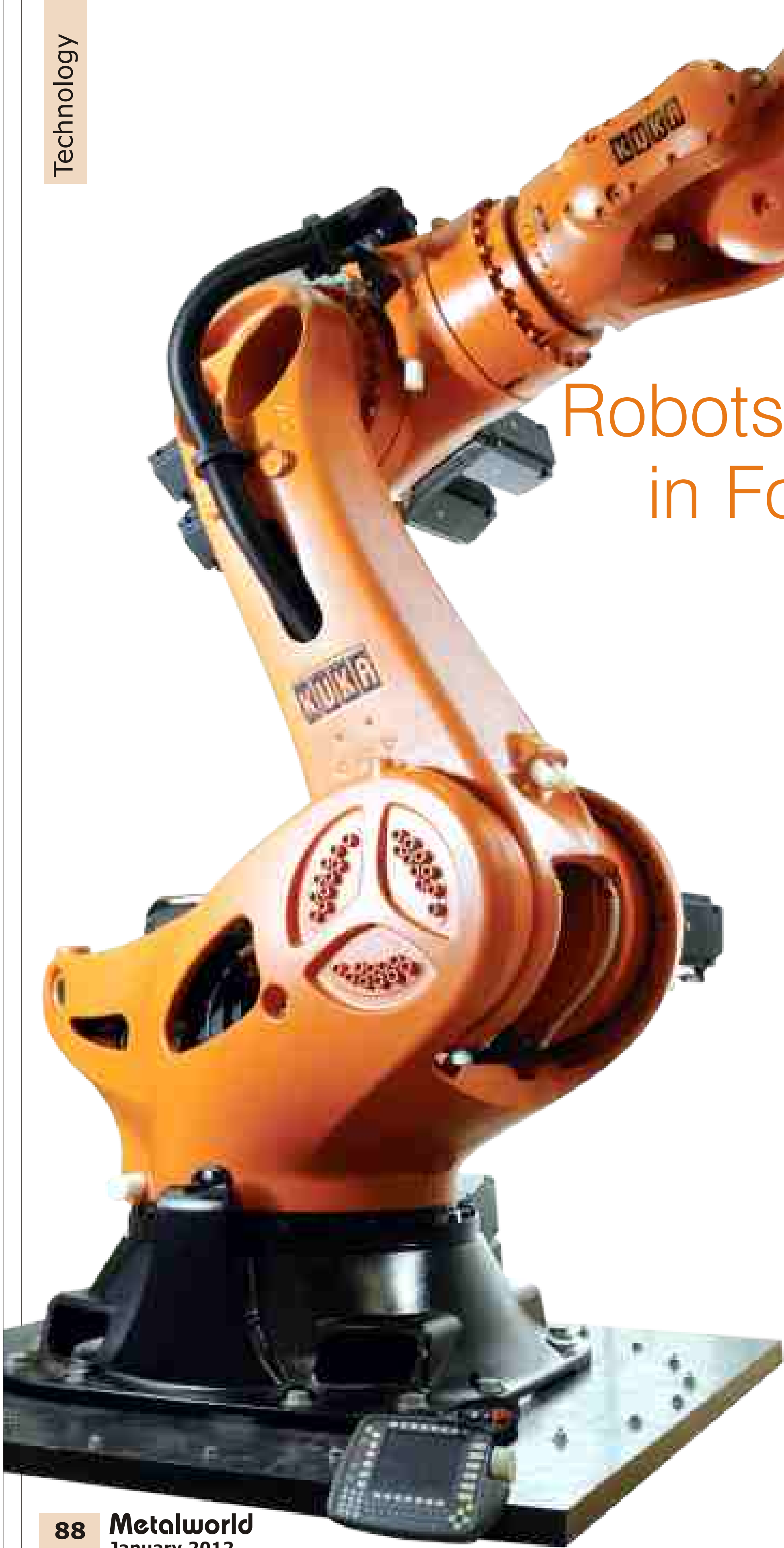
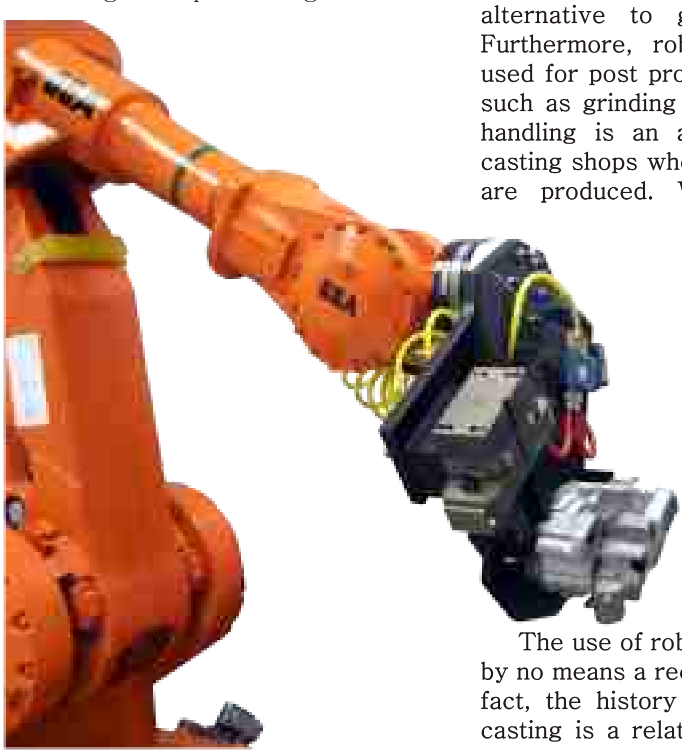


