our choices according to pressure drop, Ultrasonic are the best because they have no more pressure drop than the pipe they replace; PD are next, but already a problem; and coriolis have the least favourable pressure drop.

The lowest pressure drop meter is not an automatic choice. Coriolis are not necessarily excluded.

One way to improve the pressure drop is to find some suitable combination of pump size and meter size or, in bunkering, to elevate the fuel temperatures. Already, some vessels are over-sizing coriolis meters in an attempt to address this issue, but does this involve unnecessary compromises? And what happens if both the vessel and the barge have coriolis meters?

We still have our three technologies as options, but cost is now likely to be a more significant factor in determining the optimum solution.

3.2 Air:

The “Cappuccino Effect”, the entrainment of lots of bubbles that “inflates” the measured volume, and air pockets. Handling air pockets is a problem for all technologies and all generally have the same range of solutions.

So is the real differentiator the “Cappuccino Effect”?

How can we deal with the cappuccino effect?

- Remove the air?
- Meter the fluid with entrained air?

Remove the air:

Getting air out of a heavy fuel oil is far from easy due to the high viscosity.

This suggests that the only option is to meter the fuels with the air in them.

If it is, it would eliminate Ultrasonic meters, but it might still leave PD meters as an option with a suitable accuracy budget.

But before looking at this approach, we should ask if this is the only solution?

It is important to understand:

- *Entrained air is not intrinsic properties of fuels.*
- *Residual fuels leaving the refinery do not have air in them.*

Air is introduced either inadvertently or deliberately. (It was reported that in trials in Singapore, air was found to be deliberately introduced).

Thus there is a third option, to prevent air being entrained.

Preventing the Cappuccino Effect:

In an “instrument free” industry air is a serious and possibly widespread problem, but with instrumentation?

Air is very easily detected by most vibrating element sensors, including (conventional) coriolis meters.

The (see: http://viscoanalyser.com/page35a.html) plot is of real time data from a digital viscometer. It shows both the density at 15ºC and kinematic viscosity at 50ºC.

In the first half of the bunker the "cappuccino effect" is easily recognised in both measurements. In the central part of the bunker the fuel is air free. (The final section shows the effect of air blowing or pockets of air passing the sensor).

Once this sort of information is visible, prevention is easy.

If it is due to poor operation then new operating procedures will solve the problem.

If it is poor equipment layout, e.g. fuel delivered by sparging, rather than stilling, then the solution is relatively easy and comparatively cheap.

Once fixed the problems should not recur.

If it is due to deliberate fraud, then simply stopping bunkering the moment entrained air is detected prevents the fraud.

Fraud depends on being undetected and profitable. Once entrained air is "visible" it is neither. It is probable that if entrained air coriolis meters are used, the problem will rarely again be presented.

Note *that just as the online sensor cannot report the true density and accuracy when there is air, unless specially handled e.g. centrifuged to remove air then remixed, samples taken for offline measurements will also give false low density and false high viscosity values and the ignition index (now a feature of the new ISO 8217 standard) will be suspect. Maybe entrained air shouldn't be tolerated no matter if we can measure mass accurately or not and, just as quantity accounting is coming under scrutiny, is quality measurement far behind?*

Meter the fluid with entrained air:

There is more than one technology we can use.

The solution on offer at the moment is special versions of the coriolis meters that can measure the mass of the fuel even if at reduced accuracy.

An alternative is to use PD meters with EGA (Entrained Gas Amplifier) Density meters.

The PD meter may accurately record 100m^3 delivered but the fuel volume fraction is unknown. If there is a 50/50 ratio of fuel to air and the fuel density is 950kg/m^3, then this is going to contain only 475kg of fuel and not 950kg.

But if we don't know the volume fraction or the fuel density, what then?

An EGA (Entrained Gas Amplifier) densitometer will report the density as 475kg/m^3 and the mass is calculated as 475kg (the mass of air is negligible, so in effect we have the mass of fuel) and we need to know neither the fuel density nor the volume fraction.

In either case, coriolis or PD meter, there is a necessary accuracy penalty.

It is inferred from the proposed standard that for coriolis meters this is 0.5%. For PD meters the accuracy is the combined volume accuracy and density meter accuracy, which for the EGA densitometer is 0.5%, i.e. perhaps 0.6-0.7% overall.

Is 0.5% too tight a cut off for accuracy even if we accept metering as the necessary solution? Should we expect an accuracy that allows a lower pressure drop solution?

Summary:

This is the point at which the industry needs to decide what accuracy it wants or can afford; to decide if air is a real problem or not; to decide if headloss is a serious enough issue to worry about and to start working out the costs associated with each technology choice.

The "cappuccino effect" is not an insoluble problem and thus it is not a unique differentiator between meter technologies. Some may prefer to prevent air and others to manage it.

If the "cappuccino effect" can be prevented then greater accuracy is possible, if it is needed. If it cannot, then is 0.5% a suitable compromise?

Perhaps the most important factor will be installed costs. Prevention may require some capital investment. This has to be balanced against the costs of metering air entrained fuels and those costs must include the issue of pressure drop and the future direction of the industry.

If headloss is to be minimised using larger pumps, meters, pipes or even high fuel temperatures, this will be expensive.

The optimum answers will likely be different for different operators and different bunker supply options.

The industry needs to be able to choose the best solution for the individual application. More colours than "black" are needed and if just one colour, maybe it shouldn't be black.

Suggested read:

The CBI.DK MPA story here (http://cbi.dk/images/pdf/MPA%20-%20CBI%20In-Line%20Blending%20Trial%20Project%202009-2010.pdf)

Control Engineering Article: "Flowmeter selection: Right size, right design"
http://www.controleng.com/index.php?id=483&cHash=081010&tx_ttnews[tt_news]=6047

Daniels: http://www.chem.info/Articles/2010/10/The-Challenges-of-Viscous-Fluids/

Ultrasonic meters (coriolis and PD meters should be more familiar):

1. Siemens Sitrans FUT 1010: upto 2,800 cst (https://www.automation.siemens.com/w1/automation-technology-inline-flow-18656.htm)
2. GE Panametrics Sentinel LCT: upto 500cst as standard, higher on application (http://www.gesensinginspection.com/en/flow/ultrasonic-custody-transfer/sentinel-lct.html)
3. Daniels (Emerson) 3804: upto 1000cst (unspecified but higher for some applications) (http://www.daniel.com/products/liquid/usonic/Model%203804%20Liquid%20Ultrasonic/Productdetail_1.htm)
4. Cameron LEFM 280Ci: assumed to be upto 1000cst but they are fussy about linking this to Reynolds numbers. (http://www.c-a-m.com/Forms/Product.aspx?prodID=cd6a7a04-3d7a-4624-b8fe-07f96e2b1e8a)
5. Krohne Altosonic V: upto 400cst (and still custody transfer, this specifically declares heavy fuel oils as an application) (http://www.krohne.com/ALTOSONIC_V__Ultrasonic_Flowmeters__en.162.0.html)