Proper Validation of Filter Test Stands is Critical for Product Development Programs

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Garbage in equals garbage out. The age-old adage that has been repeated in many undergraduate engineering courses for the past decade is still an important principle to remember for many of today's engineering challenges – including filter testing.

Today's designers rely heavily on testing and simulation data coming from a number of sources around the globe to make their design decisions. If today's designers are basing their decisions off of "garbage," what can we expect as an end product? With poor testing and simulation data, the starting point for future development and designs has already been skewed.

SIMULATE DESIGN TEST VALIDATE

Global manufacturers work hard to utilize an iterative validation process for new product development. Unfortunately, more often than not, the simulated results vary significantly from the physical test data. The two areas that contribute to the majority of these discrepancies are:

Too often in new product development there is a misunderstanding or misinterpretation of the true physics within the device or system being developed, tested, and measured. The produced results show test data that can differ from original simulation models and data by as much as 100%

Data acquisition inaccuracies due to electronic noise and accuracy of the test instruments used may occour.

So What Are the Major Factors That Influence Test Accuracy and Reliability?

Based on Chart 1 from ISO 16889 we can see the many factors that affect testing results. Some of the most challenging being: viscosity, differential pressure, solids loading, and flow rate.

FILTER TESTING CONDITIONS

Monitoring testing conditions and parameters is certainly an important step to insure accurate results. Specifically, viscosity plays a most important role and, as a temperature-dependent function, temperature must be precisely monitored and controlled, typically within 0.5 degrees. Uncertainties in temperature measurement can lead to more than 8% uncertainty in the measurement of pressure differential.i Likewise, flow rate measurement is another important parameter shown to have high-impact on the influence of retention capacity.

For every parameter however, it typically boils down to the accuracy of instruments and data acquisition software. This can vary as high as 10% (or more), and should be carefully calculated and accounted for when performing and analyzing tests.ii

SIMULATION DATA

Similarly, simulation and CFD analysis is becoming a more and more widely used tool in a design engineer's toolbox. However, the level of detail, and nuances of setting up a computer simulation, varies from software to software, including mesh size and mesh controls, operating conditions, input parameters and even the features of the CAD model.

Instrument Accuracy and Test Condition Variation

Test Parameter	SI Unit	Instrument Accuracy of Reading (±)	Allowed Test Condition Variation (±)
Conductivity	pS/m	10%	-
Differential Pressure	PA, kPa or bar	5%	-
Base Upstream Gravimetric	mg/l	-	10%
Flow			
Injection Flow	ml/min	2%	5%
Test Flow	l/min	2%	5%
APC Sensor Flow	l/min	1.5%	3%[1]
Kinematic Viscosity[2]	mm^2/s	2%	1 mm^2/s
Mass	g	0.1 mg	-
Temperature	°C	1°C	2°C[3]
Time	SI Unit	1 s	-
Volume			
Injection System	l	2%	-
Filter Test System	l	2%	5%

1 - Sensor flow variation to be included in the overall 10% of allowed between sensors.

2 - 1 mm^2/s = 1 cSt (centistroke).

3 - Or as required to guarantee the viscosity tolerance.

Chart 1

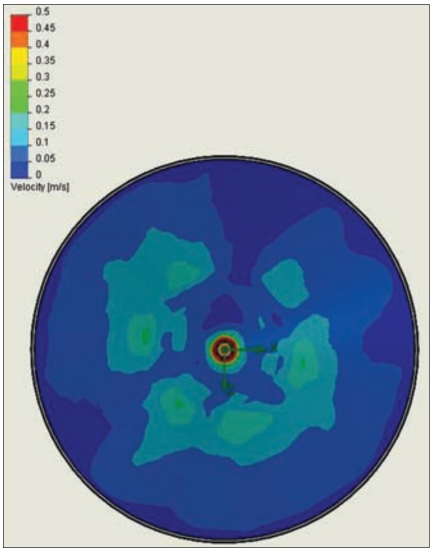
TEST STANDS

Not all test stands are equal. Recent discrepancies in testing between labs caused our experts to look more closely at the differences between filter test stands. We had heard that with some stands the injection circuit reservoir did not mix well and test dust was often found in the bottom of the reservoir after testing during cleanup. What we found is that differences in tank mixing design approaches produced different results. Test dust, which settled on the tank bottom was assumed to be injected and therefore would over state the dirt holding capacity of the sample test filters.

Near zero fluid velocities on the injection tank inner surfaces indicate less than adequate mixing.