Robots and Robotics in Foundries

- Dr. Thoguluva Raghavan Vijayaram
FET Faculty (Engineering and Technology)
MMU Multimedia University, Malaysia

Modern foundries are constantly on the lookout for ways to improve efficiency, increase flexibility and improve workplace safety. The uses of robots make it easier to deliver the productivity you need to be competitive. Foundry operations encompass the three dreaded D's in industrial labor: Dull, Dirty and Dangerous. Work at foundries is less than desirable for people, but perfect for robots, which are ideally suited to take on the worst aspects of the process. Robots provide flexibility in foundry applications, including ladling and secondary operations such as degating and material removal. Using automatic tool changing, the robots place sand cores into bench stations, pour molten aluminum into molds, extract and degate the castings, and clean the crucible. Robot based automation helps to optimize foundry processes and productivity. Like many other industries, foundries are constantly on the lookout for new ways to boost their productivity, cut costs and increase quality. Nevertheless, once the decision for leading high-performance robot technology has been made, there is no need to look further. Lower production costs and scrap rates, increased up time and consistent, superior quality are the compelling benefits with robots. With the massive shift from iron to aluminium and other light alloys and for both ecological and economical reasons, foundries are investing heavily in new machinery. Robots are always there to gain efficiency along the entire value chain. This synergised system concept based on specific robots designed for the need of each process offers many advantages like enormous flexibility, high levels of reliability, and consistent capacity utilisation all along the foundry line.

