机器人结合金马产品应用

When maximum flexibility and perfect coating quality are required, robots are the solution.

Multi-axis robots specially developed for the coating industry are equipped with modern powder application technology. Once programmed, the robots efficiently coat parts to the highest quality as if by magic.

The advantages of uniform and reproducible coating results, cost reduction through increased efficiency, optimization of labor costs, optimized throughput, easy adjustment and storage of various programs and safer as well as improved working conditions become obvious.

机器人解决方案适用于在实现最大化灵活性的同时获得完美喷涂品质的生产需求。

结合先进粉末喷涂技术应用的多轴机器人专为喷涂行业开发。编程后的机器人犹如被施了魔法一样高效喷涂工件获得最佳品质。

The advantages of uniform and reproducible coating results, cost reduction through increased efficiency, optimization of labor costs, optimized throughput, easy adjustment and storage of various programs and safer as well as improved working conditions become obvious.

机器人喷涂的优势显而易见：喷涂效果连贯且可重复，可提高喷涂效率以降低成本，可优化劳动力支出和产量。可轻松调节参数，储存多种喷涂程序，工作环境也可以得到改善。

There is no doubt that in the future coating will increasingly give way to a flexible and efficient application processes using robots.

毫无疑问，未来的喷涂工艺将会更多地依赖灵活高效的机器人。

Gema

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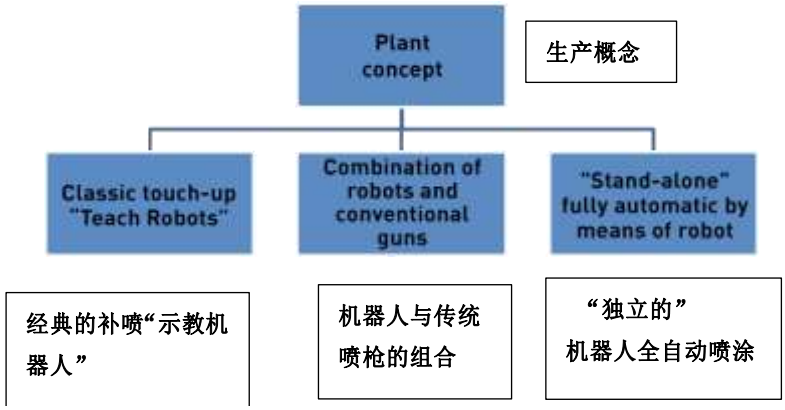
In this respect, it does not matter which coating concept is pursued. At the beginning of this century, manual coaters were traditionally replaced in manual systems for process stabilization, especially on stationary parts. In combination systems (oscillating axes supplemented with robot stations) with a running conveyor, the robot is used to replace or relieve the manual coater, for example to coat recur- ring inner product contours and edges. Automatic systems with a recurring part geometries, which run in 3-shift operation and coat fully automatically with several robots, form the stand-alone concept.

关于将来哪一种喷涂概念会被更多地采用其实并不重要。本世纪之初，为了实现生产工艺的稳定，特别是在固定部件制造领域，传统手工喷涂器被手动喷涂系统大量替代。在配备运行输送机的组合系统（配有机器人站的摆动轴）中，机器人用于更换或淘汰手动喷涂器，比如说要循环喷涂产品内部的轮廓或者边缘。循环喷涂重复几何形状部件的自动系统采用若干个机器人进行三班轮岗和全自动喷涂，形成了独立自动喷涂的概念。

The conveying speed tends to be in the low range up to 2m/min, but can also be operated at higher speeds of 5m/min depending on the complexity of the parts.

链速通常低至 2 米/分，也可以加快到 5 分/米，具体设定取决于工件形状的复杂度。



Once the motion sequence is tailored to the object to be coated and programmed accordingly, robots ensure that the guns operate at the correct speed, inclination and position to achieve the required surface qualities with minimum powder consumption.

调整好待喷涂物体的运动序列并进行相应地编程后，机器人能确保喷枪以正确的速度、倾斜度和位置展开运作，最终以最小的粉末消耗量获得所需的涂层品质。

Once defined, the programs can be called up on demand and the coating result is reproduced accordingly. Robots can be programmed in different ways. Depending on the robot manufacturer, different technologies are available for this purpose. However, despite their simplicity, the intuitive and comprehensible user interfaces require in-depth knowledge from the operator and familiarity with the coating process in order to exploit their full potential

程序一旦设定好，就能够随时按需调用并再现相同的喷涂品质。不同的机器人生产商能够采用不同的技术方法对机器人编程。然而，尽管经过编程后的操作十分简单，用户界面直观易懂，但是仍然需要操作者对喷涂工艺熟练掌握同时具备深入的知识，才能充分发挥机器人喷涂的潜力。

Many impressive, integrated robot solutions exist however in many cases these standard parts that are high in volume but low in variation. In the case where high product variation exists (typical of powder coating installations) then deeper analysis should be carried out to determine the best solution.

