A New Cleaning Concept: Flexible Solutions for High-Performance Engines

Matteo Ducceschi

Tecnofirma Spa (Monza, Italy) 🖂 matteo.ducceschi@tecnofirma.com



Opening photo: The layout of the plant, equipped with a mechanical deburring unit and five cleaning stations.

he automotive industry is among the ones requiring the highest cleanliness degrees because any kind of contamination can affect the reliability and performance of parts, for example the mechanical components of engines. In addition, car manufacturers

need flexible, compact, and environmentally friendly cleaning with minimum investment and operating costs.

Tecnofirma (Monza, Italy), specialising in the construction and installation of cleaning and coating solutions for the surface treatment industry since 1949, has designed a new concept that meets all these requirements (**ref. Opening photo**). Installed at the FCA plant in Termoli (Campobasso, Italy) in 2016, the plant was specifically designed for cleaning a type of aluminium V6 cylinder engine intended for high-end cars. The close collaboration between the two companies' teams, which worked side by side for this intense co-design project, resulted in a system combining processes that are usually performed by several different cleaning machines, while guaranteeing excellent part cleanliness and occupying a limited space inside the factory.

The characteristics of the V6 engine

The engines for which the system was designed pose high requirements in terms of cleaning process quality, in order to guarantee high performance: downstream of the final cleaning stage, any residual particle can have a maximum size of 500 µm, without any possible exceptions. Moreover, the complexity of the project was due to the structure of the engines themselves, composed of six different elements, i.e. underbase, base, left and right heads, and left and right overheads (Fig. 1), and to the need to actually treat the components of two different types of engines, i.e. a 4x4 drive one and a rear-wheel drive one. The new concept was therefore based on the need to build a single system capable, on the one hand, of perfectly cleaning both engine types both during the machining process (interoperational stage) and at the end of it (final stage) and, on the other hand, of quickly adapting to any production planning requirement in a reactive way.

Another challenge was related to the fact that each of the six elements to be cleaned can be arranged in eighteen different configurations. That is why twenty-eight cleaning and handling programs were set in the machine. This gives maximum flexibility to the operators, since they only have to position the workpieces in the loading station and select their related program, thus avoiding any downtime that could compromise the regular production flow.

The layout of the cleaning system

The plant covers an area of about 11 x 8 x 4 m and it is composed as follows:

- 1 mechanical brush-off station;
 5 cleaning stations performing hydrokinetic, ultrasonic, fixed-position, fluxed, and high-pressure processes;
- 2 medium and high-pressure rinsing tanks;
- 2 drying areas;
- 1 cooling station.

Within the cleaning machine, two robots handle the components along the different process stations. This is made possible by the plant's compact design, which guarantees that all processing areas can be easily reached while ensuring adequate accessibility for operators during maintenance. Another key element guaranteeing the system's flexibility is the use of workpiece-holding pallets. The plant is equipped with seven pallets of three different types, i.e. one to transport bases, one for underbases, and one for heads, able to manage all eighteen possible configurations; they all feature conventional gripping points for robotised handling. The pallet loading and unloading stations are located at the beginning of the two rollers that take the parts in and out of the machine. Only the workpieces' arrangement on the pallets and transfer of the pallets themselves between the exit and entry roller are performed manually, in order to guarantee maximum ergonomics for the operators.



Figure 1: The design of the 6-cylinder engine cleaned in Tecnofirma's system.

Twenty-eight custom cleaning programs

Each process operation can be selected or excluded directly from the operator panel, depending on the workpieces' characteristics and the required cleaning stage, i.e. the interoperational or final one (**Fig. 2**). In particular, the hydrokinetic cleaning process is aimed at generally cleansing the surfaces and it is performed at room temperature with a pressure of 10 bars. The ultrasonic one is selected to effectively reach the components' cavities. The fixed-position operation is chosen in the presence of blind holes, with a pressure of 10 bars and an indicative flow rate for each nozzle equal to 10 l/min. The fluxed cleaning stage is selected to treat the through channels of the engines' cooling circuits, as it fills them with the cleaning liquid. Finally, the high-pressure cleaning (about 350 bars) is chosen for a more intensive treatment on oil channels and bush housings, also performed with a special robot that makes sure that all surfaces are reached by directing its nozzle.

Two rinsing stages, the second of which occurs with hot water at 60 °C, follow the cleaning process in

order to warm up the components' surfaces, so as to facilitate drying and the evaporation of any water residue. A dripping phase then takes place, where the robots' movement facilitates the removal of water from the parts' channels, followed by the compressed air blow-off and final vacuum drying phases. Finally, the cooling tunnel at the end of the plant was designed to lower the parts' temperature, still around 50 °C, to make them handleable during unloading and enable the correct execution of the quality controls performed downstream of the cleaning process.



Figure 2: The scheme of the processes implemented on board of the machine.

The advantages of the new system

It is worth to highlight a few advantages brought by the new system, as follows:

flexibility guaranteed by the handling system featuring pallets and two robots, which ensures that, if it was necessary to add further cleaning stages or modify the current ones, any change would take place quickly and effectively (**Fig. 3**); reduced installation and maintenance costs because, instead of having different auxiliary systems for several cleaning machines, all stages are centralised and combined in a single plant; reduced electricity, water, and air consumption, comparable to that of a machine cleaning single components in one step;

possibility to operate with a just-in-time approach for any changes in the production planning; machine compactness for reduced impact within the production site.

"The future is now": the cleaning plant 2.0

Given the results achieved and expecting an increase in the production volume of its 6-cylinder engines, FCA asked Tecnofirma for a second, almost identical plant that will come into operation in mid-2020. Currently under construction, this machine actually has even higher performance than the first one. It will be able to manage five different engine types and it will be equipped with a piece recognition system: the operators will no longer have to select the component type and its cleaning program, the whole process will be further improved, and new phases will be integrated. Like the previous system, this will also be able to be easily reprogrammed according to any customer need that may arise in future.

Conclusions

The need to treat all the main elements of V6 engines, i.e. cylinder heads, bases, underbases, and covers, in different configurations and in different processing phases, together with a limited annual production volume, required the development of an innovative, almost unique machine: a single cleaning system capable of

STABILIZE YOUR CLEANING PROCESS FOR THE EXTRA MILE

The proven MAXISTAB[™]* S-Series – specially developed for the DOWCLENE[™]* 16 Series

- Extended lifespan of DOWCLENE[™]* 16 Series bath
- Safeguard for your cleaning machine
- Increased process stability
- Better cleaning experience

www.safechem.com



™Trademark of SAFECHEM ™*Trademark of The Dow Chemical Company



Figure 3: Plan view of the plant and processes description.

treating a complete engine by performing all the necessary phases, guaranteeing a high flexibility degree, and maintaining the highest cleanliness standards. As proved by the new project currently in progress, the challenge was won brilliantly, also thanks to the fact that the design and development of new systems able to meet the increasingly complex demands of customers and overcome the most difficult challenges posed by the market have always been and always will be Tecnofirma's mission.

Production volumes

Annual production: 10,000 complete engines Daily hours: 22.5 h (3 shifts) Cleaning cycle time: 40 minutes per engine

Cleanliness requirements

Allowed particle size: $\leq 500~\mu m$ Maximum number of particles: 2 over 100 μm Residue weight: $\leq 2.5~mg$

Operating results

Hours worked: 20,000 Engines produced: 32,000 Parts processed: 200,000 Cleaning cycles: 450,000