Even for a robot, a foundry is not a workplace like any other. The exceptionally tough work environment demands appropriate protection, the more comprehensive the better. An extensive range of foundry-adapted robots with payloads up to 650 kg, with specialized high function controllers can be utilized. Cost-efficient offline programming is the best way to maximise return on investment in foundry robotics. Simulation and offline programming software, Robot Studio, allows robot programming to be carried out in the office without shutting down casting production. It also enables robot programs to be prepared in advance, increasing overall productivity, completely sealed, equipped with a two-component high-resistance enamel surfaced foundry adapted industrial robots can take more than just the heat. These robots are ready to meet the challenges of spits, sands and lubricants of modern high-performance foundries on a daily basis. A fast and strong bending backwards robot is suitable for die-casting machines from 400 to 800 tons. It is faster than any other competing robot in its class and the payload options are 5 or 7 kg and up to 10 kg with wrist down. Robots are used for easier palletising application in the downstream and upstream production in foundries. Handling of ingots and palletising of final castings are good examples. Robots are designed and optimised to work together with medium sized die-casting machines from 800 to 2000 tonnes in spraying and ideal for foundry through its compact wrist and working range in downward direction. Foundries are a very complex environment to work in. The automation of specialised tasks such as investment casting, and ingot handling requires detailed process knowledge and the right hardware to handle castings and cores with power and precision. This is where robots enter the foundry industry arena. Castings like aluminium cylinder heads need to be labelled with information like date, time and status to ensure traceability. A Robot equipped with a simple pneumatic graver is one of most flexible and cost-efficient solutions to easily label the cast parts whenever and wherever necessary. Dipping wax trees in water based slurry to continuously build the ceramic shell with special sand. It is a process in investment casting that is often robotics principles are applied. With a reach of up to 3.5 m and a handling capacity of 150 kg, robot is the perfect alternative to get the job done. Furthermore, robots are frequently used for post processing applications such as grinding and polishing. Ingot handling is an application found in casting shops where aluminium ingots are produced. When it comes to handling, the four-axis robot is the perfect tool for the task. It comes equipped with a special purpose pneumatic gripper for handling the solidified aluminium ingots and features a payload of up to 250 kg to 650 kg.



Robotics in Foundries

The use of robots in the foundry is by no means a recent development. In fact, the history of robotics in die-casting is a relatively long one. The first such recorded application dates back to 1961, when the Ford Motor Company installed a robot to tend a die-casting machine at a foundry in the United States. The anticipated benefits of this initial application namely, improved worker safety, and more predictable production output were soon realized. In addition, part quality is improved due to the regularity of robot operation, which maintained die temperatures at a constant level to improve the consistency of the castings. These basic benefits of robotics still apply today. However, as robot, technology has developed and industry's demands have changed, other advantages have emerged. So, the true potential of the industrial robot is now being better realized.

The key reason a robot is more economical than a dedicated device lies in its flexibility and its ability to undertake a wide variety of other functions. The one capital asset can be readily reconfigured to respond to changing demands and provide a practical way of automating an array of tasks. The foundry robots are designed for high-duty cycle applications, and offer heat and contamination protection so customers may automate more applications with a longer robot life and reduced maintenance needs. The wrists and forearms are coated with a corrosion-resistant and high-heat reflecting finish, so they function for short periods in environments up to 180°C. They reach up to 3,700 mm, giving them a larger work envelope. The line's mounting options give customers the flexibility to install on the floor, wall, ceiling, or on top of a casting machine.

Reasons for Robotic Automation In Foundries

Powerful Design

Hefty payload capacities and wide work envelopes allow robots to tackle the heavy lifting and wide loads common in foundries. With robotic automation installed in a foundry, workers are saved from harmful repetitious movement and the strain of lifting heavy parts.

Safety

Foundries are known for being extremely hazardous. Human workers deal with the continuous threat of burns, heat exhaustion, repetition injuries, or breathing in metallic dust. Foundry robots are required to have an industrial protection rating. They can endure the hazards with ease and work without fatigue.

Savings

Incorporating robotic automation in foundries conserves money and time: With robots, there is less of a chance of dropping or damaging parts. Fewer accidents mean less financial output as well. Since foundry work is taxing and hazardous, there can be a high turnover of workers. Robotic automation eliminates this challenge because it is quick and easy to program robots. Robots work without breaks or vacations, saving companies and increasing productivity. Unlike their human counterparts, they do not need to rehydrate periodically.

Accuracy

Robotic automation offers top-notch repeatability. This is extremely important when it comes to handling molten metal. Every movement is programmed every point exact. When it comes to deburring or sanding, robotic systems provide the precision necessary.

