Opening photo: The trident logo has always recalled a refined style combined with pure lines, two peculiar elements of Italian design.

The Advantages of Robotics 4.0 for the Flame Hardening of Maserati Car Bumpers

Monica Fumagalli ipcm®

Estimates in the field of robotics are only partly reassuring: in its preliminary World Robotics Report, the International Federation of Robotics (IFR) wrote that 384,000 robotic devices were sold worldwide in 2018, i.e. one percentage point more than the previous year[1]. According to the findings of the international association, Italy ranked fifth in Europe and tenth on a global level in 2018, with 190 robotic systems installed for every 10,000 employees. Eastern countries lead the ranking: South Korea is firmly in first place since 2010, with 710 robotic systems for every 10,000 employees.

The automotive industry is the main beneficiary of the Industry 4.0-oriented developments in this sector: from

1 https://www.ifr.org

welding and assembly to coating and sealing, every stage of a car manufacturing process involves the use of increasingly cutting-edge and high-performance robots. In the Mirafiori plant (Turin, Italy), the bumpers of the Maserati Levante car model are coated. It has replaced its robotic devices with two new generation robots built by CMA Robotics (Pradamano, Udine, Italy) for the flame hardening of plastic components. This has guaranteed several strategic advantages for its coating process (**Fig. 1**), including greater compliance of painted surfaces to quality standards, significant operational savings in terms of process and consumption, and greater operator safety thanks to an innovative access system that was tailor-made for this factory.

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Maserati: attention to detail and unique design

The trident logo has always recalled a refined style combined with pure lines, two peculiar elements of Italian design (**ref. Opening photo**). However, it is the care with which every detail is designed and built that makes every Maserati car unique (**Fig. 2**).

“The recently updated plant,” explains Mirafiori-Maserati Bumper Shop Production Manager Daniele Balzano, “is devoted to the flame hardening of all plastic components built in polypropylene and intended for the sportiest Maserati cars. Attention to detail is evident even in the choice of materials and moulding technologies: this is the only FCA plant that coats plastic components both in polypropylene and in ABS, characterised by versatility and high impact resistance, as well as polyurethane, which enhances the vehicles’ lines better than polypropylene.”

Flame hardening: a crucial phase for the coating of plastics

Flame hardening is a crucial phase in the plastic coating process, because it enables plastic polymers to increase the

Figure 1: **The two robots for flame hardening plastic bumpers built by CMA Robotics (Pradamano, Udine).**

Figure 2: **The Mirafiori plant in Turin manufactures bumpers for all versions of the Levante car from Maserati range.**

surface tension of the substrate and therefore the adhesion of the paint layer applied later (**Fig. 3**). "This is the first station of our coating process for plastic components (**Fig. 4**)," says Balzano. The workpieces come here after undergoing an alkaline-acid pre-treatment operation, performed to remove any oil, dust, and particle residues left on the surface, and a drying phase.

The flame hardening plant consists of a booth equipped with the two robots designed and installed by CMA Robotics, the company that won the tender issued by the FCA purchasing department for the updating of this system. "We included CMA among the candidates," states Mirafiori-Maserati FCA Engineering Paint specialist Ilario Crosio, "because we had appreciated a robotic system we had seen in operation within a coating line in Modena: the application was different, but the installed technology was the same. This was the first time that CMA participated in an FCA call for tenders: it was an important success for them. At the same time, it gave us the opportunity not only to add a new supplier to the list of those already known to our factories, but also to deepen the knowledge of a new robotic technology."

CMA flame hardening robots: main features

The two 6-axis robots installed belong to the GR6150 HW series of CMA Robotics. "This is the top model of CMA," says CMA Robotics Sales Director Marco Zanor while describing the selected devices. "It has a load capacity of 15 kg and it is designed to possibly ingrate pumps and colour change units, which are then managed by the robot control module in order to guarantee speed, waste reduction, and high quality. Its work area allows handling large parts and it can be increased by using ground or overhead transfer carts (**Fig. 5 and Table 1**). The robot can be equipped with multiple guns or rotating bells and perfectly integrated with any air and paint flow regulation device, by using extremely sophisticated software that is also easy to use and equipped with all the diagnostic tools required by the Industry 4.0 parameters (**Figs. 6 and 7**)."

