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Opening photo: **A VIRTUS series' tractor manufactured in the SDF's plant in Treviglio (Bergamo, Italy).**

Innovative Industrial Choices for SDF. Eco-coating Technologies for High Productivity Lines Integrated into a Low Environmental Impact Plant

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A current trend in the finishing industry is the development of innovative and industrially sustainable solutions especially focused on:

- Industry 4.0;
- Eco-friendliness and safety of the working environment;
- Lower energy and processing costs;
- High quality of the applied films;
- High performance coating application cycles;
- Proper integration of plants into latest generation processes.

In particular, nowadays, no new coating plant can be designed without considering the Industry 4.0 principles: digitisation of production, interconnection among machines, and the possibility to collect and process all system data automatically are just a few of the requirements imposed to the manufacturers of coating plants, machines and devices. SDF Spa (Treviglio, Bergamo, Italy) made one of latest Industry 4.0-oriented plant investments in the Agricultural Construction Equipment (ACE) sector early in 2017. This was aimed at installing a new high-

efficiency, fully automatic coating line with application systems borrowed from the automotive industry.
Verind is a company of the international Dürr group, which designs innovative technology solutions by integrating expertise, industrial system engineering, and equipment and eco-coating technologies; following its corporate philosophy, it supplied SDF with an innovative automatic application system 4.0, perfectly integrated with the process and ideal for the complex components treated.
"In order to develop such a high-productivity and automation coating system, we had to consider a mix of significant variables such as ecology, investment costs, production efficiency, plant complexity, coating performance, predictive maintenance, safety of the working environment, product quality, and product complexity in terms of both shape and material," says Alessandro Soba, the Industry Sales Manager of Verind. "Not to mention that we also wanted to offer SDF a digitised global service."

Figure 1: From left to right: xxxxxxxxxx Achille Giussani, SDF Group Industrial Treviglio Plant Manager Massimiliano Tempesta, and SDF Plant Treviglio Head of Manufacturing Engineering Gianluca Schiavulli.

Project One: creation, development and implementation

Since the beginning, the SDF Group has always been characterised by a particular propensity to technological innovation. Established in 1927 for the development of one of the first diesel tractors in the world, the company has continued to evolve to become a leading manufacturer of tractors, harvesting machines and diesel engines, distributing its products with the brands SDF, DEUTZ-FAHR, Lamborghini Trattori, Hürlimann, and Grégoire (**Ref. opening photo**). This aptitude for innovation has recently translated into the renewal project that has involved the headquarters as well as the facility of the Group with the highest production volumes, precisely located in Treviglio, where everything started. The project named "Project One" has set up an intervention programme in different production phases, with an investment of over 20 million Euros and the insourcing of some manufacturing stages that were previously outsourced, such as the assembly of tractor's front axle. "Our Treviglio plant handles the highest production volumes of the Group and it is the most complete one in terms of production process. Here, we machine some transmission components, weld cabin frames, produce 6-cylinder engines and spare parts and have several assembly departments for transmissions, cabins, front axles, and of course the whole tractors," says Massimiliano Tempesta, SDF's Group Industrial Treviglio Plant Manager (**Fig. 1**).
The machining department has undergone profound changes, as well as the assembly process, whose transformation process is still ongoing. "We have completely reconsidered our tractor assembly system," states Tempesta. "In the past, we had three conventional assembly lines. The coating systems were located at their centre without any logistic optimisation. Moreover, the length and arrangement of the assembly lines before and after the painting stations had been designed for a product that was significantly different from the current one: much more assembly operations were needed before painting and much less of them were required in the subsequent stages. The technological transformation of our tractors called for a total change.

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Figure 2: The new assembly line.

In the framework of the Project One, at the beginning of 2017 we started one tractor assembly line; in January 2018, we will also start a second line and we will dismantle the old one (**Fig. 2**)."

