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Opening photo: **Components of agricultural machines painted by Agrostroj.**

Agrostroj: Coating Equipment to Better Serve the ACE and Automotive Sectors

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Over one hundred years in business, a new 16,000 m^2-wide industrial coating line that is about to become the largest one in Europe (**Fig. 1**), and the record of having been the first Central European company to invest in the automation of its agricultural machinery powder coating processes with the installation of four Italian-made pre-retouching robots (**Fig. 2**). These are just some of the characteristics of Agrostroj Pelhřimov, a large-sized Czech company founded in 1896 that currently boasts over 2,600 employees and a turnover of 246 million Euros (2018 data), manufacturing drum and disc mowers, flail mowers, grass cutters, and disc spreaders for itself as well as for other important global brands (**Ref. Opening Photo**).
Project complexity, increasingly stringent quality requirements, and the aim of expanding its production volumes were the reasons behind its project of extensive department modernisation and purchase of

cutting-edge technologies for all its production phases, including coating. The primary criterion for these investments was environmental and production sustainability, closely linked to energy efficiency and process automation. This was also the case for one of Agrostroj's most recent investments, dating back to the end of 2016, for the automation of pre-painting touch-up operations, which are crucial to guarantee coating quality in terms of both coverage and penetration, through self-learning robots provided by the Italian firm CMA Robotics. In fact, Agrostroj's positive experience with coating robotisation has quickly become a benchmark for the whole Central European ACE sector.

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A 122-year long story

AGROSTROJ Pelhřimov, established in 1896, has survived the turbulent history of the central European region in good shape but not unscathed. Following the collapse of its markets in Eastern Europe in the 1990s, the company was on the brink of bankruptcy. The man who acquired the struggling business and invested in its turnaround was Lubomir Stoklásek, the company's current owner and Managing Director, who incidentally also won the E&Y Czech Entrepreneur of the Year Award in 2018. Today, AGROSTROJ employs 2,600 people and serves a customer base of global OEMs from the agricultural and commercial vehicles sector. While the company also manufactures agricultural machines under its own brands,

Figure 1: **Agrostroj's new 16,000 m²-wide industrial coating line by Eisenmann is about to become the largest one in Europe.**

Figure 2: With the installation of four Italian-made pre-retouching robots by CMA Robotics, Agrostroj is the first Central European company to invest in the automation of its agricultural machinery powder coating processes

Figure 3: Libor Zdvihal, coating manager of Agrostroj

such as mulching machines, tractor feeders and drum rotary mowers, 96% of AGROSTROJ's business is general subcontracting for two dozen of the world's or Europe's top leading OEMs. In addition to production, the company runs its own logistics to secure deliveries just in time and just in sequence as required by customers.
AGROSTROJ is headquartered in Pelhřimov, in its 230,000 m^2 production facility housing the latest technologies.
"Over the last two decades, we have spent almost €500 million on new machines and equipment," said Lubomir Stoklásek. "AGROSTROJ is the largest universal subcontractor for agricultural machines and commercial vehicles in Europe, with the two segments being almost equally divided," said Stoklásek. "The volumes of deliveries for each customer are substantial. For example, for one leading manufacturer of commercial vehicles we make 240 components, of which most are key components mounted in the truck chassis."
Jaroslav Habáň, Commercial Director at AGROSTROJ added: "We are a comprehensive supplier, covering the whole process from tool design through production process to final assembly and dispatch to the customers' specified location. That is our key competitive advantage, further supported by the degree of flexibility based on the range and availability of technology. We are able to change production within a very short space of time to meet specific customer requirements. Quality is absolute key. Our company meets the ISO 9001: 2008 standards and has been classified as a 'Class A supplier' by our partners. We have recently also achieved IATF certification, further enhancing AGROSTROJ's reputation as a first-class partner."
Speaking about the modern technology base, Lubomir Stoklásek pointed out that the company had started to implement currently promoted concepts such as Industry 4.0 and sustainability long before they became buzzwords. "We installed our first welding robots in 2000. Today, their number has reached 150, we have introduced painting robots and 85% of production is completed on CNC technologies. We plan to increase this figure to 98% by 2022."
In this modernisation process, sustainability and environmental protection have remained at the forefront, and the company not only satisfies all mandatory regulations and customers' environmental audits, but ecological thinking has become an inherent part of its functioning, as well as of its investment in new technologies.
Such has been the case of the recently commissioned state-of-the-art paint shop, currently the most modern and the largest universal paint shop in Europe.
"The paint shop really boasts a unique technology," explained Jaroslav Habán. "Components as heavy as six tonnes can be processed there, which will enable us to accommodate requirements for more complex and larger parts, further expanding our capability."
Lubomir Stoklásek also acknowledged the fact that the company has been using progressive, lightweight high-strength materials, nowadays increasingly required by vehicle makers, for quite some time – another valued advantage.