An innovative offline system for PC program generation

"Currently, the robots work on two shifts," says Balzano, "and they have a production capacity of one skid per minute, with a flame hardening time of approximately 50 seconds; the plant however could potentially process 400 skids per shift. Each frame can accommodate 1 to 4 parts, depending on the type and shape of the component (**Fig. 8**). Thanks to the monitoring of the workpieces

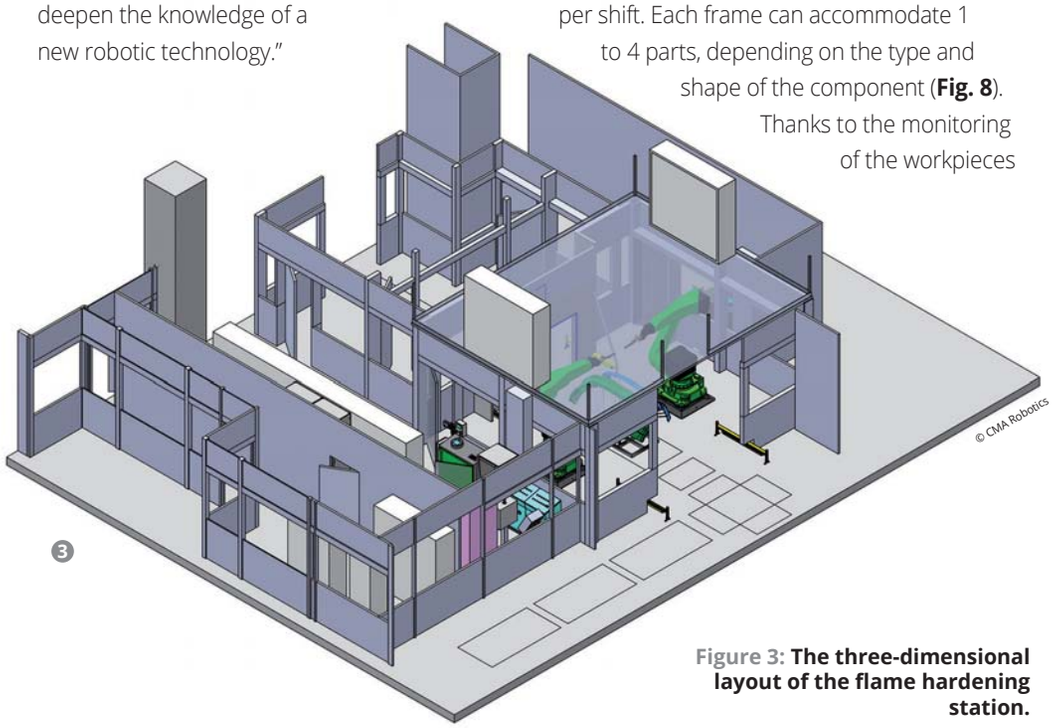

Figure 3: **The three-dimensional layout of the flame hardening station.**

through the 3D scanner, the system selects the most suitable flame hardening program based on the type and number of components on the skid. The robots can store 99 programs each, with several secondary options: therefore, the variables for the creation of programs are numerous."

"The offline system," adds Zanor, "allows developing and verifying the programs executed by the robots. The system detects the three-dimensional conformation of workpieces, on which some flame hardening spots determine the trajectories to be followed by the robot (**Fig. 9**). The program also enables to manage all the flame hardening parameters of the guns, in order to obtain the required results. The software package uses the same interface of the robot control unit and it includes an online guide with suggestions for various features. After saving, a program is sent to the robot to be elaborated as a flame hardening program; similarly, the programs executed on the robot can be elaborated by the software package for possible modifications."

