Caprari: Maximum Energy Efficiency and Minimum Environmental Impact for Coating Water Management Pumps With 72 Years of History

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When we observe the irrigation of fields or the snowmaking of ski slopes, we immediately think about the water required for these activities. However, we rarely wonder how it is transferred to the devices supplying it. A key component for these applications are the mechanical and electromechanical pumps that take the water and transfer it to the surface, or to the areas to be sprayed. They are complex mechanical components that must operate reliably in harsh environments for a long time. Therefore, they need a functional as well as aesthetic coating, able to protect them from corrosion and erosion (**ref. Opening photo**).

During the 1990s, some industry players began experimenting with one-layer systems with water-soluble products in order to reduce the environmental impact of coating operations. In the early 2000s, the trend was reversed and many industrial users developed systems combining solvent and water-based products. Used with the proper application and abatement equipment, such systems enable both to fully meet aesthetic and corrosion resistance specifications and to limit VOC emissions.

In the last ten years, however, another issue has forced itself to the forefront of the coating industry: energy saving. In 2017, the plant builder Trasmetal, based in Milan (Italy), completed the project of a highly flexible, eco-friendly and energy efficient coating plant for a major Italian enterprise, the Caprari Group. Its products are now coated with a mixed system including a solvent-based primer and a water-soluble topcoat.

Figure 1: At the centre, Caprari's Operative Director Donato Marchi, with Dario Zucchetti from Trasmetal and Caprari's Manufacturing Manager Giovanni Rizzati on the right.

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Opening photo: A clear water pump produced by Caprari.

Figure 2: **The showroom displaying a part of the huge range of pumps produced by Caprari.**

The Caprari Group: for 72 years, a leader in the integral water management field

A major Italian enterprise in the international sector of advanced integral water management solutions has specialised, perfected and exported its pumping know-how in the world for over 72 years, led by the same family since three generations. Caprari Spa (Modena, Italy), now the leader of the homonymous Group, has continuously expanded and diversified its business to meet the specific and ever-changing needs of the water world with innovative products and services, while creating increasingly closer and more specialised partnerships with its customers.

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Mechanics enthusiast Amadio Caprari opened a small workshop in 1945 and started producing irrigation pumps. Over time, the activity extended to the design and construction of deep well, distribution, and civil and industrial waste water treatment pumps, thus offering an integral water management product range. The company currently owns a main production site in Modena with over 300 employees, a second production plant in Rubiera (Italy) manufacturing electric motors for submersible pumps, a small production site in Shanghai, and a production joint venture in Turkey. It also has commercial branches in Spain, Portugal, France, Germany, United

Figure 3: Their certification for drinking water contact and corrosion resistance properties are two basic requirements for Caprari's pumps along with a pleasant look.

"The Caprari Group produces exclusively water pumps. The core application sector is the irrigation one: that is where the company started from, and they now seek to preserve their knowledge heritage. Caprari have then specialised in the industrial, deep well, water authority, water distribution, waste water, and steel mill sectors, but also in some very peculiar niches such as artificial snowmaking."

Kingdom, Tunisia, Greece and Australia, a network of agencies with their own warehouses on the Italian territory, a commercial branch in Milan, and a worldwide network of distributors. In 2017, the group achieved a consolidated turnover of 95 million Euros with approximately 700 employees throughout its plants. "The Caprari Group produces exclusively water pumps. Our core application sector is certainly the irrigation one: that is where our company started from, and we now seek to preserve our knowledge heritage," states Donato Marchi, the Operative Director of Caprari Spa (**Fig. 1**). "We have then specialised in the industrial, deep well, water authority, water distribution, waste water, and steel mill sectors, but also in some very peculiar niches such as artificial snowmaking. Moreover, we are proud to be partners in a few global water management projects: for instance, we supplied the tank filling and emptying pumps of the Venice MOSE, based on our conventional waste water pumps but built entirely in stainless steel. Finally, in the last few years, we have started approaching new markets such as the oil & gas and offshore platform ones, which we supply with service pumps. We can safely say that some of Caprari's product lines are the international leaders of their respective fields, especially our range of submerged well pumps, very wide and diversified also in terms of applications (**Fig. 2**)."

Figure 4: A part of the new coating plant installed by Trasmetal (Milan).