"Over the last ten years, we have acquired extensive experience and in-depth know-how
of incorporating these materials into our products; today, we process S700 to S1100 grade materials, as opposed to standard S355 to S500."
AGROSTROJ is ready for the next stage of development. Within the next five years, the company plans to increase turnover from the current €300 million to €400

million both by increasing production for existing customers and by starting new projects for the commercial vehicles segment.
This growth will be further supported by a major investment currently being implemented in Russia: a new factory with a 42,000 m^2 covered area, which will house all the processes run in Pelhřimov.
"We are now the second biggest Czech investor in Russia after Škoda Auto," noted Lubomir Stoklásek. "If everything goes according to plan, the factory will be commissioned towards the end of 2020. The new factory will significantly improve our market position but that is not the only direction we are going. In the medium term, we may also consider a new acquisition in the European market," he concluded.

Three coating lines, automation, and process flexibility for a highly diversified production

"Agrostroj mainly manufactures forage harvesting and shredding machines under its own brand, as well as agricultural machinery for other brands, including John Deere, Claas, Krone, Fendt, Pöttinger, and large components for commercial and public transport vehicles for brands such as Volvo, Mercedes, MAN, and DAF," states Agrostroj coating manager Libor Zdvihal (**Fig. 3**). "We analyse our customers' needs and we produce systems and components with the highest possible operational reliability, the longest possible service life, and the lowest possible purchase and operating costs. We also offer technical assistance and spare part supply services.
Our flagship products are ZTR drum rotary mowers and mulchers. Their robust and sophisticated design guarantees operational reliability, stability, high productivity, and a long service life even in the harshest environmental conditions.
"Our production cycle starts from raw materials, that is, machined sheet steel and aluminium.
Our in-house tooling department produces highly sophisticated and customised tools, and metal stamping dies. Our production plant accommodates cutting machines, machining centres, presses, heat treatment ovens, and surface treatment and finishing plants.
Finally, we have three Eisenmann coating systems performing cataphoresis and powder and liquid painting operations."

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Figure 4: One of the four Wagner's powder coating booths installed on Agrostroj's Painting Line 1.

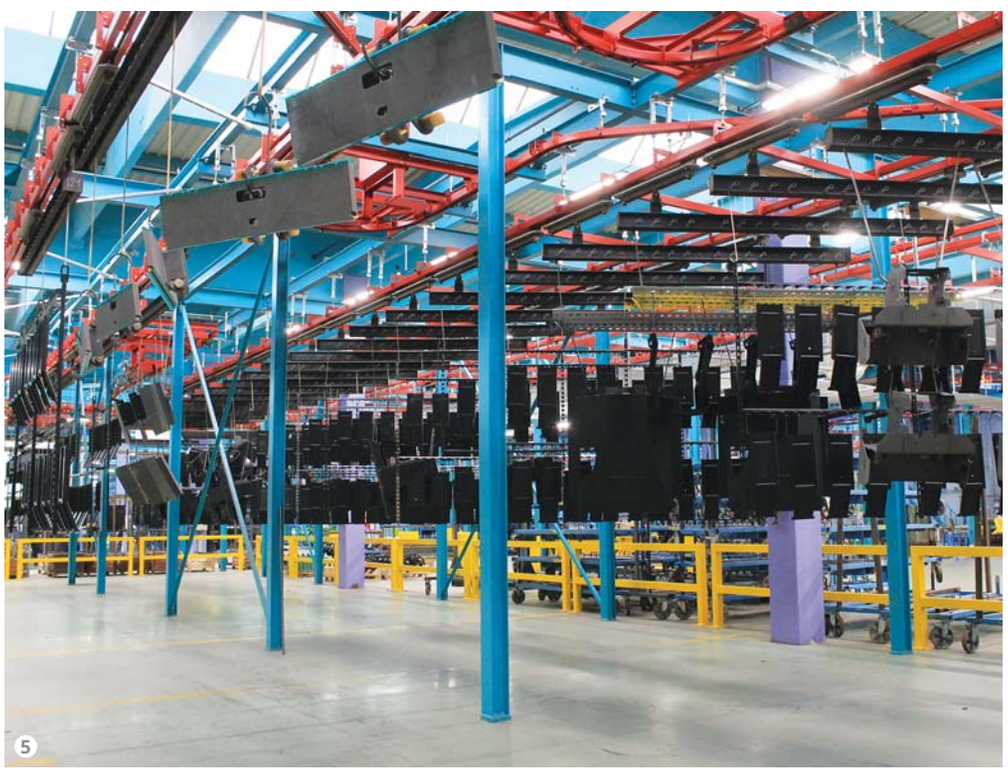

Figure 5: The power&free conveyor, which feeds Agrostroj's Painting Line 2 dedicated to automotive components.