The most significant part of the investment project, however, has concerned the tractor body coating phase. Once in full operation, the new systems' production capacity will be enough for both assembly lines. "We needed to change our entire coating process, which was performed by three outdated systems that had too many limits in terms of expansion as well as environmental and quality improvement. In particular, we did not have any space to improve the pre-treatment stage with the installation of a multi-stage tunnel," says Massimiliano Tempesta. "Automation was also lacking. The most recent machine, dating back to the late 1980s, had been integrated with a topcoat application robot; the primer was applied in a semi-automatic booth with a reciprocator that, however, did not ensure satisfactory coverage of the workpieces. On the other two lines, the primer was applied manually and the topcoat with a reciprocator; however, several manual touch-up operations – almost a repainting operation, indeed – were needed."

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The new coating plant: from the 1980s to the Industry 4.0

The new coating plant designed by Eisenmann is equipped with an automatic application system developed and supplied by Verind. It

Figure 3: A bird's eye view of the new coating plant.

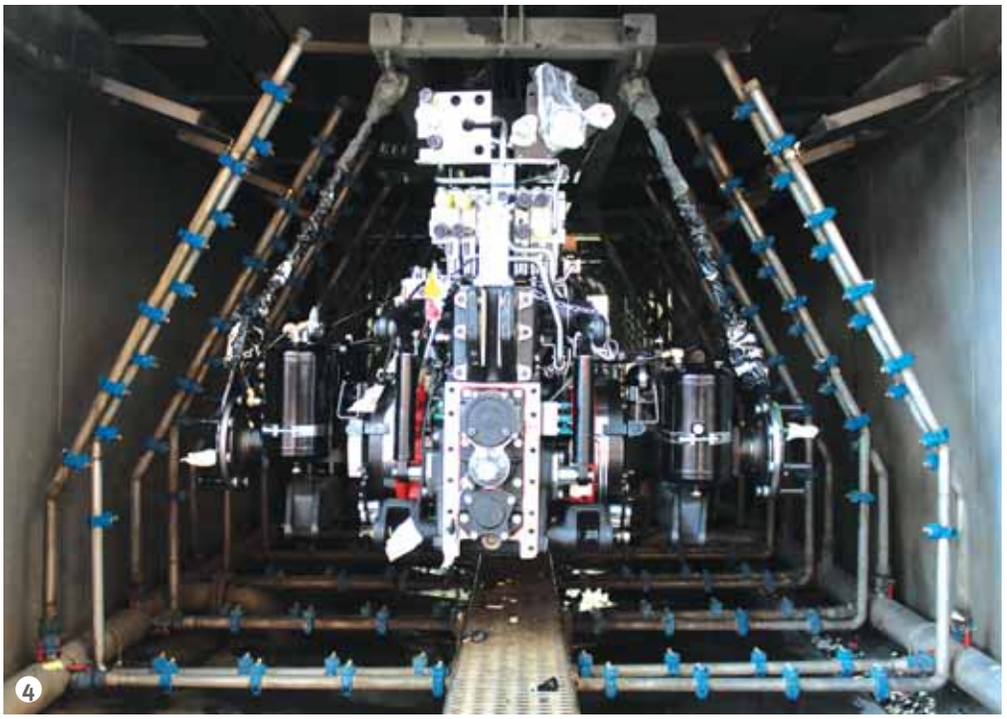

Figure 4: A tractor body at the entrance of the pre-treatment tunnel.

“The technological transformation of the tractors called for a total change. In the framework of the Project One, at the beginning of 2017 SDF started one tractor assembly line; in January 2018, it will also start a second line and it will dismantle the old one. The most significant part of the investment project, however, has concerned the tractor body coating phase. Once in full operation, the new systems’ production capacity will be enough for both assembly lines.”

Figure 5: **The only remaining manual workstation is the one devoted to masking operations.**

Figure 6: **The coating management unit.**

has already been started and it will reach full operation by early 2018. The plant engineering choices were based on the criteria of productivity increase, eco-friendliness, quality improvement, and integrated automation (**Fig. 3**). The new system has two main features: a 5-stage pre-treatment tunnel (**Fig. 4**), which has considerably increased the corrosion resistance and the quality level of SDF tractors, and the automation of all coating processes. A robotic blow-off station has been added to eliminate the manual drying operation: the only manual station left is the one devoted to the masking operations needed to protect the surface areas that must not be coated or wetted during pre-treatment (**Fig. 5**).