"The benefits of this system, "states Balzano, "include the possibility of programming without interrupting production, the process simulation option, the ease of programming (which is actually performed by our staff), and the use of the same interface for the scanning system and the robot control unit. Since this technology enables the robot to recognise the parts on the skids, the device only processes the material actually present on the frame, which reduces methane gas costs, VOC emissions, and the amount of CO_2 in the booth, as well as increasing productivity thanks to the reduction of cycle times."

Figure 4: **Bumpers subjected to flame hardening.**

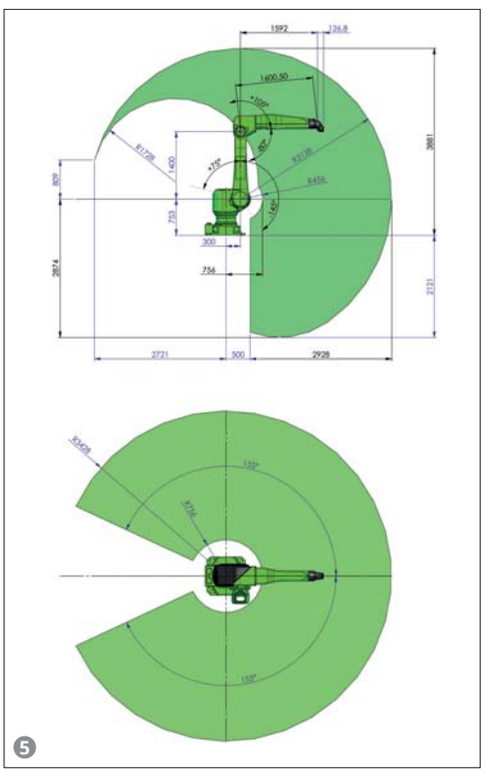

Figure 5: **The work area of the robots' mechanical arms.**

Applied robotics 4.0

The robot management system is linked to a series of Industry 4.0-oriented digital checks that allow real-time detection of information on the two robotic devices, from methane gas consumption to executive parameters such as voltage, flame temperature, and other process variables. Such real-time monitoring also enables the generation of alarms in case of failure.

"Another important feature of this 4.0-oriented system is the fact that, if the robot detects a process defect, the management system records the anomaly and prevents the execution of subsequent operations: this saves material, time, and labour also involved in operations that do not directly concern the flame hardening process. The faulty parts are therefore immediately eliminated from the production flow, without being treated and discarded at the end of the process as was the case previously."

Robot model		GR6150 HW
Payload		15 kg
Axis		6
Range of motion	J1	+/-155°
	J2	+75°/-145°
	J3	+105°/-80°
	J4	+/-360°
	J5	+/-360°
	J6	+/-360°
Max. Speed	J1	103.3°/s
	J2	139.5°/s
	J3	111.8°/s
	J4	452.8°/s
	J5	521.7°/s
	J6	666.7°/s
Wrist allowable torque	J4	51.6 Nm
	J5	44.8 Nm
	J6	35.1 Nm
ATEX control box size		L400*H500*D210 mm
ATEX control box weight		15Kg

Driving power	Motor	AC Brushless
	Total Power	3kW
	Working Voltage	400V
Brake		J1~J6
Position repeat accuracy		±0.5 mm
Max. working radius		3300 mm
Wrist threading hole size		Ø66mm
Weight		900 kg
Atex		Optional
Robot IP-Class		IP65
Cabinet IP-Class		IP52
Installation		Floor/Ceiling
Operating temperature		0°C/+40°C
Storage temperature		0°C /+55 °C
Air supply (Pressure)		At least 6 bar (0.6MPa)
Air (Flow)		> 220 Nl/min.
Air precision requirements		<5µm
Robot control box size		L1000*H1100*D500 mm
Robot control box weight		185 Kg

