Internal Memo

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Re: Development of the 0.455 exponent in regards to the VAP³® Pitot Design

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Back in the early phases of the design, I realized that the parallel plate pitot (EI patent # 5402687) would work well in a particulate environment by changing the location of the pressure ports to all downstream, i.e., neither the high or low pressure ports should face upstream. Initial testing indicated that the flow signal was not exactly proportional to the square root of the pressure drop between the two chosen port locations. Once I realized that the signal would not be exactly a square root value, and accepted that fact, time was spent optimizing the port locations for two main attributes-- (1) insensitivity to Reynolds number in the operating range, and (2) maximum resistance to plugging, while still being able to take advantage of our velocity averaging design (EI patent #5753825).

Since plugging is such a detrimental issue to all standard pitots with upstream facing ports, I felt that if the power required was not exactly 0.5, it could easily be calculated in a DCS system. Modern computers are very good at calculations---let them calculate and optimize the mechanical design for the best operating attributes and robustness.

The only real drawback is that multivariable transmitters on the market lumped all the calculations together under the square root term, and do not allow either separating density and dp and/or raising to any other power. They will, however, usually transmit all three variables as individual values, which the DCS can then calculate.

To avoid the problem of the unusual power, we designed and built a system which has all three transmitters (dp, static, and temperature) and then computes the mass flow rate based on raising to a power rather that an exact 0.5 (this is the quoted EI Differential Pressure System (DPS)). The output is then mass flow. Its main drawback is that it is slightly more expensive than a standard multivariable transmitter.

We have contacted Rosemont, Honeywell, and Yokogawa to see if they would add this feature to their multivariable units. Only Honeywell responded positively that they are looking at the assembly code to see what would be required.

Additionally, when installed in our High Beta® Flow Element, (EI patent #7228750), the performance of the VAP® pitots are enhanced by the flow profiling and straightening characteristics of the High Beta® Flow Element's design.

The initial pass on determining all powers and coefficients resulted in a dp power value of 0.465. Later test and analysis of the data indicated that 0.455 was a slightly better fit, which would result in less that 1/2% difference between the two values over the entire operating range. Additional testing with more accurate references may result in minor adjustments even though it is felt that the current equations are more than accurate for the current industrial market.

All head meters need to be calibrated against known standards-- this is the way all the coefficients for flow nozzles, orifices, etc. were obtained.

Even so, we are embarking on a test program at CEESI (Colorado Experimental Engineering Station), located outside of Ft Collins, CO to improve our values. This is being done at the request of the Navy,

since AMCA will only claim absolute uncertainties in the order of ±5.0%-- which were able to confirm with a test there earlier this year.

Also, CEESI can go to a flow rate of ~1,000,000 lbs/hr (about x2 what AMCA facility is capable) at 0.5% uncertainty, traceable to NIST and certified by MVLAB. After reviewing all options, we feel that the only valid certification to theses accuracies requires NIST tractability. While this is much more than is needed in the current industrial market, we, at Eastern Instruments, believe that improvements should be made to accommodate the future.

Our system, in my opinion, is the first real advance in plug resistant pitot technology (if indeed you call it a pitot since it does not follow Bernoulli's equation) in the last 30 years. I should know, since I have designed the vast majority of pitots in today's market.

I hope this helps explain our VAP® pitot and the theories behind my design. If not, feel free to contact me anytime.

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