然而目前许多有作为的集成机器人解决方案都是出现在产量大变化小的标准件喷涂案例中。如果在产品存在较大差异（普遍存在的粉末喷涂配置情况）的情况下，则应当进行更深入的分析以确定最佳解决方案。

In order to select the correct robot to meet the application requirements, comprehensive analysis of the process must be carried out beforehand. Criteria including the part size and shape geometry will determine the reach requirements of the robot, production volumes are also considered, this will determine the number of robots and coating devices required. In addition consideration must be given to the conveyor system, continuous or stop-go as this will influence the application method. The method of programming, program transfer, color change, communication interfaces, security concept, assembly etc. result in a complex task. Moreover, the appropriate coating technology must be selected and the coating results must meet expectations.

为了选择正确的机器人型号以满足应用要求，必须事先对生产过程进行综合分析。包括部件尺寸和形状结构在内的标准将决定机器人需要达到的要求。生产量也要考虑在内，它将决定所需机器人和喷涂设备的数量。此外，传输系统的连续性能或启停灵敏性也会影响应用方法。还有编程方法、程序传输、换色、通信接口、安全概念、装配等都是综合影响因素。可见，只有选择合适的喷涂技术，才能获得符合预期的喷涂效果。

A robot becomes a coating robot only with the integration of a coating device. Gema supplies not only the coating guns but also the individual mounting adapters for connection to the robot arm, these are compatible with most makes models of robot available. Gema delivers also different solutions for the signaling communication between robot control and coating guns, thereby ensuring precise starting and stopping of the coating process. In addition, the data exchange of coating parameters via modern industrial bus systems is also covered. The optimal connection of the guns to the robot also includes a 3D file of the guns used in order to provide the robot

Point (TCP). TCP in robotics refers to the last element of the kinematic chain (stringing together all moving parts and joints of the robot). It is the decisive point for which the positioning requirements apply; in the case of coating robots, therefore, the point at which the powder emerges, the nozzle.

机器人只有与喷涂设备集成应用才会成为喷涂机器人。金马不仅提供喷枪，还提供用于连接机械臂的独立安装适配器，此类适配器与目前制造的大多数机器人型号兼容。金马还为机器人控制器与喷枪之间的信号通信提供不同的解决方案，从而确保精确启停喷涂程序，同时通过现代工业总线系统进行喷涂参数数据交换。喷枪与机器人的最佳连接还包括喷枪的 3D 文件，用于向机器人整合装置提供确定工具中心点（TCP）所需的信息。机器人学中的 TCP 是指运动链的最后一个元件（将机器人的所有活动部件和关节串连在一起）。它是实现定位要求的决定点；因此，在机器人喷涂中就是指粉末喷出的那个部件，即喷嘴。

In robotic applications, it is imperative that the objects are suspended absolutely precisely and optimally in the desi red position on the conveyor so that the sequence program together with the powder coating, delivers reproducible results. Depending on the manufacturer, the repeatability of the robot ranges from+/- 0.05 to 2 mm.

在机器人应用中，必须将物体以绝对精确的最佳位置悬挂在输送机上，以便序列程序对应粉末喷涂需求从而重复呈现相同的喷涂效果。根据生产商的不同，机器人的重复性机动范围为+/- 0.05 至 2 mm。

In order to run the coating programs in automatic mode, an encoder which records the conveyor speed and synchronizes it with the sequential program must be installed especially for the robot. In general, the objects are coated in stationary or continuous operation. Ideally, a generated program should adapt to the conveyor speed.

为了在自动模式下运行喷涂程序，必须特别为机器人安装一个编码器，该编码器用来记录传输速度并将其与序列程序同步。通常，物体是在静止或者连续移动的状态下被喷涂。理想情况下，生成的程序应当适应传输速度。

Furthermore, it should be noted that the use of robots is subject to safety guidelines. The directive RL 2014/34 EU (designated to the European Union) for use in potentially explosive atmosphere also applies to the coating industry.

此外，应当注意的是，机器人的使用必须遵循安全指南。适用潜在爆炸性环境的指令 RL 2014/34 EU（欧盟指定）也适用于喷涂行业。

Gema products for robot coating
适用于机器人喷涂的金马产品

Gema offers an extensive portfolio of application devices for robots that covers a variety of products and combinations. Guns are suitable for organic or enamel powder and can be used with pump or injector technology. All coating guns for use with robots are based on the latest gun technology available from Gema.

金马为机器人提供广泛的应用设备，涵盖各种产品和组合。喷枪适用于有机或搪瓷粉末，可与粉泵或发射器技术结合使用。所有与机器人组合使用的喷枪均基于金马最新的喷枪技术。

They impress with their robustness, coating quality, a large selection of nozzles and are an important key to mastering complex coating requirements. The high transfer efficiency, i.e. how much powder sticks to the component to be coated, from this new generation of guns significantly increases the productivity of the system and the low weight is also suitable for robots with a low payload. The advantages of professional coating equipment must be used for any robot-supporting coating task. Particularly in stand-alone systems without subsequent manual coating, unreliability of devices can cause serious concern. Qualitative and reliable coating devices combined with the advantages of a robot ultimately lead to success.