Table 1: **Technical data of the GR6150 HW robot produced by CMA Robotics.**

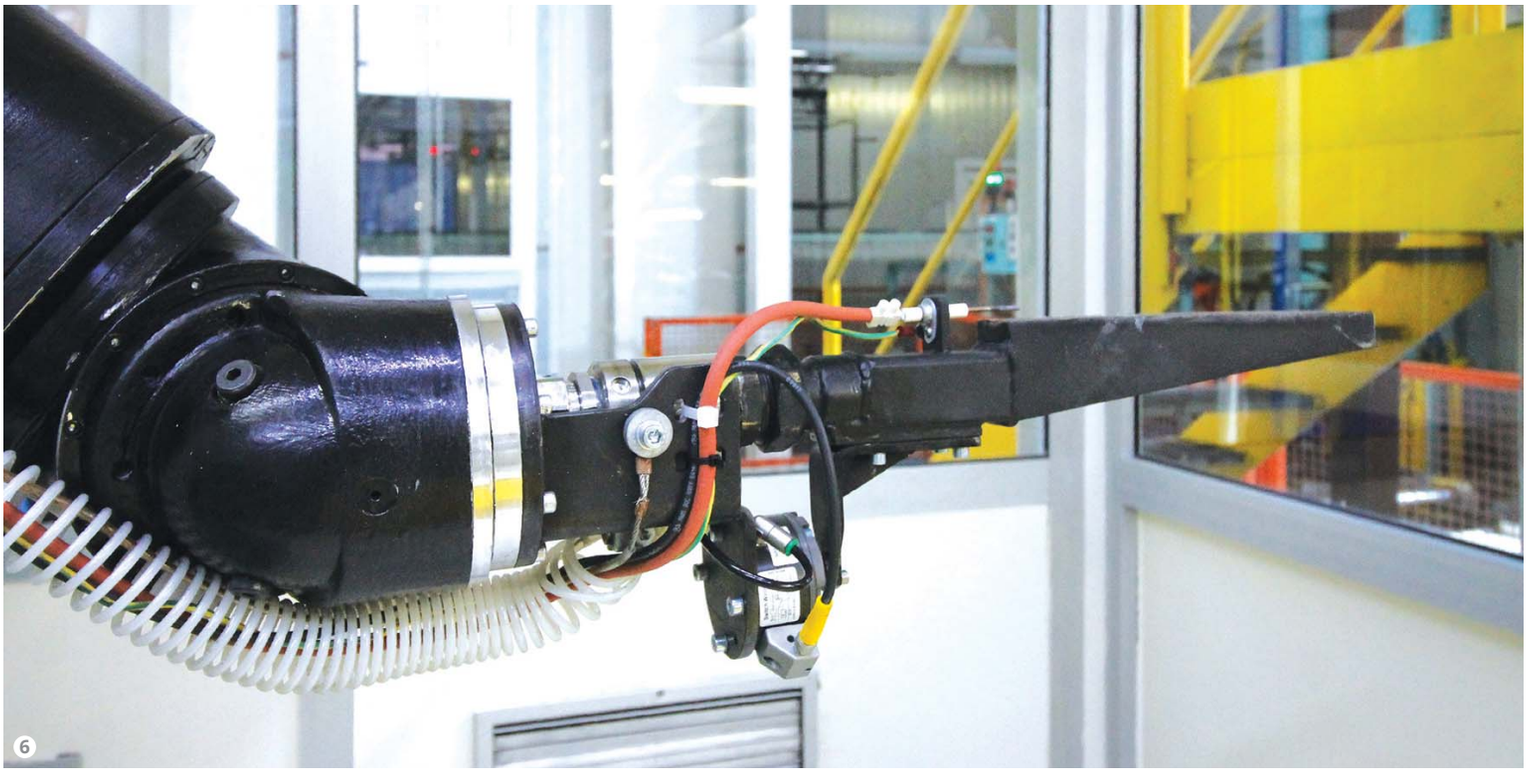

Figure 6: **A detail of the wrist in function.**

"The two 6-axis robots installed belong to the GR6150 HW series of CMA Robotics. This is the top model of CMA. It has a load capacity of 15 kg and it is designed to possibly ingrate pumps and colour change units, which are then managed by the robot control module in order to guarantee speed, waste reduction, and high quality. Its work area allows handling large parts and it can be increased by using ground or overhead transfer carts."