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Figure 5: **Each load bar has a maximum capacity of 1800 kg, up to 1000 kg per hook.**

A production process without any bottleneck

The production process carried out in Modena is not 100% verticalised. However, all strategic activities for the quality of products are performed in-house. "We have departments for the R&D, engineering and industrialisation of all our products," says Giovanni Rizzatti, the Manufacturing Manager of the plant. "Each new project is tested through prototyping, engineered by our technical office, and finally industrialised, that is, translated into operational activities. We manufacture our pumps by machining steel bars or cast iron castings supplied by our foundry partners. In terms of machining activities, we produce in-house about 70% of our total volume. The rest of the production is entrusted to external partners, especially the pumps that do not fit our machine tools due to their size or other particular characteristics." After machining, the production process continues with the washing of pumps' individual components, the assembly of pump bodies, and the coating and packaging stages. "We chose to paint our pumps after assembly because our product range is very heterogeneous, ranging from relatively simple cylindrical objects to complex machines with several undercuts and cavities. On the other hand, it would not be feasible to clean a complete pump because it would be

"Caprari cleans the parts contaminated with machine tools' lubricants and machining shavings in a continuous flow basket tunnel performing a phosphodegreasing, two rinsing, and a passivation phase."

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Figure 6: **The coating management unit linked to the primer application booth.**

“Unlike cleaning, the coating phase takes place after the assembly of pumps. This operative choice results in the impossibility to use powder coatings, because thermosensitive components, such as rubber gaskets, would not withstand the high polymerisation temperature.”

impossible to dry it perfectly and the coating quality would be affected,” states Donato Marchi. “We clean the parts contaminated with machine tools’ lubricants and machining shavings in a continuous flow basket tunnel performing a phosphodegreasing, two rinsing, and a passivation phase.” The coating stage follows.

Coating: a complex phase

Unlike cleaning, the coating phase takes place after the assembly of pumps. “We cannot paint individual components due to the presence of several couplings with minimum tolerances, which would require reworking,” states Donato Marchi. “This operative choice results in the impossibility to use powder coatings, because thermosensitive components, such as rubber gaskets, would not withstand the high polymerisation temperature. It is also important to note that our pumps’ coatings must be compatible with drinking water, since they can come into contact with it, even accidentally. We therefore need to use coating products certified according to the Ministerial Decree no. 174 for Italy, the WRAS approval in the UK, the CS approval in France and the KTW 270 certification in Germany.”

“Our requirements to our coating suppliers are therefore complex: we need a product that can be applied with robots, is anticorrosive, ensures salt spray test values of at least 600 hours, dries in the required time, and is certified for drinking water contact,” states Giovanni Rizzati. “For all these reasons, after using a one-layer water-soluble system during the 1990s, we switched to a mixed system featuring a surface tolerant two-component solvent-based primer and a two-component water-based epoxy enamel. When we examined the project of the new coating plant with Trasmetal, we immediately clarified that the process had to be perfectly fine-tuned for the products already in use, since this mixed cycle has allowed us to meet the increasingly high quality requirements of the sector for some years now.”

