(*Above*) A medical implant manufacturer, Symmetry Medical Jet in Lansing, Mich., uses robots for its application. The unit on the right, guided by a vision system, picks up a single cold preform from the in-feed conveyor and places it in a rotary furnace. It takes a hot preform from the same furnace and places it onto the forging press. It completes its cycle by returning to pick up another cold preform. The unit on the left removes a forged part from the lower die impression, sprays release agent onto the tooling and places the forging on the trim press. Once the flash is trimmed, the robot places the part onto the exit chute and completes its cycle by returning to remove another part from the die.

Part one

Forge Shop Automation

Jan Hutson
Rimrock Corp., Columbus, Ohio

This is the first of a two-part article designed to help forgers understand robotics in the forge shop. Readers will obtain an overview of technical and commercial criteria that will be useful in influencing any decision to invest in robot-based automation in hot-forge production. This article will introduce readers to robots and offer application examples of industrial robotic arms in forging production processes.

There are two basic elements in modern industrial robots: the mechanical robotic arm and the robot controller. The arm executes the physical motion based on instruction sets from the controller, which also serves as a communication portal to the rest of the manufacturing system and the robot programmer. Robot manufacturers provide robots in a variety of reach configurations ranging from a few feet to a few yards and weight capacities ranging from a few pounds to a half-ton or more (Figure 1).

The basic design model of the modern industrial robotic arm has changed very little during the last two decades and continues to rely on the six-axis, servo-driven configuration (Figure 2). However, the dependability and performance of these units have continued to evolve and improve into one of the most reliable pieces of equipment in any manufacturing process. A key element in this evolution has been the need for robot manufacturers to penetrate heavy-manufacturing markets containing the harshest of production environments, including forging applications.

Like most solid-state devices, robot controllers have benefited from technological advancements in microprocessors. They have evolved into smaller, less complex control cabinets and have become significantly more reliable and efficient in their ability to control the motion of the arm. In addition, robot manufacturers have continued to develop powerful programming tools with simpler, more user-friendly human-interface options (Figure 3).

Recent Advances in Robotic Technologies

The practical aspects of robot deployment have benefited from other technological advancements, both by robot manufacturers and leaders in related industries. The list of these advancements is almost endless and some are specific to certain manufacturers that have targeted a particular industry segment. However, the following general advancements will provide insight into those that could benefit automation applications.

Figure 1

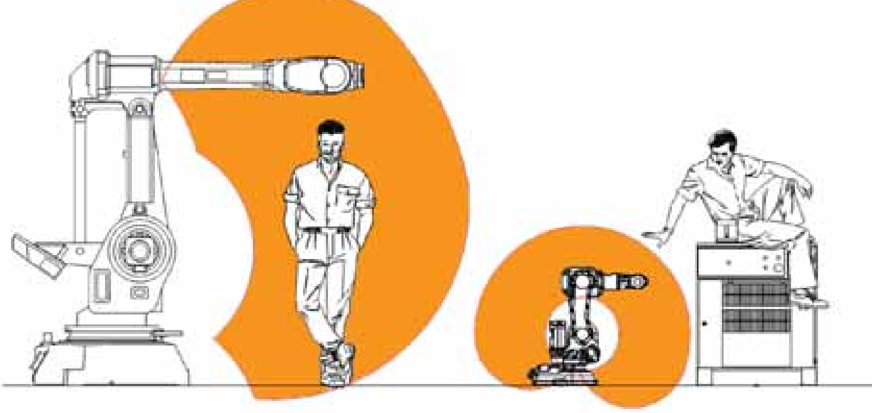

Figure 2

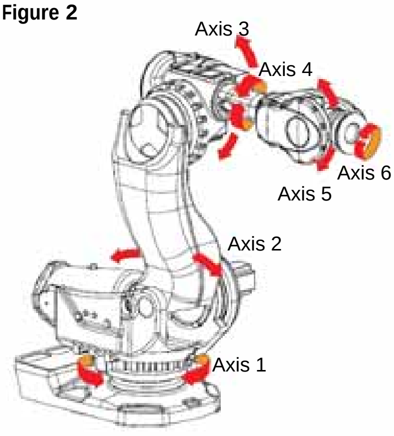

Figure 1. Robots are available in a range of sizes and capacities.

Figure 2. Typical 6-axis configuration: Axis 1 is the mechanical arm's main rotational axis; Axis 2 allows the upper arm to move fore and aft of Axis 1; Axis 3 raises/lowers the upper arm from the fore and aft position of Axis 2; Axis 4 rotates the entire upper arm assembly; Axis 5 positions the gripper for use and usually works in coordination with Axis 6; Axis 6 rotates the gripper for use position and usually works in coordination with Axis 5.