The company's original coating department includes a cluster shot blasting machine for components with a maximum size of 1,800 x 2,200 mm and a continuous flow one for parts with a maximum size of 1,800 x 2,200 mm and a maximum length of 6,000 mm. The cataphoresis line was designed for workpieces up to 6,000 x 1,800 x 2,200 (H) mm, with a maximum weight of 2,200 kg; it uses the PPG Powercron 6200 HE lead-free technology to apply a primer layer between 20 and 45 microns. This cataphoresis line is connected to two finishing lines.

The first one coats 6,000 x 1,800 x 2,200 (H) mm workpieces weighing up to 2,200 kg; it is composed of four Wagner powder coating booths (**Fig. 4**) for components intended for the automotive, commercial vehicle, and transport sectors and one Wagner manual liquid coating booth applying epoxy enamel on agricultural machines. This line works on three shifts and produces approximately 7,500 m^2 of painted surface per day.

The second, more recent finishing line is exclusively devoted to automotive parts

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Figure 6: Agrostroj's Painting Line 2 features four Gema automatic coating booths arranged in a dust-free chamber.

(**Fig. 5**) and it only applies powder coatings. Installed in 2016, it consists of four Gema automatic coating booths with a quick colour change system, arranged in a dust-free chamber (**Fig. 6**). Here, automation is the protagonist: Agrostroj was the first company in the Czech Republic to install four new generation robots supplied by CMA Robotics (Pavia di Udine, Italy) to automate the pre-retouching stage on two of the four booths; moreover, all Gema booths are equipped with the Laser 3D piece recognition device (**Fig. 7**) launched by their manufacturer last year. The plant operated on two shifts and coats 70% of the production intended for Volvo, MAN, DAF, Mercedes, Scania and BT Toyota.
"This powder coating line receives components in various sizes, all intended for the car and commercial vehicle sectors, from the cataphoresis station of the line no. 1. We installed two opposing robots (**Fig. 8**) on both the first two booths of the line, whereas the touch-up phase of the other two is still manual, at the moment. Each booth is equipped with ten Venturi injector-technology automatic guns, five per side, mounted on opposite reciprocators, two automatic guns mounted on the pre-retouching robots, and two manual groups for the post-retouching stage, occasionally required for the components with the most complex shapes," explains Zdvihal.
"The booths operate simultaneously and they are fed through a power&free conveyor featuring three loading stations with elevators, which create storage buffers before each booth," adds Jiří Drápela (**Fig. 9**), painting junior project manager at

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Agrostroj. "This finishing line is equipped with two different ovens, with set temperatures of 195 °C and 205 °C: the parts enter one or the other depending on their finish colour and substrate thickness/mass. The total thickness of the coating, including cataphoresis, is between 100 and 160 microns. We apply almost fifty different tints using polyester or epoxy-polyester powder paints."
"We chose to install pre-retouching robots to increase the quality of our products, minimise labour, and reduce our touch-up times. We intend to eventually automatise all four booths but, even with the current configuration, the coating process is no longer a bottleneck for us," notes Libor Zdvihal. "Our daily production is equal to about 1,700 m^2 of coated surface per day, with a chain speed of 6 m/min. Now that we have tested the potential of robots on this powder finishing line, in 2020 we will implement other four of them on the two remaining booths.
Gema's dynamic shape recognition technology with a 3D scanner is a sophisticated solution that guarantees a high finishing quality level through automation, especially if combined with pre-retouching robots".
This device identifies even the most complex part shapes and brings every gun mounted on the reciprocators to the most suitable position for optimal coating.
The dynamic shape recognition process occurs in three phases: workpiece identification thanks to laser barriers located at the booth entrance to cover its whole height and width; dynamic shape recognition by measuring the object's distance to calculate its shape with precision and sending of these data to the Magic Control unit of the booth; dynamic coating where, the shape of the object is segmented and translated into the accurate positioning of the independent axes and the adjustment of each gun.