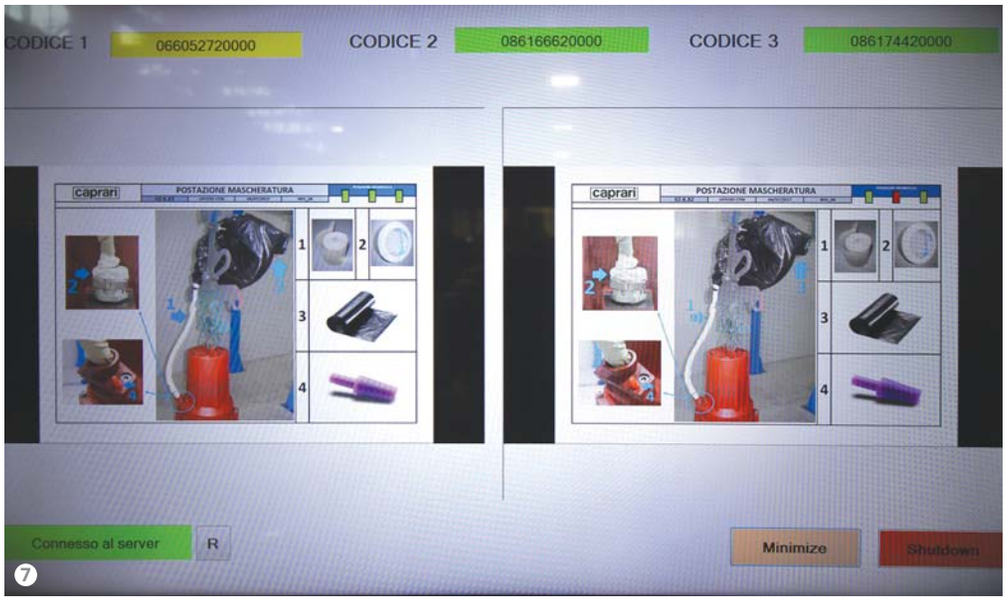

Figure 7: The monitors installed on a pulpit in the loading area display pictures of the incoming workpieces and their related hanging and masking instructions.

“Trasmetal designed and installed a plant that can meet the long-term needs of the Caprari Group in terms of both flexibility and productivity. It has a maximum load capacity of 1800 kg per bar and up to 1000 kg per hook, a size capacity of 1500x1500x1000, and the ability to coat components up to 2 metres in length.”

For the Caprari Group, coatings are applied primarily for functional reasons: they must be certified for drinking water contact and give the products the corrosion resistance required. Secondly, there are also aesthetic reasons, since the product quality perception is a crucial factor – nowadays, no product can afford not to have a look that is pleasing for its buyers (**Fig. 3**).

The realisation of the new plant

For its new coating plant, Caprari imposed the following requirements to Trasmetal:

1. It had to accommodate a larger average size of pumps than the old system – built twenty years ago according to the needs of that time, it had a maximum load capacity of 250 kg per hook and a size capacity of 800x800.
2. It had to ensure better quality results, because the use environments of pumps are increasingly harsh, water is harder and harder, and intake walls are increasingly deeper and, therefore, more polluted by brackish water.

Figure 8: Primer application.