"We have designed and installed an automation, 2K coating pumping/dispensing, and application system that has met SDF's needs for greater application efficiency and productivity optimisation. We have transferred this technology from the automotive sector to the industrial coating one," says Marco Assorgia, Technical Sales Engineer at Verind. "Moreover, in order to meet the thickness and cycle time requirement, 2K water-soluble primers and topcoats are applied with the electrostatic technology. This optimises transfer efficiency and reduces overspray."

"Together with SDF's management, we have also decided to interconnect the automation systems of all robotic stations, following the Industry 4.0 principles," says Alessandro Soba. "The collection of process data on the consumption of paints and washing products during the colour change operations on all units, including the manual touch-up one, and the monitoring of the temperatures, pressures and levels of the coating management unit ensure a clear view of the application process."

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Figure 7: **The electronic dosing device EcoDose 2K supplied by Verind.**

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Figure 8: **CMA robots' control modules.**

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Verind has developed its application systems with this in mind, in terms of both process flow and robotics. The features chosen were as follows:

- An automatic coating management unit with an EcoPump system with the "4 Ball" technology (**Fig. 6**);
- Automatic filling of process tanks from the paint manufacturer's drum;
- An insulation system designed for Dürr's 100 kV and 500 µA electrostatic generators;
- Continuous measurement of the tank levels and of the temperatures and operating pressures of paints and catalysts;
- A modular automatic colour change device with a recirculation system;
- A 2K coating dosing and flow control system with a Dürr gear dosing pump;
- Hollow-wrist robots that can be programmed offline;
- Application technology with Dürr Twin Gun devices and an automatic control system of the atomisation parameters;
- An automatic gun cleaning system;
- An electronic dosing equipment EcoDose 2K for the manual touch-up workstation, able to collect consumption data and equipped with a Direct Injection Technology (DIT) system with A and B channels (**Fig. 7**).

Each booth is equipped with two opposing robots provided by CMA (Pradamano, Udine, Italy), each featuring two Dürr automatic guns and their related electronic dosing equipment (**Fig. 8**). This enables to separately control their flow, air pressure and other parameters for proper paint application. The blow-off

"The SDF's product range is highly varied. It produces about seventy tractors per day that belong to over twenty different families. Each family, in turn, is greatly varied in terms of options available. It is therefore very difficult to handle all coating processes with a robotic system. However, thanks to the possibility to program the robots offline based on the 3D drawings made by the design department, the quality of the coating process has greatly improved despite such diversity. We now operate with about forty different programs selected by the robots depending on the order of production."

Figure 9: **In its Treviglio factory, SDF manufactures 70 tractors per day belonging to 20 different product families.**

Figure 10: **Manual touch-up operations.**

station is equipped with two robots with a centrifugal turbine blow-off system and special nozzles recovered from the old plant. "Our product range is highly varied. We produce about seventy tractors per day that belong to over twenty different families (**Fig. 9**). Each family, in turn, is greatly varied in terms of options available. It is therefore very difficult to handle all coating processes with a robotic system," explains Massimiliano Tempesta. "Especially for some products, we still need a manual touch-up stage (**Fig. 10**). However, thanks to the possibility to program our robots offline based on the 3D drawings made by our design department, the quality of our coating process has greatly improved despite such diversity. We now operate with about forty different programs selected by the robots depending on the order of production."

"The application process is developed for the largest-sized tractor body currently produced. At moment, this equals to 50/52 m2 of surface to be covered; the dosing and dispensing system must therefore ensure adequate thicknesses (50 to 70 microns) in a 5-minute cycle time."

