Listening for Leaks

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NI Products Used:
LabVIEW 2012
cDAQ-9172
NI-9205

Category:
Life Sciences
Automated Test

The Challenge
The customer wants to create a more effective way to detect leakage on filter masks. The current technique is messy, provides limited information, and can only be done in controlled environments.

The Solution
Paving the way with new information and more realistic tests, a new method for measuring filter mask fit was demonstrated, using LabVIEW, cDAQ, and ultrasonic sensors.

Introduction
Data Science Automation (DSA) is a premier National Instruments (NI) Alliance Partner that specializes in automating and educating the world leading companies. Clients choose DSA because of DSA's deep knowledge of National Instruments products, disciplined project development process, its staff of skilled Certified LabVIEW Architects and Certified Professional Instructors, and its unique focus on empowerment through education and co-development. DSA has long been the leader in respirator testing, working with the government organization that defines and administers the certification tests and the manufacturers who develop and produce masks for a variety of uses.

The client had observed a misleading conclusion in the current rating system of particulate masks. The established "fit factor" measurement was limited. The fit factor did not adequately communicate the quality of the seal to all users' faces.

The current standard for fit factor testing is done by atomizing corn oil into the air within a test chamber where the test subject's stand connected to particle analyzers during the course of the test. The test subjects breathe through masks equipped with a sensor probe that pierces through the material to sample the amount of oil particles that breached the mask. The probe itself required the mask to be modified to some degree to test. The measured results are compared to a probe reading the amount of particles in the test chamber to determine the fit factor. This testing did not allow the test subject much mobility, partly due to the probe being connected to the analyzer, and partly due to the area where the corn oil is dispersed.

The root problem that had been noted was that a fit factor rating of 100 only covers about 95% of the people that wear the mask. So even if a mask achieves a rating of 100 it will not fully fit everyone that needs to wear it. The fact is that different styles of masks are produced by different vendors and that every person's face is different. The goal of the new test was better correlate a relationship between the measured fit factor and real world performance. The new data would better measure the fit of wearing the mask while working or performing a task in real world applications over an extended time.

For help developing a system for a new way to quantify fit, the client chose Data Science Automation due to a long standing relationship and a proven track record of successful projects.

Using ultrasonic sensors to detect the differences in the sound levels inside and outside the mask was at the heart of the new measurement. The researcher was faced with the challenge of providing a known source of sound that could be detected without adding extra equipment to the existing mask. It was determined that the sound created by the test subject breathing thru their noses could be used as the sound generator. The test would be conducted by placing transducers around the mask to read levels of transmitted breathing noise. A base line sensor was placed inside the center of the mask. A series of reference and detection sensors were placed along the masks edge. Each set of samples included the base sensor and the two outlying sensors. The data was collected at 60 kS/s to help avoid aliasing of the sounds produced by respiration. The turbulence of the air going through the fossa creates a source sound for the measurement so each set of sensors needed to be read at the same time.

The equipment that was used for the initial round of testing allow for a limited number channels. Once the data was collected, the system compared the baseline, reference, and detection values. The comparison was achieved by converting the waveforms into an RMS value then subdividing them to quantify the differences in the noise levels. Using this method it was possible to determine the total amount of leakage the mask allowed. Additionally, the new process makes it possible to determine the location and amount of leakage. This information will allow more focused work when improving the mask design. This kind of information was not available using previous practices.

Now that the idea and the science have been proven the work of establishing the new gold standard begins. Going forward the goal is to reduce the measurement and logging equipment to allow the test to be worn in real world situations, for longer periods of time, and in a wider range of environments. The test equipment could even wirelessly transmit live data to a monitoring station. Tests will be able to run over longer durations as the mask will not need to be cleared of existing corn oil let in during earlier parts of the test.

The National Instruments products allowed for quick prototyping using readily available off the shelf parts. The NI equipment was able to perform the higher rate synchronous measurements needed for the test. The tools ability to show the live measurements allowed the sensor placement to be refined allowing the researcher to get to meaningful results faster. Going forward much of the existing DAQ and analysis routines can be reused as the testing of fit factor goes from desktop to wearable.

The end result is to produce new insights into the fit of the mask to different individuals under different conditions. By detecting and quantifying the location of the leaks in the mask, we hope to improve the mask technology to provide better protection for particulate filter mask users.

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Figure 1-This is a typical type of mask that would tested with the new ultrasound setup.