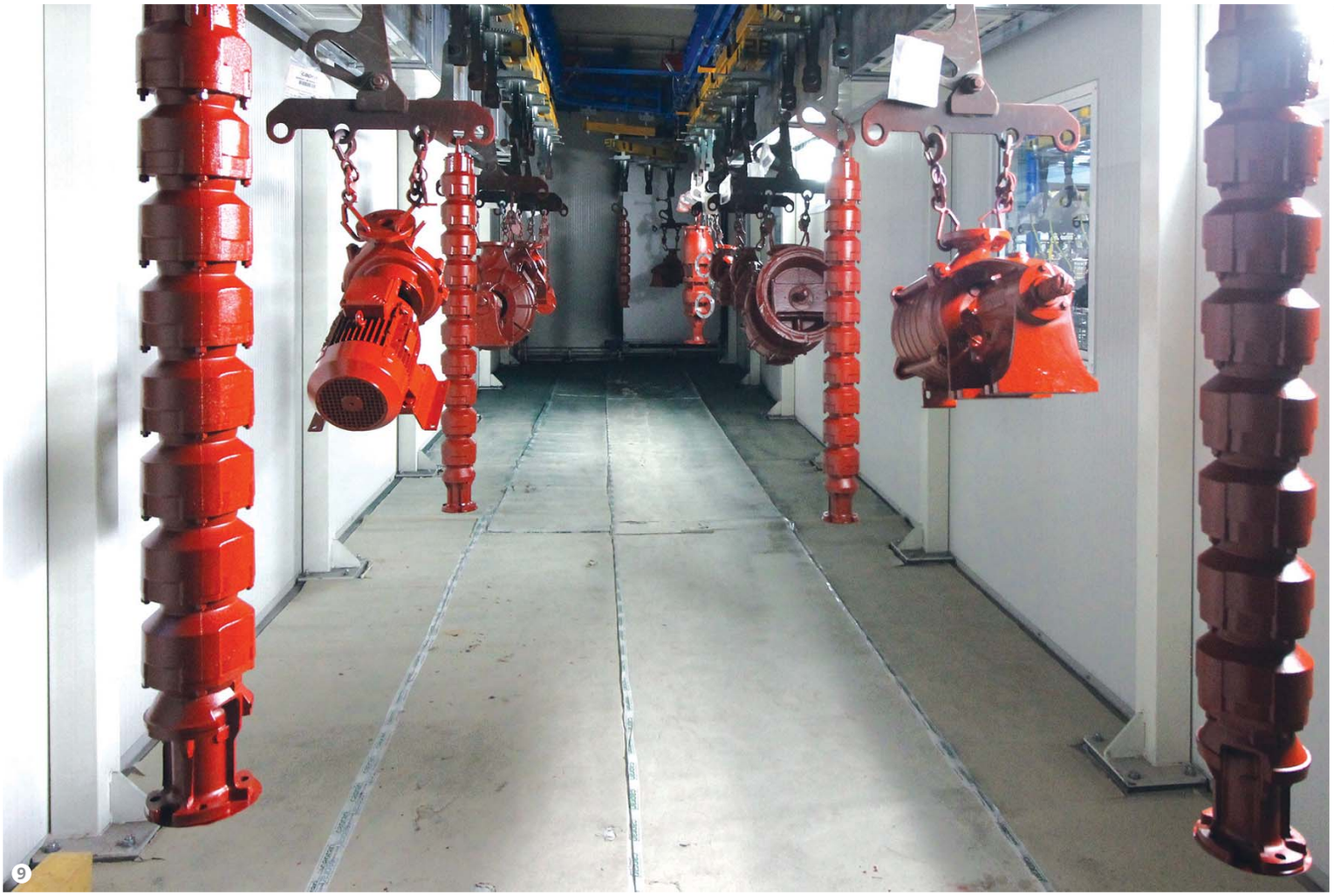

Figure 9: **The flash-off tunnel between the primer and enamel application.**

3. It had to ensure a significant increase in production capacity.
4. It had to perform a low environmental impact process in terms of both internal and external environment healthiness (VOC emissions) and energy efficiency. As for overspray, Caprari already had a proven dry filtration system (**Fig. 4**).

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“Each product to be coated is identified by a barcode. Thanks to CMA’s software, the operator reads the barcode on the pump’s tag and the monitors installed on a pulpit in the loading area display pictures of the incoming workpieces and their related hanging and masking instructions.”

The pumps are transferred from the assembly department along a special corridor. An area in front of the hanging station acts as a buffer. “We chose to plan the application of colours: 95% of our products are green or black with a 4:1 ratio: 30 out of 120 pumps per day are black. We decided to apply black in two phases every day in order to minimise colour change operations and therefore lower our cleaning solvent consumption. The workpieces requiring special colours, about 5% of production, go through the