Figure 11: **The application of a light coloured primer enables to check that the topcoat layer is applied uniformly.**

Figure 12: **The topcoat application stage.**

The application process

Beckers Industrial Coatings has followed the implementation of the new plant since the beginning, designing a highly performing painting cycle based on the new operating parameters and with high quality standards. The primer has been specially developed to allow adhesion to all types of support in use and it can be recoated with the required topcoat in very short time. The epoxy primer and the polyurethane topcoat are both water-based two-component products and perfectly in line with the environmental choice adopted by SDF since many years. Two colours are mainly used: SDF grey and a lighter grey for a tractor produced for a third party. The primer is light coloured for improved quality, since it enables

"Since the factory is located in the city centre, the plant design also focussed on eco-friendliness factors. Although water-based, low solvent-content products had long been used, the new E-Cube dry filtration systems installed by Eisenmann on the primer application booth and Edrizzi's filtration system mounted on the topcoat application one now enable SDF to effectively reduce overspray."

Figure 13: **The drying oven.**

"The main challenge posed by this project was working in a factory with limited spaces and in full operation, as SDF has never been able to stop production. At the SDF time, it did not have the opportunity to build a new facility to start the new plants or move the existing machining departments. Therefore, it had to rearrange the different areas, making spaces to gradually install the assembly lines. Although the cycle time has not changed with the new plant, the coating process is now independent from the assembly line thanks to the presence of small storage buffers; when the system will be fully operating, this will enable SDF to exploit even breaks to increase the productivity."

to check the dark coloured topcoat coverage (**Figs. 11 and 12**). The wet-on-wet application is followed by a 30-minute flash-off stage and a 45-minute drying one at 80 °C (**Fig. 13**).
"The application process is developed for the largest-sized tractor body currently produced. At moment, this equals to 50/52 m² of surface to be covered; the dosing and dispensing system must therefore ensure adequate thicknesses (50 to 70 microns) in a 5-minute cycle time," says Alessandro Soba from Verind (**Fig. 14**). Verind's Technical Sales Engineer Marco Assorgia states: "That is why the twin gun technology has been adopted, which divides the product volume to be applied between two atomisers (**Fig. 15**), thus reducing the atomisation air pressures. Moreover, the compressed air consumption of the coating management unit has been optimised with "4 ball" technology pumps featuring opposing horizontal pistons."

Figure 14: A coated tractor body.

"There was an important improvement also in terms of primer," says Gianluca Schiavulli, the Plant Treviglio Head of Manufacturing Engineering - SDF. "In the past, we used a one-component primer because the old systems did not offer enough space to perform the flash-off stages required by a two-component product. Now that we use a two-component primer, we have doubled our salt spray resistance results. Since the factory is located in the city centre, the plant design also focussed on eco-friendliness factors. Although

Figure 15: The twin gun technology enables to divide the product volume to be applied between two atomisers.

Figure 16: The primer application booth is equipped with Eisenmann's E-Cube filtration systems.