金马喷枪的坚固耐用、优质的喷涂性能、多种适用喷嘴类型是其能够应对复杂喷涂需求的重要品质。新一代喷枪的高上粉率（即粉末粘于待喷涂部件上的量）显著提高了系统的生产率，重量轻便能适用于低有效载荷的机器人。专业的喷涂设备能够支持所有的机器人喷涂任务。特别是在没有后续手工喷涂的独立系统中，设备的不可靠性会带来严重的问题。可靠的喷涂设备结合机器人的优势会获得成功的喷涂效果。

Figure 1: Gun with angular displacement for connection to the robot arm

图 1：用于连接机械臂的角位移喷枪

Figure 2: Gun with 45 °angle nozzle for axial connection to the robot arm

图 2：用于轴向连接机械臂配有 45 °角喷嘴的喷枪

In today's market, most robots have an internal installation (Figure 3) of hose, pneumatic and power lines. This means that they are guided centrally within the robot arm (hollow wrist robot).

目前市场上，大多数机器人的粉管、气动和电源线均为内部装置（图 3）。这意味着指挥装置集中于机械臂中心（空心腕式机器人）内部。

This gives the robot complete mobility. Collisions between objects and the hose installation do not have to be taken into account during programming and thus allow to move close to the contour and enter into cavities. Possible color contamination during color change applications is also avoided through easier cleaning of the outer robot surfaces.

这给予机器人完全的机动性。在编程过程中，无需考虑物体与粉管装置之间的碰撞，允许喷枪靠近物体轮廓并进入空腔。只要简单清洁机器人的外部表面，就可以避免在换色应用过程中可能出现的粉末污染。

An adapter tailored to the robot arm connects the guns to the robot, whereby the gun flanges can be removed, making the connection maintenance-friendly. (Figure 4)

适合机械臂的适配器将喷枪连接至机器人，从而可以移除喷枪的法兰，便于拆卸装配维修（图 4）

The guns are supplied with powder either by the OptiSpray application pump or by the classic OptiFlow powder injector.

喷枪通过 OptiSpray 应用粉泵或经典的 OptiFlow 粉末发射器获得粉末供应。

If high-quality coating results are required over long periods of time, pump technology is the right answer to achieve constant and reproducible quality. Long hose lengths and bends in the robot arm have no impact on powder output. Pumps do not wear out due to powder abrasion and therefore do not change the amount of powder output over time. The pump technology is also characterized by an extremely precise and fast response, so that the powder output is started and stopped at the same time as the triggering.

如果需要进行长时间高质量的喷涂，粉泵技术是获得恒定和可重复喷涂效果的关键。机器人手臂中的粉管长度和弯曲度对粉末输出没有影响。粉泵不会由于粉末摩擦而磨损，因此不会随着时间的推移而改变粉末输出量。粉泵技术的另一个特点是响应非常精确和迅速，可以在触发瞬间灵敏启停粉末输出。

The output quantity can also be adjusted with extreme precision. For maximum powder output, two such pumps can supply one gun and thus increase productivity. (Figure 5)

粉末输出量也可以非常精确地调整。为了获得最大的粉末输出，需要两个粉泵供应一把喷枪，从而提高生产率。（图 5 ）

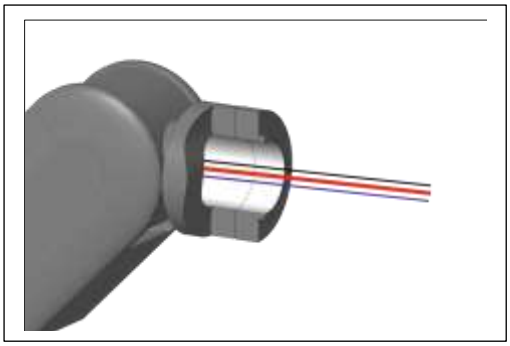


Figure 3: Robot with hollow wrist
图 3：空心腕式机器人

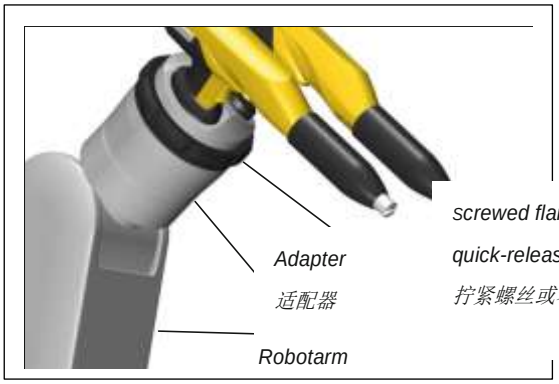


Figure 4: Gun connection to a hollow wrist robot; with or without quick-release lock
图 4：空心腕式机器人喷枪连接；带或不带快速释放锁

Figure 5: OptiSpray dense phase conveying technology for highest demands and consistent coating results
图 5：OptiSpray 密相输送技术，可满足最高要求并获得一致的喷涂结果

Figure 6: Proven and optimized powder conveying with OptiFlow injector technology
图 6： OptiFlow 发射器技术-=经过认证和优化的粉末输送技术