FCA has long invested in training a team of highly specialised engineers, able to independently deal with the offline programming of all bumper processing phases, including flame hardening and coating (**Fig. 10**). "Our staff has the necessary skills to resolve any critical issue that may arise during processing and prevent future failures with a predictive approach," states Mirafiori-FCA Product Process Specialist and Coating Technologist Andrea Russi. "CMA's robot technology was also based on these premises."

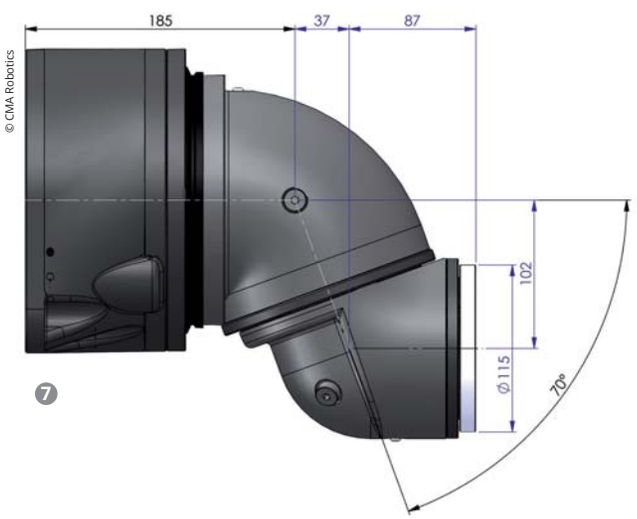

Figure 7: **End view of the wrist and gun support coupling.**

Safety comes first

"There are also important benefits in terms of safety," says Balzano. "First of all, the robots' design guarantees that the gun supply cables and connections are completely integrated inside the arm and no longer exposed. This eliminates the risk of critical issues that could jeopardise the flame hardening process and increases the safety degree of the booth. A further precaution for the health of the operators is the innovative system using nominal tokens that correspond to the role of each employee, placed at the entrance to all workstations: this allows performing different operations based on the type of token inserted, thus further improving

Figure 8:
Each skid can house 1 to 4 components depending on the type and size of the workpieces: for instance, only one bumper and its strip or, alternatively, 4 smaller size mouldings can be arranged.

the safety of our operators. Last but not least, we should mention the two robots' dual anti-collision system: the first device allows stopping production in the event of a collision with the components on the frame; the second one is based on a dynamic software system that constantly checks whether pre-set areas may interfere one with each other and stops the robot before this happens."

Conclusions

After the flame hardening operations, the components reach the coating plant, where the primer, base coat, and final clear coat are applied. The cycle ends in the cross-linking ovens of the coating system (**Fig. 11 and 12**).