Figure 7: All Gema booths are equipped with the Laser 3D piece recognition device (see the 4 red laser devices at the entrance of the booth).

Figure 8: Two of the four CMA opposing robots installed for the automatisation of pre touch-up phases.

Figure 9: **Jiří Drápela, on the right, with Alessia Venturi and Luca Di Giusto of CMA Robotics.**

Figure 10: **CMA GR 650 ST is a 6-axis robot.**

CMA's technology for car and commercial vehicle components

Agrostroj chose GR 650 ST robots, which are ATEX certified for the application of powder coatings and programmed with direct self-learning or point-to-point methods. "Our GR 650 ST is a 6-axis robot (**Fig. 10**) suitable for in-line painting processes with either overhead or floor conveyors," explains Luca Di Giusto, area manager at CMA Robotics. "It can be programmed with both point-to-point and self-learning techniques (**Fig. 11**). Thanks to its sturdy structure, it is suitable for treating large workpieces and it can be synchronised with the conveyor for adjusting the parts' pace. It is 1,976 mm high and it has a maximum range of 2,175 mm. In order to further expand its work area, the robot can be mounted on transfer cars. Its load capacity is 5 kg."
"We chose CMA's robots because we believe they are the best in terms of self-learning process," states Libor Zdvihal. "Their programming is very fast. As 'time is money', we preferred to select these self-learning robots rather than other options with offline programming methods. We coat 70,000 different components and our CMA robots are programmed for 18,000 of them (**Fig. 12**): this choice has enabled us to save a great deal of time and almost completely eliminate the need for post-retouching operations. Moreover, this robot programming mode allows checking in real time if the position of the guns is correct or not: this is a great advantage for our engineers."

Figure 11: **The programming device of CMA robots.**

The largest agricultural machinery coating line in Europe: the future goal of Agrostroj

What has been defined as Europe's largest coating line for agricultural machinery parts up to 3,200 x 2,700 x 16,000 mm (e.g. wheat harvester blades – **Fig. 13**) is currently in its ramp-up phase in a new construction-smelling building adjacent to Agrostroj's old one. Designed by Eisenmann, this enormous plant covers an area of 16,000 m^2 and it is arranged on two floors, connected by an elevator. It is a cataphoresis + powder or liquid finishing line. It even accommodates a smaller line with an overhead conveyor for small components – almost like in the "Inception" movie, except it is for coating. "This all-purpose line can be used for the industrial finishing of any metal component, be it large or small," states Libor Zdvihal. "The ramp up phase will be completed by the end of the year 2019 and it will be fully productive from 2020. The choice to install it stemmed from our need to insource the coating of non-standard agricultural machines, which we produce in particular for the American company John Deer: we used to rely on a

Figure 12: CMA robots are programmed for the coating of 18,000 different automotive parts.

German contractor, but the related logistics processes and the consequent quality problems had become a critical issue to be solved for Agrostroj."

The line no. 3 of the Pelhřimov-based firm includes two combined loading/unloading stations with an elevator (**Fig. 14**), the pre-treatment and cataphoresis line and its related oven on the lower level (**Fig. 15**), whereas the upper one accommodates as follows:

- 4 manual application booths, 3 of which are devoted to powders (**Fig. 16**) and 1 to liquids, all equipped with lifting platforms for operators and 4x75 kW absolute filters for air purification and recirculation;
- 6 curing ovens, 4 of which are combined systems treating both powder and liquid coatings, with a temperature range between 80 °C and 220 °C;
- 4 cooling areas (**Fig. 17**).

Figure 13: **Wheat harvester blades.**

Each pre-treatment and cataphoresis tank has a capacity of 250 m³ and they are linked to three synchronised overhead cranes (**Fig. 18**). Their cycle includes degreasing, rinsing, activation, zinc phosphating, three rinses with demineralised water, cataphoresis, and ultrafiltrate cleaning. The flying bars tilt inside the cataphoresis tank to minimise the formation of bubbles due to the large size of the immersed mass. The workpieces are hung onto them obliquely to promote drainage and avoid bath pollution (**Fig. 19**).

“The flying bars tilt inside the cataphoresis tank to minimise the formation of bubbles due to the large size of the immersed mass.”