Figure 7: Organic powder
图 7：有机粉末

Figure 8: enamel powder
图 8：搪瓷粉

Figure 9: Single gun

图 9：单枪

Figure 10: Dual Guns
图 10：双枪

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Figure 11: Coating booth

图11：喷涂粉房

Figure 12: Outside cleaning station for the gun

图12：喷枪的外部清洁站

The more cost-effective injector, which is based on the simple Venturi principle, currently delivers constant powder out- put and thus consistent layer thicknesses on the components thanks to precise air flows. Enhanced and advanced injector geometries nowadays reduce wear considerably and allow wear parts to be replaced without tools within a few seconds, this combines ease of maintenance with reliable and consistent coating results. (Figure 6)
现在，基于简单文丘里原理发明的更加节省成本的粉末发射器凭借精确传输的气流，在部件上提供恒定的粉末输出，因此能够保持相同的膜厚。改进过的发射器形状大大减少了磨损，无需工具即可在几秒钟内更换磨损部件，维修简便且能确保喷涂结果一致。（图 6 ）

Guns and powder delivery (pumps and injectors) are available for applications with organic or enamel powder. The components for the application of enamel powder have been specially developed to counteract the abrasive character of this powder. (Figure 7 and 8).
喷枪和粉末输送装置（粉泵和发射器）可用于有机粉末或搪瓷粉末的应用。已特别开发出用于搪瓷粉末应用的部件，以抵消这种粉末的研磨特性。（图 7 和 8 ）。

Depending on the conveying speed or required area output, a single or dual gun configuration is required. Depending on part complexity and layer thickness requirements, an applicator covers an area of 0.5 to 1.5m^2/min. An average area of 1m^2/min can be considered as a dimensioning value. (Figure 9 and 10)
根据输送速度或输出区域来确定单枪或双枪配置。根据部件的复杂性和膜厚要求，涂料器覆盖的面积为 0.5 至 1.5 m^2/min。1 m^2/min 的平均面积可视为尺寸值。（图 9 和 10）

The robot requires correspondingly large booth openings for a large area of movement. This must be taken into account when designing the air balance of the booth. On the other hand, excellent coating results require uniformly smooth air flows in coating booths.
机器人需要相应大的粉房开口来进行大面积的运动。设计粉房气流平衡时必须考虑到这一点。另一方面，好的喷涂效果需要喷涂粉房内气流均匀平滑。

The MagicCylinder/ MagicCompact booth series with patented EquiFlow technology offer the

ideal coating conditions and are also extremely suitable for quick color changes. A freely placeable gun blow-off supports the external cleaning of the gun and the robot arm. (Figure 11 and 12)

MagicCylinder 和 MagicCompact 粉房系列采用专利 EquiFlow 技术，可提供理想的喷涂条件，也非常适合快速换色。可自由放置的喷枪清吹装置可对喷枪和机械臂的外部进行清洁。（图 11 和 12）

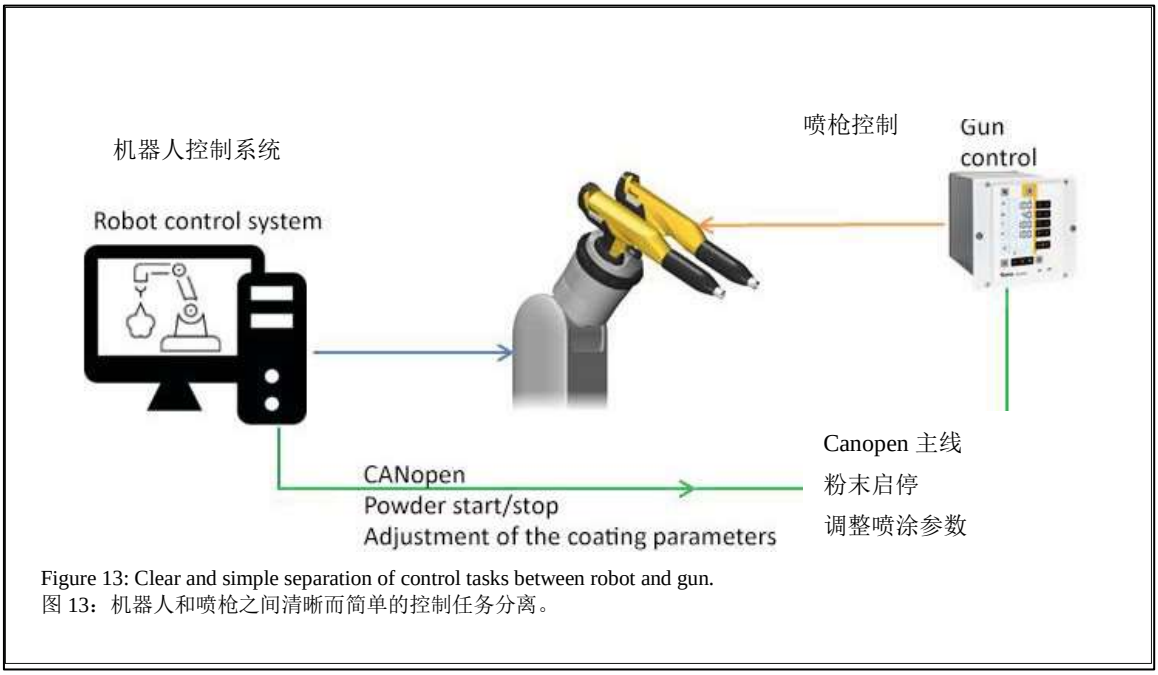


Figure 13: Clear and simple separation of control tasks between robot and gun.
图 13：机器人和喷枪之间清晰而简单的控制任务分离。