Flexibility

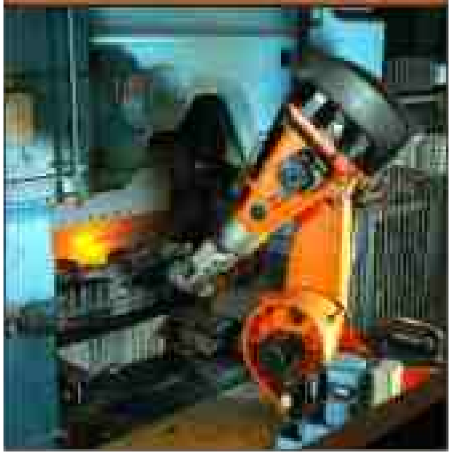
Robotic automation gives foundries flexibility. Robots can handle a wide range of applications from material removal and grinding/sanding to pick and place and dispensing. Using automatic tool changers they can switch quickly between tasks, which leads to simplified, faster production.

Foundry Robots

Foundries in general are not very hospitable places to work. They are hot, noisy, physically demanding, and potentially dangerous. Foundry robot is an industrial robot, which is an automatically controlled and reprogrammable one. It is also a multipurpose, manipulator programmable in three or more axes. Foundry robots are the tough ones, able to lift heavy loads in harsh, hot environments. They are fully capable of playing other roles as well. Industrial robots prove the ideal solution for a wide range of foundry jobs from material handling to dispensing, finishing and painting. Material handling is a central part of foundry processing. Robots are extremely useful when it comes to the repetitive work of moving and manipulating parts, cores, molds, castings and dies.

Foundry robots and wrists are able to handle extremely hot pieces and work in close proximity to potentially dangerous machinery and substances. Other material handling jobs that are common in foundries include machine tending, inserting and extracting, part transferring, and core making. Dispensing jobs, whether pouring or ladling molten metal or spraying release agents on molds are common to foundries. Robots are protected so they can handle the dangers of heat, hazardous fumes and smoke, and overspray from harsh chemicals. They conserve materials by moving and dispensing with extreme precision. Once pieces have been cast, a lot of finishing work must take place. Robots offer the dexterity and flexibility required to carry out the jobs of cleaning, water jet blasting, deburring, polishing, milling, drilling, machining, trimming, chiseling, painting and more. A tool changer allows a robot to switch from one task to another with ease. Besides, industrial robots extreme accuracy leads to consistent, high quality results. A foundry robot handling the molten metal from a melting furnace is shown below in Figure-1.

Figure 1 : A Metal Die Casting Robot in an Industrial Foundry



Requirements of Foundry Robots

Robots provide flexibility in foundry applications, including ladling and secondary operations such as degating and material removal. Using automatic tool changing, the robots place sand cores into bench stations, pour molten aluminum into molds, extract and degate the castings, and clean the crucible. Robot based automation helps to optimize foundry processes and productivity.

Robots are often working in very severe environments that require that the robots are tight and withstand penetrating material. Foundries rank among the toughest environments for a robot. The requirements of foundry robots are listed below.

- A high sealing standard on the robot's joints is vital to withstand coolants and lubricants.
- It has to withstand heat and spits from the different foundry applications.
- Robots in a foundry need to be designed to withstand the harsh environment and be washable with adequate washing equipment.
- The robot needs to be tight and to withstand lubricants, and coolants.
- It has to withstand aluminum spits and flashes arise when machining or tending.
- It should be a hot steam washable robot, high-pressure steam is required to wash away dirt, and spits form the robots.
- It should be corrosion protected.
- The robot's wrist should be totally leak proof.
- The robots must have special sealing for gears and bearings.
- It should have flange sealing, protection plugs, sealed motors, and extra covers.
- The robots should have

Table 1: Application of Robots in Foundries

Material Handling Applications	Dispensing Applications	Finishing Applications
Machine Tending ; Part Transfer Insertion ; Coremaking ; Diecasting	Pouring ; Ladling ; Blasting ; Water jet cleaning ; Die spraying	Deburring, Trimming, Chiseling Cleaning Castings ; Painting ; Polishing ; Machining : Milling, Sawing, Drilling

connectors for difficult environment.

- It should be a cabling and electronics protected one and with special casted covers.
- The complete foundry robot unit should be painted with two-component epoxy paint steel.
- The foundry robots must have special sealings, parallel brackets, balancing spring joint, bearings in lower arm, special sealing sand covers.