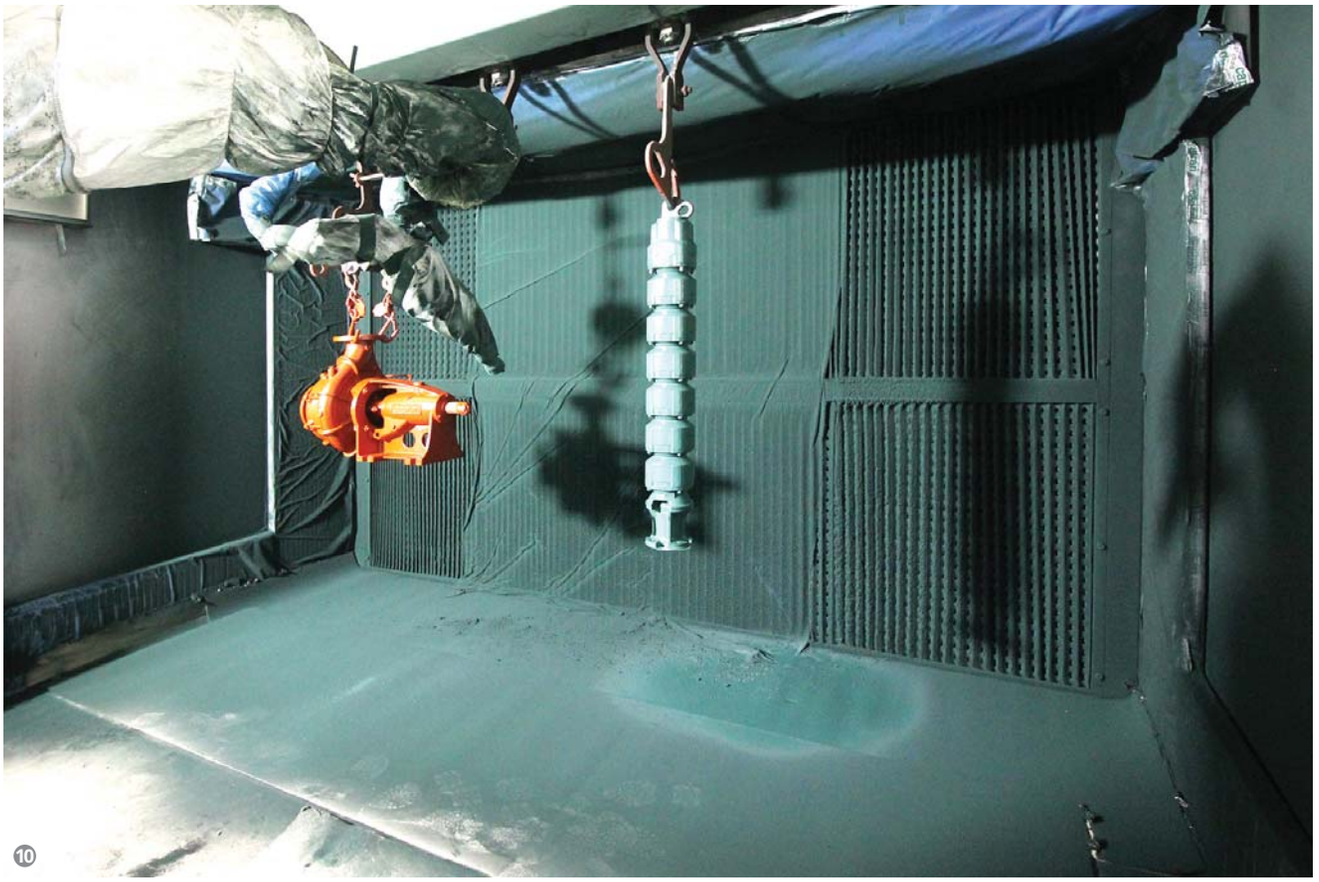

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Figure 10: **The dry application booth devoted to enamel.**

