DFV: A certified and guaranteed coating process with the application of the Industry 4.0 innovations to aluminium finishing

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DFV is a major coater of extruded and rolled aluminium for architecture and an Italian leader in the field of powder-on-powder wood-effect decoration (**ref. opening photo**). With its three plants in Surano (Lecce), Meolo (Venice) and Favara (Agrigento), this firm covers almost the entire national territory thanks to sophisticated logistics, highly computerised production management and cutting-edge coating systems.

This modern and technological approach to contracting coating enables DFV to maintain consistently high quality and service standards. This makes it a strategic partner for window manufacturers, distributors of aluminium profiles and metal architecture designers. Being at the forefront of the coating sector since the late '90s, it could only be among the first companies in Italy to implement the principles of Industry 4.0 and the technological innovations related to it.

In the last two years, DFV has replaced all the spray paint booths of the vertical plants installed in its three facilities with last generation "V"-shaped booths designed by SAT (Verona, Italy). Two patents cover this system, one concerning its layout and the other related to the cyclone cleaning system, which reduces the powder recovery time during the colour change operations. Initially installed only at the Agrigento plant, the new booth proved so efficient that the De Francesco family, owner of DFV, decided to install it also on the vertical systems of the other two factories.

Well aware that nowadays diversification is the key to success, especially for a contractor treating workpieces with very different shapes even within the same product category and working with increasingly small production lots, DFV has chosen to start an advanced industrialisation plan whose requirements can only be met with technologies 4.0, that is, with the interaction among machines. In this framework, DFV is implementing the Smart Coat vision system patented by SAT, able to recognise a profile from its section and automatically control all process settings, thus ensuring a fully repeatable finish. When fully fine-tuned, the Smart Coat system will enable DFV to achieve a level of efficiency and production optimisation rarely, if ever, achieved so far.

Figure 1: From left to right: Alessia Venturi, Luciano De Francesco, Andrea Trevisan and Pino Coppola, production manager DFV.

Opening picture: White wood effect on aluminium profiles.

DFV

"This company was established in 1972 as a distributor of aluminium profiles. In 1997, however, it transitioned to coating. At the beginning, it only worked with wood-effect finishes, which had recently appeared on the market and had considerable appeal to consumers," says Luciano De Francesco (**Fig. 1**). "The wood-effect aluminium windows have quickly become successful in Italy and particularly in the South, where the aluminium market has always served more the residential construction field than the commercial or public ones. In 2000, we opened our first plant coating with the whole RAL range in Surano. In 2004, we became part of the Trevisan/Cometal group and we annexed the Agrigento plant, which was in its starting phase. In 2009, we decided to buy back the shares sold to Trevisan/Cometal, thus returning 100% owners of the company, and to acquire TSM Italia, another coating firm of the group that had the plant in Meolo, in the province of Venice. Since then we operate in three factories from which we cover the entire national territory. The Agrigento plant serves the markets of Sicily and Sardinia, the Venice one Northern Italy up to Tuscany and Marche, and the Lecce one Southern Italy to Lazio."

"DFV is the undisputed leader for what concerns the powder-on-powder technology, of which it owns nearly 90% of the Italian market shares."

"The three plants are virtually clones of each other: despite the different areas of competence, they all have the same manufacturing organisation and the same finishing systems. The administrative management, the sales office and the R&D department are located only in Lecce," De Francesco adds. "Our typical customers are distributors of window systems, retailers of aluminium profiles and to a lesser extent the door and window frame industry, especially from the shutter, mosquito net and awning fields. We provide our clients with a complete service that goes beyond the coating process, as storage at our warehouse, and order picking from their stock."

The plant organisation: working like clockwork

In the plant of Surano, there are two coating lines. The horizontal one (**Fig. 2**) treats sheets as well as small and very small extruded parts, while SAT's high productivity vertical one finishes 90% of extruded workpieces, applying both RAL and metallic colours as well as the basecoats needed for the wood-effect coatings (**Fig. 3**). Such finishes remain DFV's core business: the company holds a relevant share of the market of wood-effect coated profiles. In particular, it is the undisputed leader for what concerns the powder-on-powder technology, of which it owns nearly 90% of the Italian market shares.

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Figure 2: The horizontal plant for aluminium sheets and profiles.

In order to handle such large volumes, DFV uses all the technologies available on the market. The Lecce factory is equipped as follows: three powder-on-powder profile coating systems (**Fig. 4**) from SAT's EZY range, which includes horizontal and offline wood-effect coating plants with great flexibility; an EZY system for metal sheets; a sublimation plant; and an EFFECTA system, a project of SAT dating back to a few years ago, integrated in the vertical plant. It is used for the in-line powder-on-powder application of wood-effect coatings and it ensures high productivity and low costs, but also less flexibility and greater handling difficulties when treating profiles with very different shapes.

