The real reason why the automotive industry needs technical cleanliness analysis

Quality control or process monitoring?

When manufacturing a complex mechanical machine, it is crucial that every single component adheres to the highest quality standard and always behaves as expected. However, guaranteeing high quality is sometimes a harsh challenge that requires substantial investments and engineering.

To minimize the waste and improve factories' productivity, quality control has evolved from a verification step at the end of production to an active inspection of the environmental causes of the failure of certain components. This approach goes by the name of process monitoring and it includes a series of activities aimed at preventing the manufacturing of parts that would not comply with the quality standards.

Particles in manufacturing: A quality engineering nightmare

One of the most common inspections performed to guarantee high component quality is the technical cleanliness analysis. This is performed according to the ISO 16232 or the VDA 19 (for the German market) and it consists of inspection of the manufactured components for the presence of contaminating particles.

These particles pose a threat to the correct and long-term function of mechanical devices, as they can create scratches, obstruct nozzles, or short-circuit contacts. For this reason, the analysis is of critical relevance in the manufacturing of all components used in fluid circulation systems, high-speed moving parts, and printed circuit boards (PCBs).

To guarantee that the components are not introducing particles in the mechanical devices, several components that are considered as a reference for a batch are analyzed for the presence of contaminants.

This analysis consists of three phases:

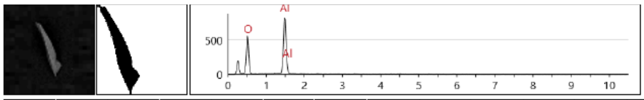
1. The part(s) is extracted from the production site and washed in a technical part washer using organic solvents to ensure that everything is removed from the sample.
2. The water containing the contaminants is filtered to capture all the particles on a filter (usually nylon or nitrocellulose, 47 mm in diameter).
3. The filter is then prepared for analysis and scanned with a series of instruments to determine the amount of contaminants.

The contaminants are then analyzed and compared with acceptance thresholds that determine whether any kind of maintenance intervention inside the factory is needed to avoid producing parts that would later be scrapped because they do not adhere to the required quality standard.

The user's reasons for deciding to do technical cleanliness analysis

Mr. Nobuhito Fukasawa, Chief Engineer, directs the manufacturing operations at a large company in Japan that manufactures air conditioning systems for automotive applications. His team has implemented a Thermo Scientific™ Phenom ParticleX™ TC Desktop SEM (scanning electron microscope) with energy dispersive X-ray spectrometry (EDS) in their manufacturing environment and rapidly extended the use of the instrument to all their other manufacturing sites worldwide. We asked Mr. Fukasawa to share something about the reasons behind his choices and what advantage it brought his team, and Mr. Fukasawa kindly shared his insights.

The secret behind the success of many Japanese manufacturing companies is the unparalleled dedication to achieve the highest standards for quality, and these users are no exception. When asked about the reasons behind the introduction of the analysis in their manufacturing process, Mr. Fukasawa promptly responded, “To protect the product performance.” He explained how the presence of small particles with high hardness has a negative impact on the correct and expected lifetime-functioning of their components. “Small particles can jam the movement of components when entering the clearance between parts,” he mentioned as one of the many negative effects that contaminants in the production environment may have.



Rank	ID	Size (µm)	Width (µm)	Class	X	Y	Aspect	Area	Roundness	Form Factor	EdgeRoughness	ECD
7	8	95.939	67.034	Al2O3	-8.103	41.559	1.431	4743.889	0.656	0.719	0.378	77.718

Figure 1. The image of an Al2O3 particle and its EDS spectrum. Phenom ParticleX uses these information to characterize the particle chemical composition and its morphology.

The user’s growing experience with technical cleanliness

Mr. Fukasawa’s team was not new to technical cleanliness analysis. “We used to analyze the weight of contamination [with gravimetric analysis] and count the number of particles [with an optical microscope],” Mr. Fukasawa said when describing the challenging task facing his team.

With the introduction of an SEM and EDS, “We can now investigate the presence of smaller particles, as well as distinguish particles with high hardness, which have a severely negative impact on the product performance.”

Hard particles, such as Al2O3, SiC, SiO2, and glasses are among the most dangerous contaminants, as they are more prone to creating scratches on surfaces or jamming moving components. The challenge with keeping such materials under control is that some of them have high transparency or low contrast (compared to the filter), and they cannot be detected with optical microscopes.

The SEM with EDX automated solution allows users to identify every contaminant and to extract their chemical composition, which then translates to which materials the particles are made of. This allows Mr. Fukasawa’s team to precisely monitor the number of hard particles collected in the washing process.

“Thanks to the information about particle composition, we reduced the risk deriving from hard particles and improved our product line in ways that were not possible before.” Knowing the chemical composition of the contaminants allowed Mr. Fukasawa’s team to identify the source of contamination and operate on it before the contaminants in the part could reach critical levels.

This preventive approach helped Mr. Fukasawa’s team increase their productivity and, at the same time, reduce the amount of scrap parts, saving costs and reducing their environmental impact by saving raw materials. “We have quickly reached our return [on] investment thanks to the speed of the analysis,” said Mr. Fukasawa. Making critical information available quickly is crucial to timely intervention on the production line.

“The systems are running even more than 20 hours a day,” he explained. “And we plan on using it in the manufacturing of new components,” which will reduce the time-to-market for the company’s new product line.

The relationship between Mr. Fukasawa’s team and Thermo Fisher Scientific has grown a lot in the last two years, and the results of the cooperation between the companies led to an increase in the cleanliness grade that his company could achieve and certify for their manufacturing. Thanks to the constantly improved Phenom ParticleX Desktop SEM + EDX, which is now the fastest particle analyzer in the market for technical cleanliness, and the one with the highest repeatability, has resulted in more precise materials analysis and faster time-to-market for Mr. Fukasawa’s team.

Particle Results

Size Class		B-C	D	E	F	G	H	I-J
Size Range (um)	Total	5 ≤ X < 25	25 ≤ X < 50	50 ≤ X < 100	100 ≤ X < 150	150 ≤ X < 200	200 ≤ X < 400	400 ≤ X < 1000
Glass	119		64	49	4	1	1	
Al2O3	111		34	68	9			
Si Rich	99		96	3				
SiO2	9		7	1		1		
Ca-Aluminosilicates	5		3	1	1			
Aluminosilicates	4		1	2	1			
Steel	2		1	1				
Oxidized Al	1		1					
Misc	19		12	6			1	
Mineral	3		3					
Non-Ferrous Metal	1		1					
Misc Salts	7		7					
Total Counts	380	0	230	131	15	2	2	0
Cleanliness Level		00	8	8	4	1	1	00
Component Cleanliness Code (CCC):		V(B-C00/D8/E8/F4/G1/H1/I-J00)						
Specification:		V(B-C00/D10/E8/F4/G3/H3/I-J00)				Pass specification		

Figure 2. An example of the reporting capabilities of Phenom ParticleX where the particles are sorted by chemical composition and size distribution. The different color separate the particles by hardness. Glass, silicon carbide, aluminum oxide and silicon oxide are among the hardest materials commonly present on the production floor.

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