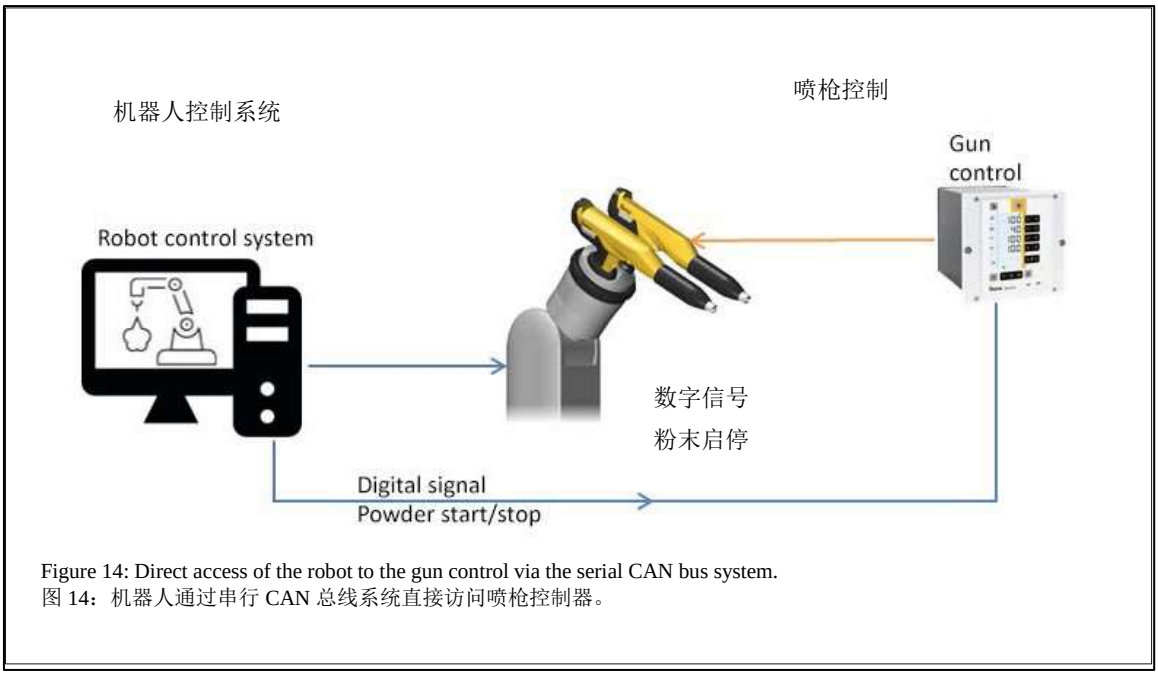


Figure 14: Direct access of the robot to the gun control via the serial CAN bus system.
图 14：机器人通过串行 CAN 总线系统直接访问喷枪控制器。

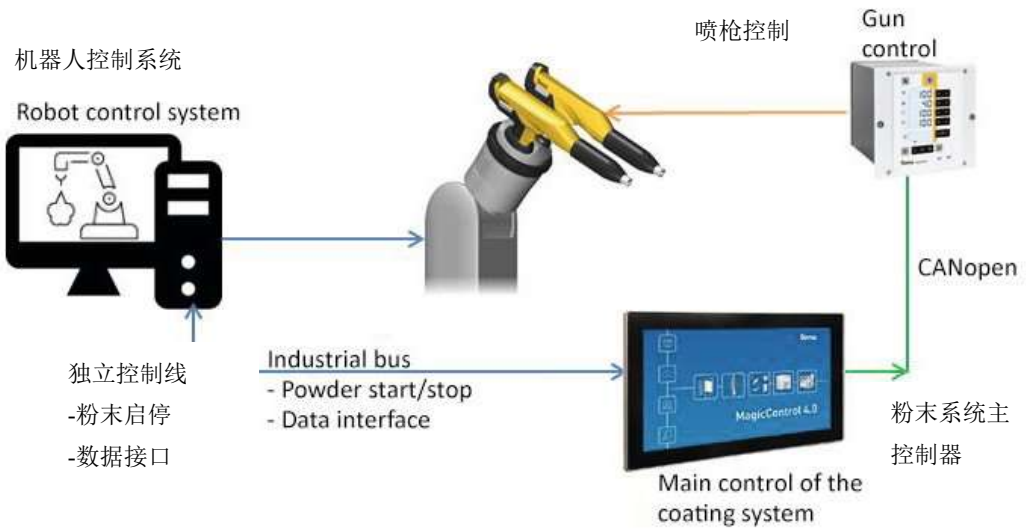


Figure 15: Integration of the coating system in a superior control system.
图 15：将喷涂系统集成到高级控制系统中

Communication interface between robot and gun

机器人与喷枪的数据接口

The primary task of a robot is to bring the coating device into position. The necessary movements are performed by a robot control. The coating technology with all its parameters and programs is controlled by a separate gun control unit. Therefore, an interface between the controls is necessary to synchronize movement and spraying.