Programmability

One of the most important recent developments is the ability to program robots off-line, from the comfort of an air-conditioned office or even from home. Offline programming gives a technician the ability to develop the majority of robot paths with a virtual robot, introduce that new path or production part to an existing production cell and define the related logic that will communicate with the rest of the production system without consuming valuable production time on the physical robot. While path refinement is required in-situ, the time from concept to completion is significantly reduced.

Vision

Vision guidance packages, condensed to include camera, lens, lighting and processor in a single unit, allow unmatched flexibility in system design and product introduction (Figure 4). Once properly set up, the use of vision guidance allows the robot to automatically recognize parts, determine the position and orientation of those parts as they move on a conveyor and calculate X-Y-Z coordinates needed to pick them up, all within a few hundred milliseconds. The communication link between the vision system and robot is generally through serial communications and requires little additional programming after initial setup. It is advisable for forgers to recognize that vision technology is not suitable for all applications in the forge shop. Infrared interference from hot parts must be dealt with on a case-by-case basis by an experienced vision-system integrator or capable robot-systems integrator. In addition, special attention should be given to lens contamination and component failure from heat. The environmental challenges are considerable, and the system designer must deal with them effectively.

Communication

Advancements in the robot's ability to communicate thru DeviceNet or other communications protocols, along with the expanded functionality of the robot controller, have allowed the establishment of a retro-style approach to robot operation on the production floor. By integrating traditional, robust and industry-hardened push-button stations, even the most inexperienced machine operators can easily move the robot to pre-defined locations, adjust normal production parameters and monitor the robot's status without the fear of having to negotiate complex HMI screens and damaging sophisticated robot programming codes.

Practical Robot Applications in Forge Shops

The following four examples offer a visualization of some of the different types of robot automation projects for hot-forge production applications (Figure 5). This is not a comprehensive list, but it includes the more common robot applications. Some can include traditional hard automation to make the process complete and economically feasible. Regardless of the application, inter-equipment communications and operator safety must always be considered.

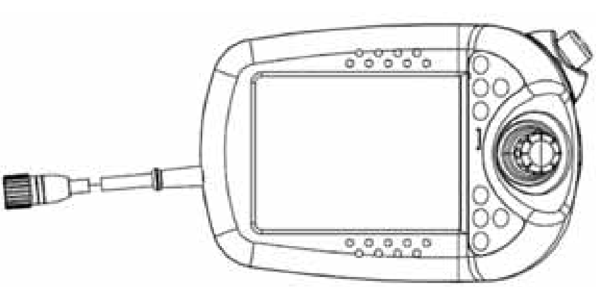

Figure 3. Robot teach pendent

Billet-Loading Robot

This is an excellent starting point for first-time robot users. In this system, the robot (Figure 5, #1) picks up one billet from a staging device and places it into the first-stage forge-press tooling. While this system is simple, it requires careful planning. A positive aspect of this system is that common billet shapes will keep hardware and programming costs low as

Figure 4. Typical condensed-vision package

well as provide easy adaptability to a variety of parts. Key issues to consider are:

- Location of the billet heater
- How to deal with billets when the process temperature is out of limits
- How to deal with operations interfacing with the robot while in production
- Robot reach

Trim-Press Loading

This appears to be a simple application, but special consideration must be given to loading the unprocessed part with flash and unloading the processed part without flash using the same gripper. In this system (Figure 5, #2), the robot picks up a part that still has flash around its perimeter from a staging device or final forge operation. The robot then places it into the trim die, waits for the press to cycle, removes the trimmed part from the die and places it for cooling. Key issues to consider are:

- Dealing with flash on the part
- How to deal with the system during robot system faults
- Robot reach

Part-Transfer Robot

This is a more difficult application than the previous examples. The most challenging aspect is how to grip/handle the parts in the process economically and reliably (Figure 5, #3). Although there are many difficult factors that define this application, one positive parameter makes it attractive. Because the robot is handling the parts at the point of use, it is usually conceivable to apply die lube with the same robot. Key issues to consider are:

- Location of robot
- How to deal with the system during robot system faults
- Dealing with flash around the part's perimeter
- Robot reach
- Changing part geometry from bust to finish dies

Spray Robot (not shown)

This can be very useful in consistent die-lube application, which in turn provides consistent die temperature, extended die life and reliable part release. The spray parameters, robot path and robot speed will combine to provide a reliable means to "dial-in" the spray process to meet most process requirements for a multitude of parts. While this can be a very low-cost robot application, consider the automated spray system that goes with the robot. Spray systems, especially for graphite lubricants, require regular preventative maintenance in order to keep them reliable and repeatable. Key issues to consider are:

- Location of spray robot
- How to deal with operations interfacing with the robot while in production
- How to deal with the system during spray-system faults
- Robot reach

Safety in Robot Deployment

The importance of personnel safety cannot be overemphasized.