The vertical coating plant (**Fig. 5**) was installed in 2005, but it has been retrofitted several times, the last of which for the addition of the new spray paint booths designed by SAT. "Some interventions have been carried out to prevent a loss in productivity when switching from RAL colours to the basecoats of wood-like effects," Luciano De Francesco explains. "The conveyor has been changed many times: we have extended some segments inside the ovens and we have created a bypass storage buffer for the application of the basecoats that cure at a low temperature."

Figure 3: **Several wood effects produced by DFV.**

The profiles treated with wood-effect finishes in the in-line EFFECTA system are sent to the first coating booth for the application of the basecoat, then to the oven at 120°C for the gelation stage, to another booth for the application of a powder layer, and finally to a roller (**Fig. 6**) that applies the wood effect on such layer. The cycle ends in the main curing oven, which polymerises both layers.

The profiles with a wood-effect finish obtained with the EZY machines follow the same route but, after exiting the low temperature oven for the gelation of basecoats, they reach the bypass storage buffer (**Fig. 7**). Here, they wait to be hung again in the same position selected at the time of loading. "The basecoats for the powder-on-powder wood-effect finishes are cured at 115-120°C, because, if they were completely polymerised, the subsequent powder layer – applied with the silk-screen technique in the case of EZY systems and with a roller in the case of the EFFECTA machine – would remain on the surface, "unbound" from the basecoat and with an unrealistic aesthetic effect. Conversely, the basecoats for the sublimated wood-effect finishes are polymerised at a higher temperature than normal. We have added a second conveyor with an alternative route and a second oven in the middle of the line to avoid having to empty the curing oven and lower the temperature for every incoming wood-effect batch. The profiles treated with a basecoat follow the secondary circuit and remain in this second oven for about ten minutes, while the ones coated with RAL colours follow the main route. The production flow, regardless of the circuit followed by the profiles, is always based on the First In First Out (FIFO) approach."

"The problem was achieving a good productivity level in terms of RAL coatings but, at the same time, optimising the wood-effect profiles' production."

Figure 4: **One of the EZY machines in use at Surano DFV plant.**

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Figure 5: The loading station.

"The problem here was achieving a good productivity level in terms of RAL coatings but, at the same time, optimising the wood-effect profiles' production," states Andrea Trevisan from SAT. "We have chosen a monorail conveyor with transferable hooks (**Fig. 8**) because the profiles that enter the oven for the gelation of basecoats can follow the circuit created to bypass the main oven (**Fig. 9**) and fill the gap on the chain in order to return to the main route for the unloading operations. In the past, DFV lost two hours of production for every switch from a RAL to a wood-effect coating, which required a transition from high to low temperature within the same oven. With the additional oven and the alternative route, they no longer have any production downtime."

The new spray paint booths

The vertical plant is equipped with two booths working alternately to minimise the time lost during the colour change operations. In August 2016, DFV replaced its old booths with SAT's new self-cleaning, "V"-shaped ones. They feature opposing guns in groups of four and two carpet walls with a cleaning system positioned at their base (**Fig. 10**), so that all the powder that settles on the carpets is recovered and recirculated after passing through the cyclone. The Surano plant was the last company's facility to implement it.

Figure 6: The roller of the EFFECTA machine.

"With the new booth out of 100 grams of sprayed paint, at least 50% is deposited on the profile."

"What is interesting is that, in the past, DFV had replaced only one of its booths, namely that of the Meolo plant, with our previous generation self-cleaning booth. After we launched on the market our "V"-shaped booths with opposing guns, in 2013, the company has replaced all six of them within eighteen months," Trevisan says. De Francesco explains: "SAT's previous generation, "C"-shaped booths only ensured benefits in terms of cleaning time. The new generation, "V"-shaped ones, despite featuring the same concept of self-cleaning carpet walls, have greatly improved the application efficiency and quality level."

First of all, the guns divided into four opposing groups improve the efficiency of the first application process (**Fig. 11**). "Out of 100 grams of sprayed paint, at least 50% is deposited on the profile; with our old booths, only 30% was. This gun arrangement also ensures better surface coverage: it is possible to perfectly cover even the most difficult-to-reach areas while depositing a lower thickness on the parts in sight," De Francesco says. "This has enabled us to perform quicker colour change operations, but also to increase the quality of our coated profiles and save about 20% of paint. The four groups of guns are started in sequence as the profile passes through the booth. This results in a great saving of paint, whereas in the past, when we used twenty guns simultaneously, we threw away some coating for about two minutes."