Table 2 : Robots in the Main Workstations in Foundries

Sand Core Process	• Core shooting • Core assembling • Core gluing • Core cleaning • Core handling
Casting	• Die-Casting • Sand-Casting • Gravity-Casting • Lost-Foam
Cleaning	• Deburring • Deflashing • Degating • Premachining
Machining	• Machine Tool Tending • Secondary Deburring • Washing • High Pressure Water Jet Washing
Surface Treatment	• Blasting • Painting • Corrosion Protection
Quality	• X-ray • Leakage test • Dimensional Accuracy

- It should be a joint upper and lower arm axis one bearing protected type.
- It should have connectors on motors, special connector sand gaskets, connectors for control cables, and push buttons for brake release.

Application of Robots in Foundries

Some of the foundry robot applications are presented below in Table-1.

Robot-based Automation For Foundry

Robots are used in foundries in the three main workstations and are listed below in Table-2

- Sand Core Process
- Casting
- Cleaning

Robotics in Die-casting Technology

From the introduction of the die casting process, automation was recognized as a key factor in achieving consistent cycle times, which in turn had a significant impact on part quality and productivity. The operation of the die-casting machine was inherently automatic, so the need was to automate the material loading and part unloading operations. While the hazardous task of ladling the molten metal into the machine was soon automated, automating the process of removing or unloading the casting was harder to justify for two reasons. In the early days, replacing relatively cheap operators with capital-intensive automation equipment was not simply economically viable. Today part unloading is one of the major industrial applications for robots in die-casting. Part removal is easy for a robot. It has not only has the power to grip the part, but it also has the dexterity to reach in the dies and remove the part in the optimum direction without damaging the casting. Change over to new parts is easy and accurate.

Robots are the solution to a wide range of other problems in the die-casting foundry as well. They perform pre and post process operations with a precision and regularity not possible with even the most skilled operators in one of the most hazardous of industrial environments now often considered unfit for human occupancy. The first of these activities was to check the integrity of cast parts. Foundry robots can check for cast parts faults that might scrap a part by passing the new casting in front of an array of sensors programmed to inspect critical areas on the part. This task is greatly simplified by the robot's ability to position the part in three-dimensional space.

A robotics system can also check the die for the presence of remaining injection material that could prove catastrophic if the next injection proceeded without the material being removed. Robotics systems soon demonstrated their worth in the next step in the die casting process, cooling the cast part. Robots are capable of dipping the part in a cooling tank, passing it under sprays or placing it onto a conveyor for air cooling and then picking it up. Similarly, a robot can easily place or hold a part under a trimming process. This application was facilitated by the development of the soft servo, which prevents the blow of the press from being transmitted to and possibly damaging the foundry robot arm. In some instances, robotic deburring replaces the press trimming operation. This saves on the cost of press tools that need to be designed and changed for each casting. A new deburring program is simply loaded in the robot when a new part appears. Further, downstream, the foundry robot has proven to be one of the most cost-effective and space saving devices available for storing and palletizing finished castings. A foundry robot is assisting the casting process in a pressure die casting machine is shown below in Figure-2.

Figure 2 : Robot in a Pressure Die-casting Machine

Innovative Technology for Robot Automation of Die Casting Process

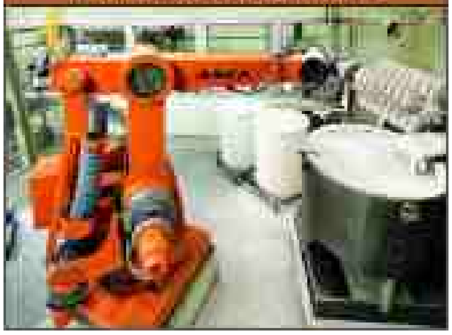
The automated treatment of casting is becoming increasingly significant for foundries. Robot automated pressure die-casting cells and the use of robots in permanent mold casting, sand casting and in core manufacturing are established technologies. However, constant development of such applications is needed in order to optimize reliability, quality and cycle times. The robot is pressurized, and has corrosion protection, is painted with special paint and is specially sealed. The benefit for foundries is reduced maintenance cost, improved flexibility and uptime, higher quality products, faster cycle times and more compact cleaning cells.