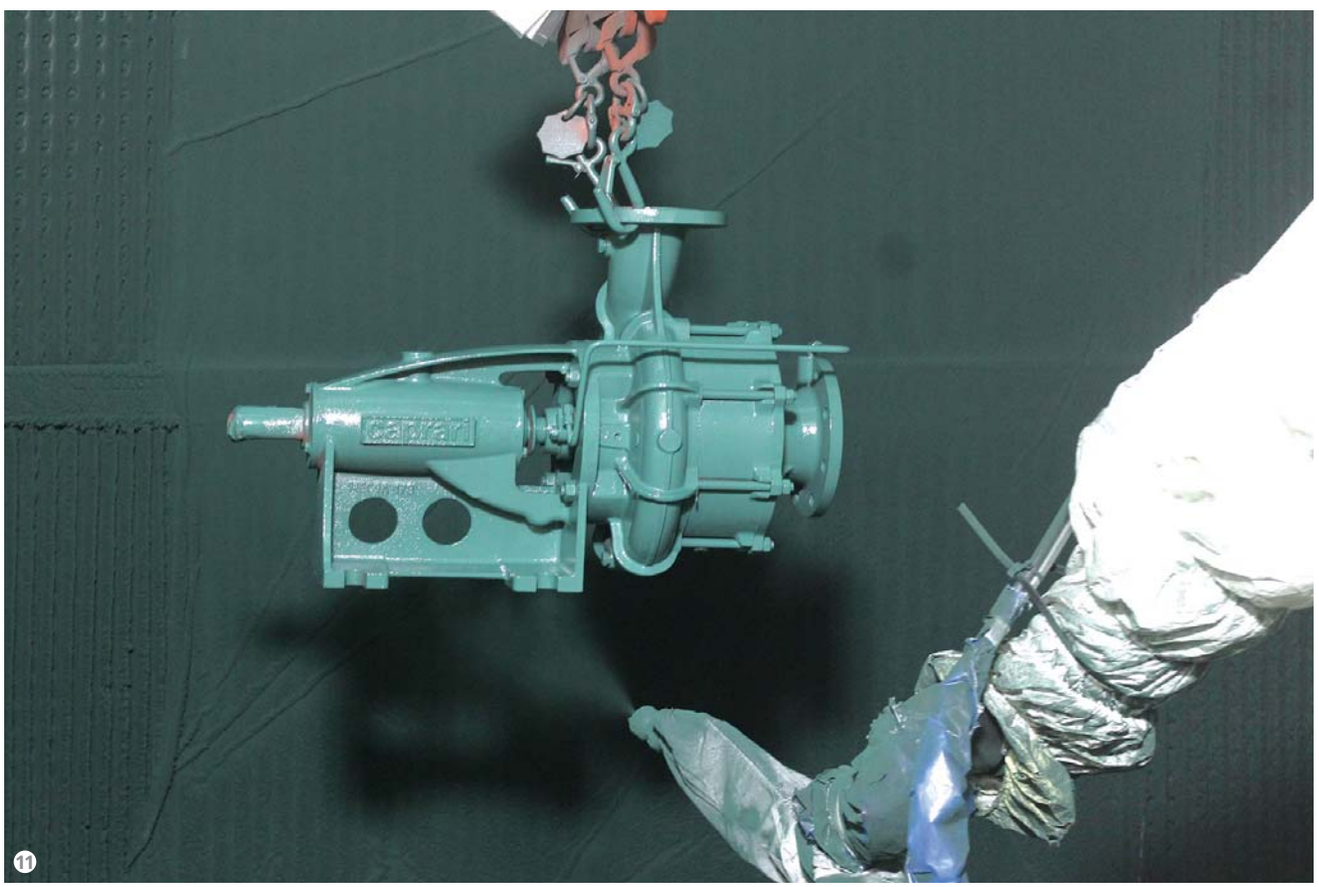

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Figure 11: **Enamel application on pumps with complex shapes.**

“Trasmetal also installed a booth separated from the main plant, equipped with a floor suction system and a saturated steam cleaning nozzle and linked to a 5-tonne crane. It is used to coat oversized pumps, up to 4 metre long and weighing up to 5000 kg. The non-in-line part of the plant also includes a devoted oven to complete the coating cycle.”

primer application booth and then bypass the automatic finishing booth in order to reach the manual one,” says Giovanni Rizzatti. “The parts are loaded randomly: each load bar is equipped with three hooks that can and must be able to accommodate different components with various dimensions and shapes.”

The plant is in fact composed of three booths: a manual one for special colours and touch-up operations and two automatic ones, devoted respectively to the solvent-based primer and the water-based enamel. They feature robots supplied by CMA Robotics (Pradamano, Udine, Italy). Each booth has its own coating management unit with Wagner dosing systems and pumps (stock meter pumps for the primer and volumetric pumps for enamel, **Fig. 6**).

Each product to be coated is identified by a barcode. Thanks to CMA’s software, the operator reads the barcode on the pump’s tag and the monitors installed on a pulpit in the loading area display pictures of the incoming workpieces and their related hanging and masking instructions (**Fig. 7**). The software program matches each part code with the right hook; the operator confirms the loading operation is finished and starts the cycle. At the booth’s entrance, the system reads the load bar number and the barcodes associated with each hook, enabling the robot to select the coating program corresponding to each product and proceed with the paint application (**Fig. 8**). A 4-spot buffer was created in front of the primer application booth. When the cycle time of a load bar ends, the software program opens the booth and the robot identifies the following workpieces.