Secondly, a booth designed with a more acute angle requires less suction power. "We used to have 40-45 Kw suction fans, but now a power of 30-35 kW is sufficient. Moreover, the suction action is dynamic: it is activated only when the guns spray and

according to the stroke of the reciprocator," Andrea Trevisan explains. "In this way, we have reduced the total intake, but suction is more efficient and takes place only where needed. The powder does not leak out of the booth and it is not taken away from the profile."

The third and main advantage offered is the new arrangement of the guns in opposing groups of four, enabling the profiles to be simultaneously coated on both sides. "The powder cloud has a lower speed compared with the booths with guns located in front of the profiles, which incidentally no longer have to rotate," Trevisan adds. "A lower speed means that the electrostatic process has more time to work, so that the powder penetrates more effectively in the profile cavities. The suction units placed at the vertices of the triangle make sure that the powder cloud properly moves towards the suction openings, encountering the transiting profiles (**Fig. 12**). In the older booths, the sprayed powder was sucked in the opposite direction to the profile transit."

All these factors have resulted in a 10% productivity increase, since DFV has raised the speed of its line from 1.5 to 1.64-1.7 m/min. "Lastly, we have achieved greater operational safety, because SAT has greatly unburdened the old reciprocator by mounting the gun groups on three different reciprocators that are very efficient linear tracks," De Francesco states.

Figure 7: The bypass storage buffer.

Figure 8: The transferable hooks system.

Figure 9: The curing oven.

Maximum productivity

The productivity of DFV's vertical plant in Surano exceeds 20 tonnes per shift, about 40% of which is made up by wood-effect profiles. The company performs a colour change operation every half hour, with a total of 30-40 daily changes. The whole production flow is computerised with a MES[1] system to follow every order step-by-step. However, with such a variability of the profiles to be painted, optimising production and making it more efficient was a challenge (**Fig. 13**). "The operating principle of the vertical plant is almost a detail in the global production process, because those 20 tonnes of coated aluminium per shift

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1 The phrase Manufacturing Execution System (MES) indicates a computerised system that has the main function to manage and control the production flow of a factory. This includes the dispatch of orders, the progresses in terms of quantity and time, and the storage operations, but also a direct connection with the machinery to collect useful information for the integration of the different manufacturing aspects as well as the generation of data for the control of production.

account for about 350 orders with an average of 120-130 kg of components in different shapes," De Francesco states. "Moreover, since our reference market is residential architecture, we are required hundreds of different colours and several wood-effect finishes. We deliver 80% of orders within five working days. Considering that, in some areas, transport only takes two days, we deliver a batch in an average of three days. We offer about 150 colours with a five-day delivery, while for non-standard shades we require five further working days for the procurement of the coating.
"This requires a highly advanced production

Figure 10: The "V" shaped coating booth.

scheduling system. Having several regular customers, we have managed to computerise all our processes. The orders are transmitted before aluminium reaches the plant, so that when the material arrives in the morning, it is immediately checked and already in the afternoon it is available for painting. However, no customer takes any commitment with us: they submit orders according to their requirements, regardless of colours or quantities. We do not know what we will have to paint until we receive the orders."