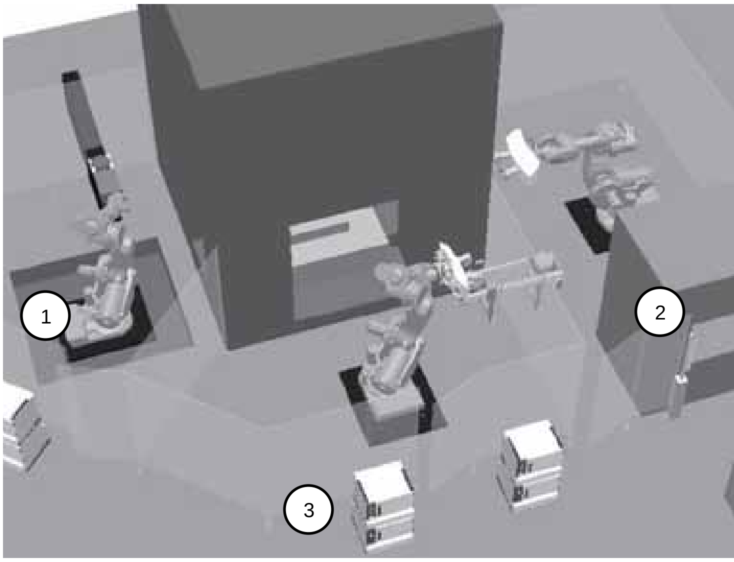

Figure 5. Virtual robot installation (spray robot is behind press)

ROBOT JARGON	
Axis	The pivot point of any two mechanical connections on a robotic arm. Typical robots have six axes.
Upper arm	The part of the mechanical arm that positions the gripper in space. Generally, the upper arm is more articulate than strong.
Wrist	The part of the upper arm that gives the robot its flexibility in moving the gripper about its work task or workpiece.
Gripper	The gripper is usually custom designed and often more costly than other system components. A gripper may be small, but the engineering required to make it work in all situations is significant.
Cable/Hose Management	The art of designing a method to control hoses or cables attached to the upper arm without damage as the robot moves.
Teach Pendent	The teach pendent is the interface between the human programmer and the robot processor.
System Integration	System integration is the act of designing and building a robotic system to perform one or more automated tasks.
Application	A robot application refers to what size robot will do what to which product, in what period.
Flexible Automation	Flexible automation can be synonymous with robot-based automation.
Robot Weight Capacity	The amount of weight the robot is designed to handle. Staying at or under this value with the combined weight of gripper and part will ensure peak robot performance and maximum arm life expectancy.
Center of Gravity	Regarding robot weight capacity, one should consider the center of gravity of the combined mass of the gripper and part. As the center of gravity moves away from the connecting point of the robot, the weight capacity will decrease. ALWAYS observe the robot load charts provided by the manufacturer.
Work Envelope	The area in space to which the robotic arm has access. Robots can position the gripper almost anywhere and in almost any orientation within the work envelope.
Robot Cell	The area that is protected by a compliant safety enclosure that may include process equipment or system components. A robot cell often will have more than one robot.

Therefore, all companies contemplating robot-based automation should be familiar with the ANSI/RIA R15.06-1999 American National Standard for Industrial Robots and Robot Systems – Safety Requirements. The purpose of this standard is to provide guidelines for industrial-robot manufacturing, remanufacture and rebuild, robot system installation and methods of safeguarding to enhance personnel safety.

This standard provides detail on established safety practices where personnel must be in close proximity to active robots. It is very technical in nature and subdivided into specific areas of safety requirements. Any qualified integrator will know these standards and will define their clients' exact needs. As such, it is not mandatory for the engineer to know every detail in this document, but a thorough understanding of how to use it to advantage should be required.

It is impossible to define robot safety requirements in a single session, and the RIA promotes entire seminars on this subject. However, it is generally accepted that a working robotic arm and a human, or human appendages, cannot share the same unobstructed workspace without a mechanical barrier or an electrical safety device separating them.

Author Jan Hutson was senior robotics systems specialist for forging and foundry applications. Reader inquiries about this article should be directed to sales@rimrockcorp.com

Ad Index

Page	Company	Phone	Website
5	Aberfoyle Metal Treaters	519-763-1120	www.aberfoyle-mt.com
10	ABP Induction	800-558-7733	www.pillar.com
8	AJAX-CECO	216-531-1010	www.ajax-ceco.com
9	Alpha 1 Service Center	800-991-2599	www.alpha1induction.com
11	Cor-Met	800-848-2719	www.cor-met.com
Inside Back Cover	Gerdau Macsteel	800-876-7833	www.macsteel.com
Back Cover	Inductoheat®, Inc.	800-624-6297	www.inductoheat.com
23	Girard Engineering	440-243-2212	www.girardusa.com
7	Lasco Engineering Services	313-579-2675	www.lascousa.com
12	Presstrade Group	49 78519376-0	www.presstrade.com
19	SuperBolt	412-279-1149	www.superbolt.com
Inside Front Cover	Weld Mold Company	810-229-9521	www.weld-mold.com