机器人的主要任务是使喷涂装置就位。由机器人控制器执行必要的移动。在喷涂技术中，所有的参数和程序由独立的喷枪控制器控制。因此，控制器之间的接口是同步移动和喷涂的关键。In the simplest case, i.e. when there is a clear separation between robot and gun tasks, the robot control coordinates both the robot-side tasks and the timing of the coating start and stop commands, by means of a simple digital signal at the gun control. The latter manages the gun parameters and the stored gun-side pro- grams. (Figure 13)

在最简单的情况下，即当机器人和喷枪任务之间有明显的分离时，机器人控制器通过喷枪控制器的数字信号协调机器人端任务以及定时喷涂启停命令。喷枪控制器管理喷枪参数和存储的喷枪程序。（图 13 ）

If the robot control (or an external control unit connected in addition) has a Can- Bus interface, the networking between robot and gun control takes place via the CANopen communication protocol. As a result, the robot control can directly access the coating parameters or stored programs of the gun control. The necessary communication objects are part of the robot control. (Figure 14)

如果机器人控制器（或另外连接的外部控制组件）具有 Can 总线接口，则机器人和喷枪控制器之间通过 CANopen 通信协议通信。这样，机器人控制可以直接访问喷枪控制的喷涂参数或存储程序。必要的通信对象是机器人控制的重要部分。（图 14）

With a higher degree of automation, communication is bi-directional between the robot (or higher-level system control) and the Gema MagicControl control unit via a common industrial bus (Profinet, Ethernet etc.). Coating start and stop commands, gun-side programs, further information such as color acknowledgement are communicated and exchanged. (Figure 15)

随着自动化程度的提高，机器人（或更高级别的系统控制）和金马 MagicControl 控制器之间通过公共工业总线（Profinet、以太网等）进行双向通信。交换诸如喷涂启停命令，喷枪端程序，颜色确认等进一步信息。（图 15 ）

In the future, the increasing digitalization and networked production as well as the approaches of industry 4.0 will generate further benefits for the user. In this context, it is important that the common communication programs are already integrated into the control systems today.

未来，日益增长的数字化和网络化生产以及工业 4.0 的推进将给用户带来更多的好处。在这种背景下，实现公共通信程序集成到控制系统中十分有意义。

Programming methods
编程方法

Depending on the robot manufacturer, workpiece shape, series size and quality requirements, various programming, editing and re-teaching methods are available for robots.

目前不同的机器人生产商可提供不同的机器人，不同的机器人可以喷涂各种工件形状，具备不同的尺寸和品质要求，掌握各种编程、编辑和再校正方法。

Point-to-Point (PTP) or Teach-In

点对点（ PTP ）或教学

Traditional programming via coordinates in space is done using the keyboard or by moving the robot arm to selected points on the component. Basic geometries (e.g. circles) simplify and support programming. For the operation and movement of the robot, an appropriate programming device such as joystick, coordinate input or intuitive gesture control is used, depending on the manufacturer. (Figure 16)

传统编程是基于空间坐标通过使用键盘或移动机械臂到组件上选定的点来完成的。基本几何形状（例如圆）适合这种编程，操作十分简单。对于机器人的操作和移动，不同的生产商采取的方法不同，会选用适合的编程设备，如操纵杆、坐标输入或直观手势控制等。（图 16 ）

Self-Teaching
自学习

This process combines the manual skill of a coater with modern motion techno logy. The operator manually implements the motion sequence once by guiding the robot arm and simulating the desired coating sequence.

这个过程结合了手动喷涂技术和现代运动技术。操作者通过引导机械臂并模拟适当的喷涂动作来手动执行一次运动序列。

During the manual movement sequence, the motors of the robot mechanics are released and balanced by a compensation system so that the robot is easy to guide. A handling device is screwed to the robot to operate the robot. In another method, a device modeled on a classic manual coating gun records the manual painting movements and converts them into a robot coating program. A laser light visualizes the coating on the component. (Figure 17)

在手动运动过程中，机器人的机械驱动被释放，并通过补偿系统进行平衡，这样机器人就容易被引导。操纵装置被拧到机器人上以操作机器人。在另一种方法中，一种模仿传统手动喷枪的装置记录手工喷涂动作，并将它们转换成机器人喷涂程序。这种激光可以使部件上的喷涂工过程可视化。（图 17 ）

The robot can subsequently follow the stored motion sequence at an individual speed. The program can be further optimized or divided into sub-programs.