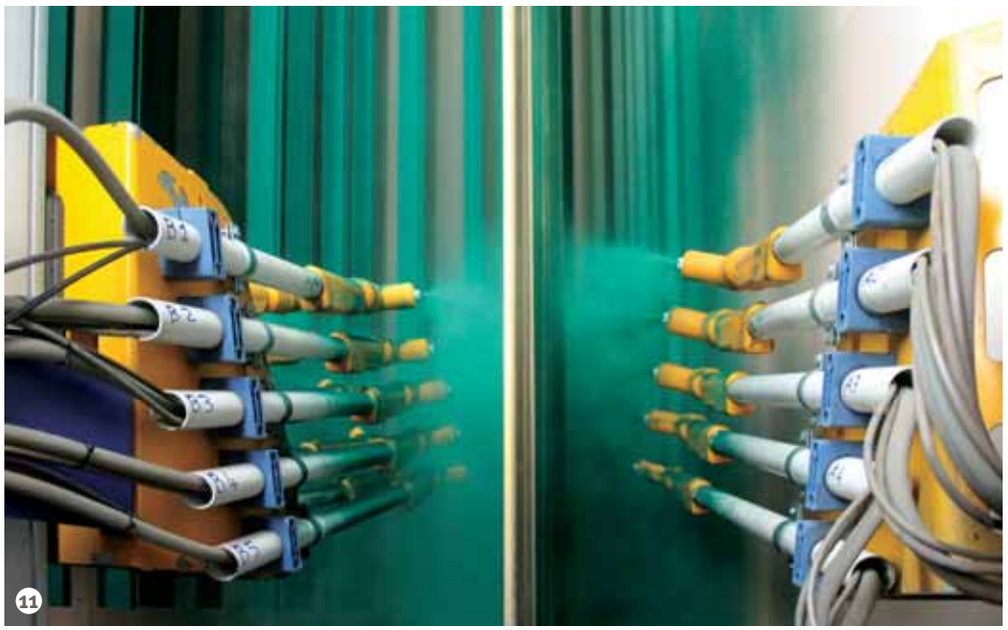

Figure 11: Two of the four groups of spraying guns.

"SAT's smart vision system is self-learning: it can recognise the shape of each profile and match it with a coating program among those preset by the client in its database."

Figure 12: The inside of the coating booth.

The future: SAT's Smart Coat vision system

The new Smart Coat system patented by SAT, an innovation for the coating field in the direction of Industry 4.0, has been developed for coating contractors like DFV, which must handle a huge number of different profiles. "Our IT production system ensures that all orders are identified and located for maximum traceability. Once checked, the orders are sent to our automatic warehouse and used by a software application to compose the operators' work program. Every batch hung onto the vertical system is assigned a tag that identifies it," Luciano De Francesco explains. "During coating, the tag records the profile's tracking information, that is, the working parameters and conditions (from the oven temperature and the curing time to the baths' concentration), which at the moment are set manually. We create an "identity card" for each order that is also available for our customers to monitor the processing of their orders via internet. We are currently working to enable them to print a certificate of conformity attesting that their components have been produced in a given period of time of a certain day, with certain characteristics (metal

removed, chrome coating thickness, gloss value) and in compliance with the standards Qualicoat 1, 2 and/or Seaside."
"However, the choice of the coating program for each profile is still a manual process performed by operators. The same applies to the adjustment of the spray guns depending on the parts' shape," De Francesco says. "The fact that the new booth enables to adjust the guns in groups of four, rather than all at once, is a big advantage compared with the old one. On the other hand, the Smart Coat system that we are testing and gradually implementing will allow for an individual gun adjustment to the shape of the profile to be treated."
SAT's smart vision system (**Fig. 14**) is self-learning: it can recognise the shape of each profile and match it with a coating program among those preset by the client in its database. "This implies the recognition of individual profiles and not just of orders,

Figure 13: DFV work with a very high productivity: only few centimetres are left between two colours.

as happens now. The guns can be automatically adjusted to the coating program to be performed," Trevisan states. "This will be a strategic innovation especially for aluminium coating contractors, for which it is normal to simultaneously have profiles with different shapes in the same booth. With this vision system, the assigned coating program will "follow" the profile in the booth even if it is hung among different parts. This will result in a more standardised production."

Figure 14: The video camera of SAT's Smart Coat vision system.

Figure 15: The entry of the pre-treatment of tunnel.

"The ultimate goal of the Smart Coat system will be recognising a profile and having an algorithm instantly create the ideal program for that component and that kind of coating. The idea is to provide our booths with a vision system with this knowledge, namely a smart system that knows how to coat," Trevisan adds. "We will get close to this objective by gaining experience and with the help of other companies that are already testing such interaction among machines. DFV is still in the setting and algorithm development phase. The profile recognition will then enable us to work on other parameters, such as the amount of chemical product to be dosed according to the m² of material loaded on the line, the burner's settings, the temperature of the oven to be changed according to the incoming aluminium mass, or the chain speed to be reduced to improve the aluminium attack in the alkaline bath required to comply with the Qualicoat Seaside standard (**Fig. 15**)."

Conclusions

In the last few years, DFV has heavily focussed on logistics and customer service. Standardisation, quality, real time parameter control, and the automatic setting of machines according to the sensors' readings enable the company to offer a product with a high and constant quality standard (**Fig. 16**).

"We have strived to perfectly organise both our physical flows and the information and logistic ones," Luciano De Francesco says. "We should manage to operate paperless by the end of 2017, and our activity will be constantly monitored for constant quality and cost control, down to every order. We aim at enabling our customers to automatically download online a 10 year warranty certificate for the Qualicoat Class 1 products and a 15 year certificate for the Class 2 ones."

Figure 16: The unloading station.