TEST DUST

Correctly selecting test dust and understanding the differences between them, is an important step in filter test-



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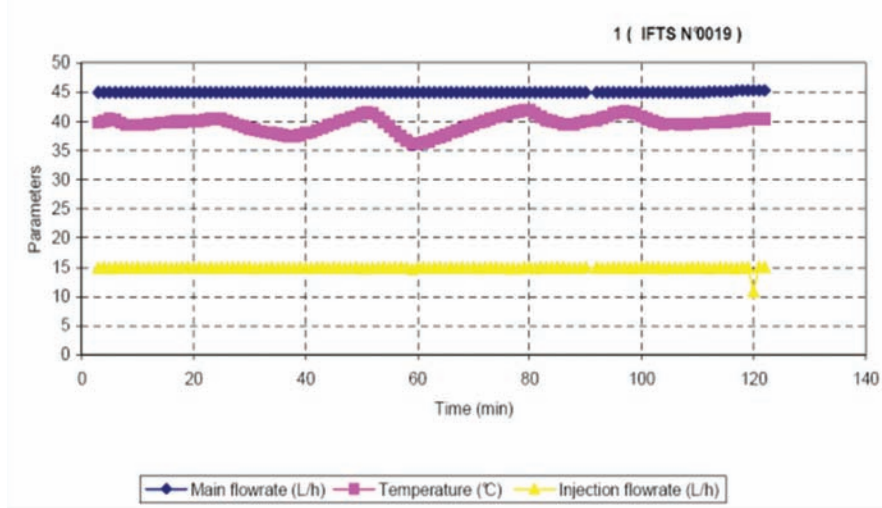

Chart 2.

ing and can contribute significantly to the level of uncertainty in filter testing. All international filter-testing standards clearly identify the test contaminant (test dust) to use. Some examples include:

SAE ARP 4205 Aerospace Fluid Power - Hydraulic Filter Elements - Method for Evaluating Dynamic Efficiency with Cyclic Flow uses ISO Fine Test Dust per ISO 12103-A2.

NSF/ANSI 42 Drinking water treatment units – aesthetic effects requires ISO Fine Test Dust per ISO 12103-A2 for filter ratings from 1 to 80 micron and ISO Course Test Dust per ISO 12103-A4 for filters rated up to 120 micron.

ISO 16689 Hydraulic fluid power filters — Multi-pass method for evaluating filtration performance of a filter element uses ISO Medium test dust per ISO 12103-A3.

Not only is the test dust used a contributing factor to repeatable test results, but so is the concentration of the test contaminant. In many specifications this is called the Basic Upstream Gravimetric Level abbreviated BUGL and reported as mg/l or ppm. Online particle counters are affected by concentration and dilution is used to maintain consistent results. Most standard fuel oil, diesel and hydraulics filter testing use BUGL between 5 – 15 mg/l.

Repeatability is the measure of the variation of outcomes in an experiment carried out using the same conditions. Repeatability and Reproducibility are important factors to consider, and can be maximized by taking proper care in setting up identical testing conditions. Additionally, post-test validation, either with previous data, simulation data or estimated results, should be conducted. As a final check using a control chart for statistical analysis will show if the process is within the desired level of repeatability.

Chart 2 shows temperature, injection flow rate and main flow rate.

Ultimately, the best way to get consistent results between filters is to always test within the same operating conditions. This includes the same test setup, particle counters, apparatus and dust. There will, however, always be some level of uncertainty, which will need to be accounted for. However, understanding and estimating this uncertainty with a reasonable level of accuracy will provide a better starting point for designers and design decisions.

Engineers must realize that even when following the above recommended guidelines, sometimes we design experiments that are too large and complicated to validate in a pragmatic cost effective way. With a recent system being developed at Sigma Design, the team had no way to validate the simulation and experimental field-testing of the entire system. The solution was to simplify the problem. By breaking the system down into smaller problems, the team could validate individual components on a simplified scale, before moving up to testing the complete device.

If one understands the challenges in data collection and recognizes testing and validation problems early on, engineers can usually develop a smart and useful solution.

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IFTS is an independently regulated laboratory and research center for liquid filtration and separation science. IFTS has locations in Europe, the USA and China, providing filtration testing and research services to many industries.

Sigma Design Company develops and builds new products, prototypes and specialty equipment. Sigma Design provides clients with cost-effective mechanical engineering, electronics PCB, controls and microprocessor development, manufacturing engineering and laboratory services.

References

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