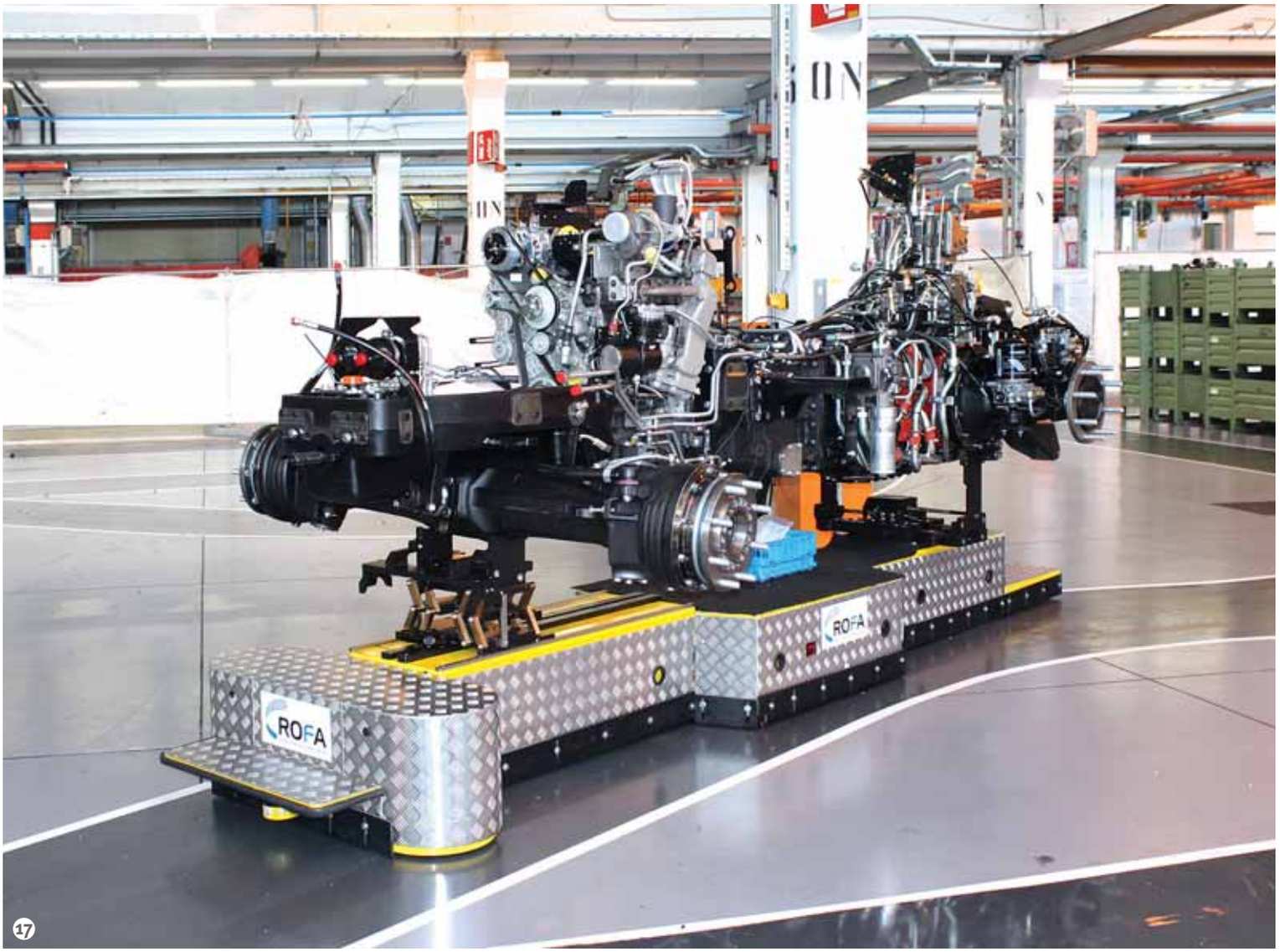

Figure 17: **The AGV module for the handling of tractors on the assembly line and during transfers.**

water-based, low solvent-content products had long been used, the new E-Cube dry filtration systems installed by Eisenmann on the automated primer and topcoat booths and Edrizzi's filtration system mounted on the touch-up booth one now enable us to effectively reduce overspray (**Fig. 16**). However, since we are very attentive to all environmental aspects, we have also installed an afterburner to ensure the complete abatement of emissions."

Conclusions

"The main challenge posed by this project was working in a factory with limited spaces and in full operation, as we have never been able to stop production. At the SDF time, we did not have the opportunity to build a new facility to start the new plants or move the existing machining departments. Therefore, we had to rearrange the different areas, making spaces to gradually install the assembly lines," says Gianluca Schiavulli. "Although our cycle time has not changed with the new plant, the coating process is now independent from the assembly line thanks to the presence of small storage buffers; when the system will be fully operating, this will enable us to exploit even breaks to increase our productivity." Also the adoption of integrated AGV systems has contributed to this result. "These are automated trolleys that move by following a magnetic field generated by two underground cables. The magnetic field powers the trolleys and creates the guiding system. Every tractor placed on an AGV moves along the assembly line at the ideal speed for the performance of operations, and more quickly during transfers (**Fig. 17**)."