A flash-off station performing a 48-minute process at 40 °C is located between the primer and enamel application booths. The load bars exiting the former are

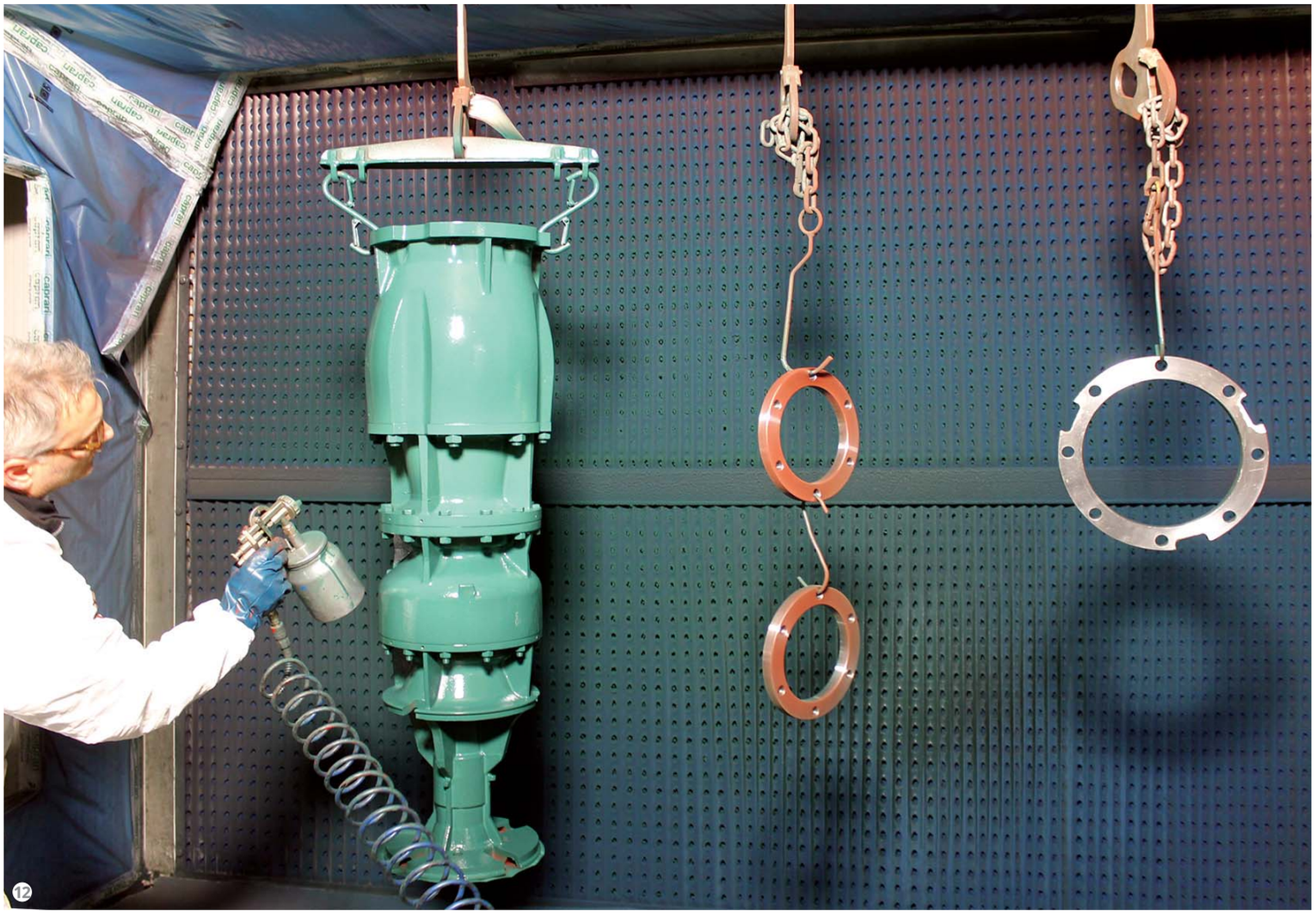

Figure 12: **The manual application booth is devoted to special colours and touch-up operations.**

transferred alternately to the right and left lane to allow the flash-off phase to take place for the time needed even in a small space (**Fig. 9**). The booth for the application of water-soluble enamel could switch to solvent-based enamel at any time, if it were necessary due to qualitative requirements (**Fig. 10 and 11**).
The plant also features a manual application booth with a direct air expulsion system (**Fig. 12**), a flash-off area to let the water contained in the enamel evaporate, and a curing oven where parts stay at 85 °C for about 60 minutes. This oven uses the heat produced by the afterburner installed outside the building to treat the air emitted from the booths. There is only one burner for the whole plant. Afterwards, the pumps reach a forced air cooling area and finally the unloading station, ready for immediate handling and packaging.
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Automation and energy efficiency: the advantages of this plant

The coating line designed and installed by Trasmetal has three main strengths: the automation of the application phase, the booths' air recycling device, and the direct heating system using the heat produced by the afterburner.