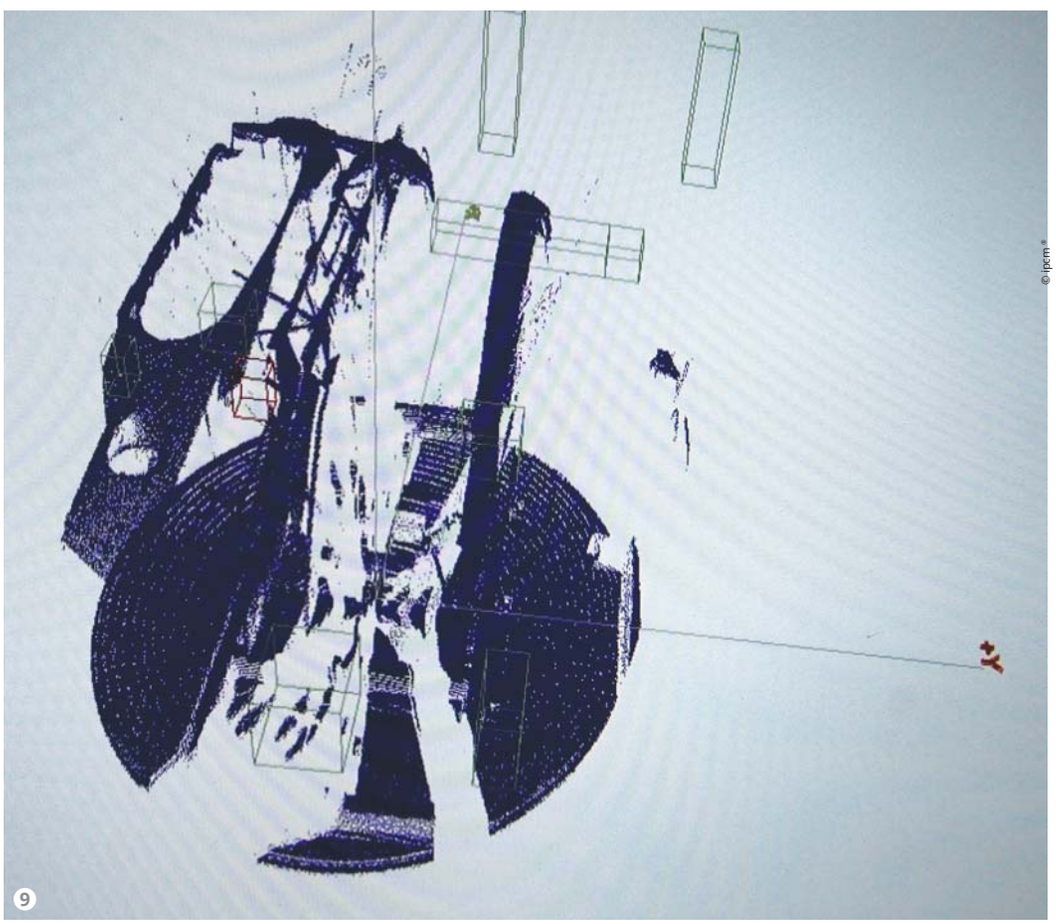

Figure 9: The result of a 3D scanning on screen.

Figure 10: **The staff of Maserati-Mirafiori with Alessia Venturi from ipcm®: from left to right, FCA Engineering Paint Luciano Paradiso, Product Process Specialist and Bumper-shop line Technologist Andrea Russi, FCA Engineering Paint Ilario Crosio and Mirafiori-Maserati Bumper-shop Production Manager Daniele Balzano.**

Figure 11: **Bumper coating.**

“The integration of the two CMA robots has led to an improvement in final coating quality degree through better wettability of substrates and greater adhesion of paint. It is worth mentioning that, since the installation of the two robots in August 2018, FCA has achieved a technical effectiveness value close ot 100%, as no faults have occurred yet. The technical characteristics of this advanced technology combined with specific IT functions has given unprecedented peace of mind: this is another benefit of Industry 4.0 for the automotive sector.”

“The integration of the two CMA robots in our flame hardening process has led to an improvement in our final coating quality degree through better wettability of substrates and greater adhesion of paint layers, states Balzano. Finally, it is worth mentioning that, since the installation of the two robots in August 2018, we have achieved a technical effectiveness valve close to 100%, as no faults have occurred yet. The technical characteristics of this advanced technology combined with specific IT functions have given us unprecedented peace of mind: this is another benefit of Industry 4.0 for the automotive sector.” Our hope for the robotics sector is that 2019 shows a steady growth in sales also thanks to the decisive push of the automotive industry, with Maserati remaining one of the flagships of its high-end segment.

Figure 12: **One of the three-layer coating systems applied on the Maserati bumpers is blue.**