Figure 14: **The two combined loading/unloading stations with an elevator of Agrostroj’s Painting Line n. 3.**

Figure 15: **The pre-treatment and cataphoresis line.**

Figure 16: **A large part entering one of the manual powder coatings booths of the new line.**

Figure 17: **Overview of the six ovens + 6 cooling areas (on the left) and of the powder and liquid coating booths (on the right) located on the upper level of the new huge line**

The parts are then transferred to the upper level through the elevator for the application of the powder or liquid top coat or they directly reach to the unloading stations located on the lower level. In the former case, the workpieces are sent to a storage buffer from where they are automatically picked by the plant management software so as to proceed to the right booth, depending on the production schedule and the finishing program required. The upper level of the plant also features the overhead conveyor of the "plant within the plant" (**Fig. 20**) and a storage buffer for its flying bars. The powder coatings booths of the "plant within the plant" (**Fig. 21**) are located on the lower level. The whole system receives clean air from an air conditioning unit that guarantees clean room conditions.

Figure 18: **The cataphoresis tanks have a capacity of 250 m³.**

Figure 19: **The workpieces are hung onto the flying bars obliquely to promote drainage and avoid bath pollution.**

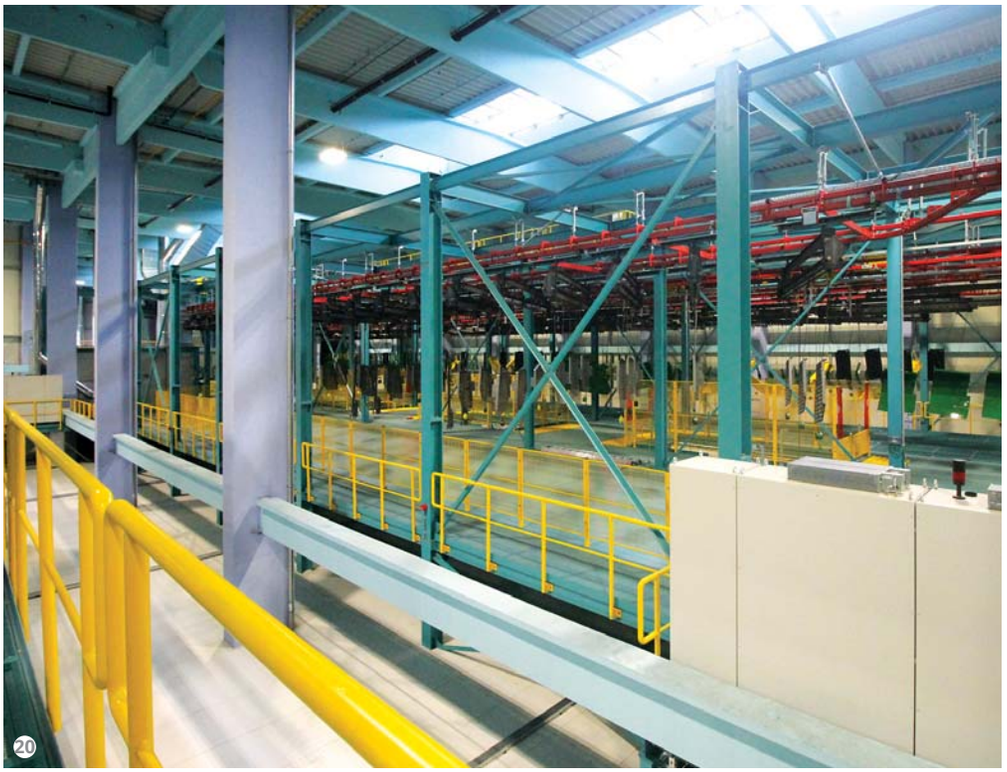

Figure 20: **The overhead conveyor with storage buffers of the "plant within the plant".**

Figure 21: **The powder coatings booths of the "plant within the plant".**

"Our employees are highly qualified: 60% of them hold a diploma or a degree. This is the result of our systematic and proactive HR policy, focused on active collaboration with local technical schools and universities."

Investing in human resources to gain a competitive advantage

In addition to plant equipment of such magnitude, state-of-the-art automation, and a fully integrated production process, another aspect contributes to make Agrostroj a leader in its sector: investment in human resources. "Our employees are highly qualified: 60% of them hold a diploma or a degree. This is the result of our systematic and proactive HR policy, focused on active collaboration with local technical schools and universities. We are also planning the construction of a training centre that will offer both theoretical and practical work experiences to our new employees before they join Agrostroj. A highly specialised technical workforce is required, in order to continue automating our processes as we have done so far, for example with the implementation of CMA's robots. This is the future of Agrostroj," Zdvihal says.