接下来机器人就能独立模仿存储的运动顺序。这些程序可以被进一步优化或被分成子程序。

Figure 16: Point-to-Point manual control unit

图 16：点对点手动控制单元

Figure 17: Self-Teaching Tools

图 17：自学习工具

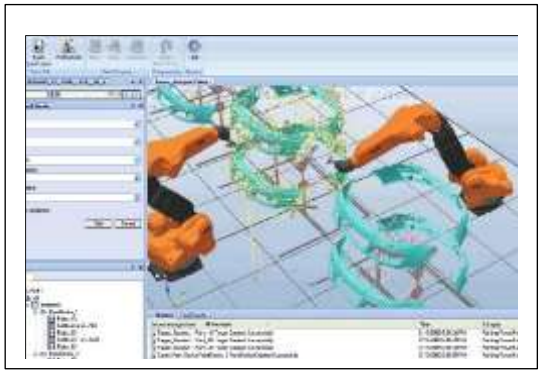


Figure 18: Offline 3D

图 18：离线 3D

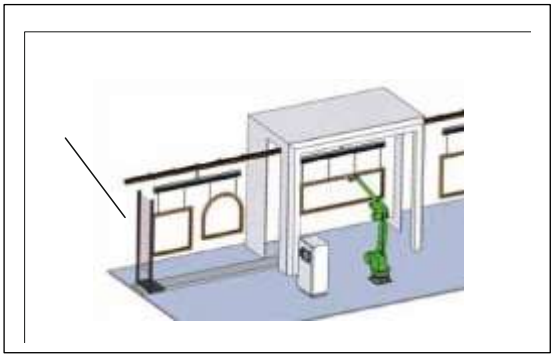


Figure 19: Automatic program generation

图 19：自动程序生成

Offline 3D

离线 3D

With this technique, the robot is programmed at the PC workstation. The programming software allows the import of the component to be coated as a 3D file. With the offline programming software, movements and spray paths can be created and simulated immediately.

利用这种技术，可以在电脑工作站上为机器人编程。编程软件允许将组件导入形成 3D 文件模拟喷涂。使用离线编程软件，可以立即创建和模拟喷枪移动和喷涂路径。

The powder application can be displayed graphically. (Figure 18). Other offline programming technologies such as interaction between programmer and 3D-objects by plugging in to virtual reality goggles or datagloves will find its way into automation in the future.

可以将粉末应用过程图形化。（图 18 ）。其他离线编程技术也会在未来应用于自动化，例如通过插入虚拟现实护目镜或数据手套实现的程序员和 3D 对象之间的交互等。

Automatic programme generation

自动程序生成

This method is only suitable for flat parts and frame-shaped components such as windows, i.e. where the robot does not perform depth infeeds. Based on a 2D scan (light bar) of the component, the software generates the motion sequence during operation based on the recorded component geometry. No programming is therefore necessary. (Figure 19)

这种方法仅适用于平面部件和框形部件，如窗户，即机器人无需深入进给喷枪。基于 2D 扫描（光栅）组件，软件可通过记录组件的几何形状在操作中即时生成运动序列。因此不需要编程。（图 19 ）

Re-Teaching
再校正

There are often differences between the real production environment or the component to be coated and the programmed simulation. These errors must be corrected by so-called re-teaching. For this purpose, the programmed points are approached and, if necessary, manually repaired by means of the Teach-In method. Possible program corrections can also be carried out offline without interrupting production. In addition, the simulation can be processed and optimized on the PC with regard to cycle times and other aspects. Depending on the industry and manufacturing process, one or the other programming method can be considered. The answer to aspects such as the presence of 3D data, recurring or non-recurring small series, justifiable programming effort per part or operator know-how already point the way.

真实的生产环境或要喷涂的组件与编程模拟之间经常存在差异。这些错误必须再校

正。为此，接近编程点时，如有必要，通过再校正方法手动修复。在不中断生产的情况下，也可以离线执行必要的程序修正。此外，还可以在电脑上处理和优化关于周期时间或其他方面的模拟。根据行业制造工艺，也可以从其他路径去校正编程。比如说利用获得的 3D 数据、反复试验总结或小批量的试喷、每个部件逐个检查程序的合理性或根据操作工的喷涂经验等。

Coating robots
喷涂机器人

Today's common coating robots consist of 6 axes for reaching the coating surfaces as flexibly as possible. With a seventh axis, the complete robot moves on a linear axis close to the ground. Meanwhile, all well-known robot manufacturers offer models that are specially developed for the coating industry. For the user, these differ in programming methods, ranges of coverage and load capacity of the robot arm.

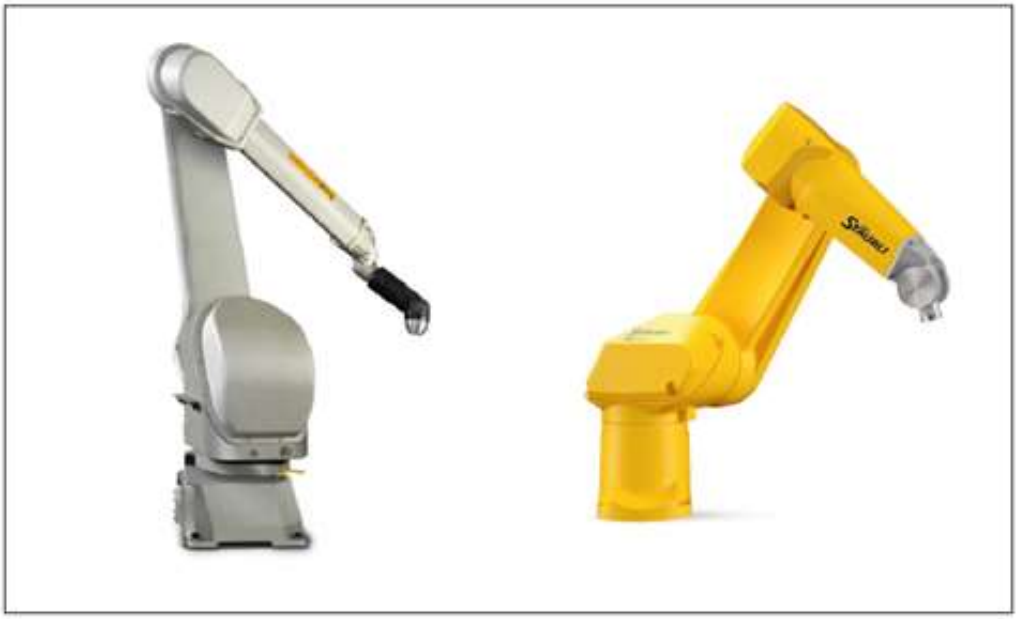
当前常见的喷涂机器人由 6 个轴组成，以尽可能灵活地接触喷涂表面。有了第七轴以后，整个机器人就能在贴近地面的直线轴上移动。目前所有知名机器人生产商都能提供专门为喷涂行业开发的型号。但是对于用户来说，这些型号在编程方法、覆盖范围和机械臂的负载能力方面是有所不同的。