"When designing this plant, we primarily focussed on its ecological aspects," states Dario Zucchetti from Trasmetal. "The coating cycle adopted was not completely water-soluble, which would have allowed for the emission into the atmosphere of the air from the booths. Given the mixed cycle employed by Caprari, it took us a long time to design the air treatment system in order to comply with regulations and at the same time achieve the main goal of energy efficiency. Once we decided to use automatic booths with an air recycling system, we had to find the most convenient device for the abatement of VOCs. We considered various afterburning technologies as well as activated carbons. Of course, the choices made for the emission treatment operations affected other plant engineering decisions."

"A system structured like that of Caprari Spa, as well as fully complying with VOC regulations, enables to save energy. It consumes half the energy it would have required, for instance, with a ceramic afterburner and a curing oven, each with its own burner. Clearly, this choice is closely linked to the automation of the coating process, because no operator can access the booths due to the high solvent concentration in the air."

"After assessing different options, we chose to install an energy recovery

Figure 13: **The energy recovery thermal afterburner.**

Figure 14: **One of the stations for the management of the robots installed by CMA (Pradamano, Udine).**

“The plant was installed in January 2017 and the start-up phase lasted a few months. Functional testing was performed in September and the plant is now working at full capacity. During the design phase, Trasmetal also supported Caprari in the improvement of internal logistics.”

thermal afterburner without any concentrator to limit emissions (**Fig. 13**). This resulted in the need to limit airflows, too, and to use high concentrations of solvent in the booths (not more than 2 gr/m^3). Consequently, both booths were conceived as completely automatic machines with an air recirculation system. The air emitted from the booths flows into the afterburner and the heat generated by the solvent combustion is completely recovered and used to heat the curing oven. The whole system, therefore, works with one burner,” explains Dario Zucchetti. “The overspray issue, on the other hand, was easily solved also thanks to Caprari’s experience. We opted for continuing with dry filtration.”

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“From the operational point of view, however, we realised that it is easier for the operators to assess the products’ coverage by the robot in the enamel application booth, since most of our workpieces are already coated with a foundry primer in an oxide red colour identical to the one we apply. Therefore, the operators perform the self-learning operations in this booth and then transfer the programs to the

primer application robot. In this way, there is no need to bypass the air recirculation system," says Giovanni Rizzatti.
"This is not a large-sized plant, but the environmental aspect was very important for us," states Donato Marchi. "Having opted for a mixed cycle, we had to be careful with emissions. The usage limit of solvent-based coatings on our territory is 50 kg per day: we consume an average of 50-60 per shift, so with a second shift per day we would have exceeded the limits. Moreover, since the whole plant is ATEX approved, we could even consider using solvent-based enamel."

Figure 15: **Coated components transferred to the unloading station.**

A plant for great flexibility

The plant was installed in January 2017 and the start-up phase lasted a few months. Functional testing was performed in September and the plant is now working at full capacity. "During the design phase, Trasmetal also supported us in the improvement of our internal logistics," says Giovanni Rizzati. "The aim was to avoid manipulating and moving the coated pumps within the factory. We installed the new coating plant in an area adjacent to the refining and packaging stations to avoid any risk of small dents, surface defects or film detachment. Also this choice was motivated by a significant increase in the quality requirements posed by our customers (**Fig. 15**). The integration of a sufficiently long flash-off process after the enamel application phase enables us to consider the use of polyurethane or acrylic enamel in future, since these products have a higher UV resistance than the epoxy one; this would be motivated by the fact that we are producing increasingly more surface pumps."
"We are pleased with Trasmetal's plant because it meets all our main requirements: greater production capacity, healthier indoor and outdoor environment, and higher quality levels," says Donato Marchi. "The possibility to exploit the heat produced to reduce emissions doubles the ecological benefits of the plant because it enables us to save energy and to further lower our carbon footprint. Above all, however, this line gives us greater flexibility, a crucial aspect to face any process changes and the introduction of new product ranges with different coating requirements in future."