Another innovation is a special vision-guided robotics system fully integrated into the robot. It combines the industry-leading robotics expertise with the revolutionary software and all with one hardware and using a single camera. By efficiently guiding robots to adjust their entire path based on the actual 3D location of parts, users can validate the accuracy of the solution before starting the production. Foundries need fewer fixtures, and accurate pallets for part positioning. This saves money and time and makes for higher quality of production. Machine synchronization for machine tending in which robot movements are synchronized through a linear sensor on a moving part of a machine. This allows for early entry of the robot as well as the safe close of the machine when it is synchronized with the moving part as it leaves. Machine synchronization can reduce extract times by as much as 10 percent, while decreasing the wear on the robot and reducing the number of collisions. Cycle times can be significantly, and safety improved. Likewise, foundry robots have electronic position switches, as opposed to mechanical switches, which also increases safety with no floor cables and reduced risk for crashes, provides less risk for breakdown in harsh foundry environments and easier replacement of robots in production. An electronic box is placed under the axis computer and a synchronization switch, which provides an external reference for the safety board.

Robots in Investment Casting Process

Investment casting fabrication is another area of foundry operations that benefit from robotics. In investment casting, the process involves dipping a wax pattern into a liquid ceramic slurry and then sand, which hardens like rock. Repeat this a few times and you will have a heavy shell surrounding the wax pattern. The shell is heated so the wax melts away, leaving a cavity having the exact dimensions of the product being manufactured. The next step is to pour molten metal inside the cavity and let to solidify. The ceramic is broken away from around the solidified metal and there is the product in its final form. There might be a need for sprue removal, a simple task for a material removal robot. The ceramic shell is fragile but is heat resistant. Robots are used for investment casting because it is a repetitive process and castings can be heavy. Some molds can be over 900 kg.

Figure 3 : Robot is Assisting the Investment Casting Process



Another key advantage is having robots dip a cluster of parts at the same time. Six-axis articulated robots for investment casting need a high-payload capacity and long reach. In investment casting, you might have to dip very large parts into different slurry mixtures and different types of sand. One can have the have equipment mounted around the robot, so long reaches are needed. Cost is a primary justification to use robotics for investment castings as robotics minimize the possibility of dropped or damaged parts. A robot assisting the investment casting process is shown below in Figure-3.

The Role of Robots in the Foundry Heat and Dust Environment

Because foundries are one of the most unforgiving production environments, robots and their peripheral equipment need to be robust enough to function day-in and day-out despite the withering heat and ever-present metallic dust. It is necessary to protect the robot's mechanisms to ensure maximum working capacity. The robot should be dust protected, especially the bearings. There are covers and wipers for dealing with dust. Micro-sand and metallic dust particles accumulate over time in the robot's crevices. Dust gets inside seals and into bearings. Through time, dust wears out components. Robots will continue to work in that environment, but will loose accuracy and repeatability. Therefore, bearings wear out by causing misalignment. Heat resistant seals and gaskets over bearings, epoxy paint for the robot, and watertight electrical connections should be incorporated in the robots. Foundry robots have an industrial protection rating. Strategies to deal with the heat of a foundry vary from ducting in cool air to a robot within a protective shroud, to locating the controller far away from the heat as is practical. Besides, stainless steel heat shields are often mounted near the end of arm tooling to reflect heat away from critical components.

Conclusion

Molten metal, unbearable heat, backbreaking, is common and repetitive tasks seen in foundries. The harsh conditions and jobs common to foundry plants are well suited to robotic automation. Foundry robots increase safety, productivity, and efficiency. They are designed to work in hot and hazardous environments. Foundry robots can withstand high levels of dust as well as exposure to harsh chemicals and high-pressure sprays. Special paint, seals, grease, and even pressurized motors allow foundry robots to thrive in the harshest of settings. The important conclusions are listed below.

- Flexibility : Robots are useful for nearly every aspect of foundry work from material handling to dispensing and finishing. This flexibility particularly saves money.
- Safety : Work in foundry

❍❍❍