A coating robot needs space. The robot arm must be able to move within the maximum usable range and the surrounding area of the robot must be protected from access for safety reasons. Not to forget the space required for the control system. One control cabinet per robot can be assumed.

喷涂机器人需要空间。机械臂必须能够在最大可用范围内移动，而且出于安全原因，机器人周围要留足安全区域。同时控制系统也需要空间，每个机器人都可能需要一个独立的控制柜。

Examples of robot specifications of some common types:
一些常见类型的机器人规格示例

ABB IRB 580　　CMA GR650



250-FANUC P　　60 Stäubli RX1

250-FANUC P　　60 Staubli RX1

Yaskawa Motoman MPX 2600.　　KUKA Dürr KR AGILUS KR 10 R1100.

KUKA Deutschland GmbH.

Costs
成本

At first glance, the procurement costs can appear deceptively low if the robot alone is evaluated. Required options such as hand-held control units or ATEX design, programming software and integration into the home IT structure as well as integration and training courses are further cost factors to be taken into consideration. Higher basic investments are required, but by automating a coating process, production output increases while costs and quality efforts decrease, which offers advantages over the years. Object variety, part geometry and throughput as well as quality requirements are decisive factors in the cost-benefit calculation.

乍一看，如果只评估机器人，采购成本可能看起来很低，但是其他成本因素也需要考虑，包括：手持控制设备或 ATEX 设计、集成到主 IT 结构中的编程软件，集成和培训课程等。喷涂自动化过程需要更高的基本投资，但是同时优势在于几年中产量增加也减少了成本，提高了质量。此外，喷涂对象的种类、形状和产量以及质量要求也是成本效益核算的决定性因素。

Conclusion robot coating

机器人喷涂总结

In the future, the use of powder coating robots will not only increase in the field of current automation. Quality advantages, flexibility, reproducibility and thus cost-effectiveness of the coating process are the drivers for distribution. Volume markets with high and constant quality requirements are the typical users of robotic powder application. Nevertheless, the costs and benefits of such investments must be carefully weighed. There is no standard solution that covers the variety of applications. The individual product portfolio of the individual robot suppliers and integrators is too large; and much depends on the object to be coated.

未来，粉末喷涂机器人的使用将不仅仅在当前的自动化领域增加。质量优势、使用灵活、品质可重复以及喷涂工艺的成本效益都是其扩大分布的驱动因素。粉末喷涂机器人应用客户的典型需求就是以稳定可重复的高质量进行量产。然而，这种投资的成本和收益必须仔细权衡。不存在满足所有应用需求的标准解决方案。单一机器人供应商和集成商的单一产品组合太庞杂；而且解决方案的制定在很大程度上取决于待喷物体的情况。

The manufacturers of robots have found numerous ways to keep the programming effort low and thus justify the time invested in program generation in relation to repetitive coating orders for a certain part.

机器人生产商已找到很多方法来降低编程的工作量，从而证明把时间花费在对某个部件重复喷涂的订单上，不如用在编程上更合理。

The most important role in robot coating continues to be played by the reliability and efficiency of the coating equipment, and Gema has a lot to offer.

机器人喷涂中重要的问题仍然是喷涂设备的可靠性和效率，这方面金马很有经验。

A high transfer efficiency of the sprayed powder, together with the advantages of the robot, simultaneously increases the overall coating performance. An uniform powder transport with a specifically applicable application technology characterizes the coating pattern and ultimately determines the quality.

粉末喷涂的高上粉率与机器人的优点相结合能提高整体喷涂性能。采用特定应用技术的均匀粉末输送确定了喷涂模式，决定了喷涂品质。

Thus, a versatile product portfolio of electrostatic coating equipment, packed with helpful features, is essential to integrate into any type of robot and to meet the coating needs of the customers. To ultimately benefit from a coating robot, the most efficient application technology must be used-and here is Gema expert.

因此，将静电粉末喷涂设备各种产品组合的多功能集成应用到不同类型的机器人中以满足客户的喷涂需求是十分必要的。为了更充分地发挥机器人的优势，必须采用最有效的应用技术-这方面金马是专家。

Figure 25: CMA Robots for Powder Coating
图 25：用于粉末喷涂的 CMA 机器人

Roman Mlakar, Product Management Gema Switzerland GmbH August 2018
Roman Mlakar，产品管理部　瑞士金马股份有限公司，2018 年 8 月