A Global Shift in Automotive Part Cleanliness Monitoring

Marion T. Graf and Bernhard E. Heneka of RJL Micro & Analytic GmbH
and Sue Benes of FEI
As the automotive industry transforms with new technologies, timely, accurate, and quality production becomes increasingly critical to manufacturers. The evolving nature of the industry has resulted in stricter standards concerning cleanliness in the fluid circuit and most other components of road vehicles such as brake systems, fuel injector nozzles, power steering pumps, and fluid hoses. An important part of the challenge is to develop and monitor adequate automotive part cleanliness.

How do manufacturers know if their cleanliness protocol is performing optimally?

As the physical sizes and tolerances of manufactured engines continue to shrink with fuel-efficiency concerns that result in lighter engines, quality-conscious manufacturers find it increasingly necessary to ensure the critical cleanliness of their parts and processes. Possible issues associated with component contamination can cause both long- and short-term limitations in vehicle performance. Further, components must be proven 99.9% reliable to avoid an increase in warranty costs, creating manufacturer interest in reducing these lapses in performance. Before they can minimize performance issues, however, manufacturers need a system to specify the contaminants involved and the source of the contamination.

ISO (International Organization of Standards) developed 16232-07, which is based on VDA19-2. This set of general specific directives for contamination testing of fluid components in road vehicles regulates which particle extraction methods and measuring equipment must be used. Adhering to standardized regulations creates mutual understanding between manufacturers and customers.

European and American manufacturers lead the automotive industry in adherence to the ISO mandate, resulting in an explosion of innovative techniques for determining the cleanliness of fluid components. Gravimetric analysis, a traditional testing method for part cleanliness, calculates the total mass of contaminants, reducing cost and providing clarity. However, this method fails to produce individual particle data such as size and shape or even composition. As a result, components with tight tolerances may pass gravimetric testing yet still fail to function due to small particles which typically are not recognized in gravimetric testing. As a result of higher precision components, some manufacturers are already seeing “dangerous” abrasive contaminants that are just 2 μm (70-µin) in size which would never be detected via traditional gravimetric methods.

Knowing More from the Data

Microscopy provides efficient, accurate microanalysis that identifies size, shape and chemical composition of particles. By sizing and quantifying particles, this method produces the information manufacturers need to identify problem particulates and more importantly, can help them know the source of contamination. The automated SEM/EDX (scanning electron microscope/energy-dispersive X-ray spectroscopy) method supplements contaminant information by providing the elemental composition of

↑ Lodged Particle. SEM image of particle found lodged inside a nozzle resulting in blockage of fuel flow.
each debris particle over an entire sample. Discerning the elemental composition of these microscopic particles assists in discovering the contaminant origin and, subsequently, changing processes which will minimize the quantity of contaminant present. Also, knowing the composition of contaminant particles affords concrete information that allows manufacturers to conduct quality control analysis and attempt to improve their production process while eliminating risks associated with fluid circuit contamination.

Particle Contamination. Aluminum Oxide particle contamination traced back to an abrasive used during the cleaning process.

When a manufacturer needs to verify that its product is suitably free of a specific kind or class of particulate contaminant, such as a toxic or abrasive material, other methods can waste time analyzing “benign materials” in the sample, decreasing accuracy and delaying production. Automated and integrated microscopy allows for rapid search of large areas in a sample, targeting problem particles while disregarding the “empty” space the sample contains.

By appropriate selection of the back-scatter contrast thresholds and the dynamic search grid, large areas of empty sample can be rapidly traversed without sacrificing sensitivity to the “bad actors.” The analysis can automatically terminate when the necessary precision is fulfilled, and go/no-go decisions can be automatically generated. These systems can also rapidly characterize large numbers of particles, employing user-defined rules to automatically classify particles in appropriate classes, and include provisions for employing or suppressing elemental analysis and storing thumbnail images for post-analysis.

The Simplification of SEM/EDX Analysis

While often SEM/EDX instruments are found in research laboratories being utilized by highly trained SEM specialists in a unique environment, this no longer is the case. FEI is pleased to introduce the new CleanCHK™ analyzer – the first fully automated particulate contamination monitor designed specifically for automotive applications. With automotive cleanliness inspections becoming more of a requirement rather than luxury, CleanCHK provides what other technologies like gravimetric and optical analysis can’t, including particle size, shape and most importantly chemical composition.

Implementing CleanCHK in your automotive manufacturing process means that no longer is it a requirement for specialized personnel to monitor and use the instrument. CleanCHK allows an administrator to set up the calibration and testing sequences and have this stored in the instrument so any operator can simply load the samples, initiate the run sequence. Once activated, the instrument takes over and the user can literally walk away and come back when the samples are completed. This eliminates the need for the user to manually run calibration and set up the instrument, freeing them up to resume their normal duties while the samples are being tested.

The International Organization of Standards (ISO) developed 16232-07 based on VDA19-2. These two directives give guidance for monitoring and reporting particle cleanliness in automotive or fluid components. FEI understands that while many manufacturers adhere to these guidance documents, some flexibility is
required to allow users to incorporate their own quality standards. CleanCHK reporting module was designed with this in mind to allow production engineers to comply with ISO16232 and VDA19 or incorporate their own standards. The reporting module also automatically classifies each sample according to the component cleanliness code which is also in compliance with the standard. Because of the vast flexibility of the module, reports can be generated using only the larger particles or viewing data through histograms.

As consumer and engineering demands for “smaller, lighter, faster” continue to increase, so will increased importance of cleanliness in parts with lower thresholds for contaminants. The ISO standards for contaminant particles during manufacturing have met these industry changes with equally progressive customer-specific directives. While traditional methods to meet these standards aid in the process, FEI’s new CleanCHK analyzer provides rapid, automatic identification and detection in quality control. What’s more, the data-driven knowledge, and not just information, derived from this analysis provides a firm foundation upon which confident decisions can be made to improve the production process and minimize the risks of contaminants in automotive manufacturing.

For instance, an automated instrument can easily produce a deluge of data that would be overwhelming without the aid of appropriate report-generating software that consolidates the measurements into readily interpreted metrics and trends. Ideally, such reporting software is further structured—i.e., customized—with knowledge of the particular kind of application so that the reports express the metrics most important to the automotive industry and specific application being served. Furthermore, the ability to access historical data from stored reports allows for long-term trend analysis that, over time, aids in a continuous quality improvement process.