The robotic application of feeder sleeves at ARVIKA Gjuteri AB, Sweden

Abstract

The Arvika Foundry identified their relatively large pattern plate dimension as a key differential advantage. To lever this advantage to maximum commercial effect, requires the use of 'ram up' feeder sleeve technology (The so-called spot feeding technique).

The use of such feeders significantly increases the effective pattern plate utilisation, permitting the production of larger castings or increasing the number of castings per mould.

The conversion from side sand feeders, to highly efficient, exothermic top feeders also reduces fettling costs, improves casting yield and allows spot feeding of inaccessible casting sections.

In order to use ram-up sleeves in the large volumes required, it was necessary to devise and introduce an automated system to handle and place the feeder sleeves. Such a system must take into account the key demands of health & safety, productivity and environmental factors.
A joint project was established between the Arvika Foundry, the feeder sleeve supplier and the engineering partner early in 2001.

Following a detailed evaluation of options, it was decided to proceed with a robotised solution. Various designs of Robot Cell were considered, key issues being the packaging, storage and handling of the ram-up sleeves. The design of the Robot Cell was constrained by the demands of balancing productivity, with flexibility, space requirement and cost.

Parallel to the engineering requirements, the feeder sleeve supplier had to develop a cost effective, bespoke packaging system capable of meeting the accuracy demands of the robot and the need for automated handling.

The outcome was a Robot Cell, with 3 integrated magazines for the feeder sleeves. The sleeves are supplied in a re-usable packaging, which can be directly loaded into the magazines.

The Robot Cell is now running successfully and has located more than 50,000 feeder sleeves since August 2002. The ability to use ram-up feeder sleeves has improved the commercial and technical competitiveness of the Arvika Foundry.

Background

Arvika Gjuteri is one of the largest iron foundries in Scandinavia, producing ca. 25,000 tons per annum of good castings with a workforce of 250 employees. Production is ca. 75% SG iron and 25% grey iron, manufactured on a Künkel & Wagner jolt-squeeze transfer-moulding machine. The box size is 1375 x 975 x 390/390 mm.

The casting programme is focused on high quality components for trucks / buses (75%), earth moving equipment and tractors, with the balance made up of general engineering parts. Typical castings are gearbox housings, hubs, rear axle housings, and rear axles, in the range 30 kg to 200 kg. Average box weight is typically 300 – 350 kg.

Cores are made predominantly using the polyurethane cold box process and normally coated with water-based coatings. After coating, cores are dried in microwave ovens.

Project Scope

Early in 1999, the foundry carried out their first trials with "ram-up" sleeves, to feed an isolated and relatively inaccessible casting section. Following successful trials, it was quickly realised that this technique could be of benefit on other castings and fundamentally change their approach to methoding.
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With a background of continuing price pressure from customers in the heavy vehicle sector, it was critical to employ the most cost effective and efficient feeding technology. It was also vital to exploit the size of the moulding box to its maximum potential, again placing a greater emphasis upon the use of smaller and more compact running and feeding systems.

The move to "ram-up" feeder sleeve technology significantly improved the effective pattern plate utilisation, permitting the production of larger castings or increasing the number of castings per mould. The conversion from side sand feeders, to highly efficient, exothermic top feeders also reduced fettling costs, which can contribute up to 30% of the total manufactured cost of a casting. Additional benefits include, improved casting yield and access to 'normally' inaccessible casting sections.

The above all contribute to reducing casting lead times and work in progress within the foundry. In addition, for certain specific castings it was possible to remove cores, the only purpose of which was to allow top feeding.

It was quickly realised that extensive use of the ram-up application technology would require an automated system to handle and place the feeder sleeves. For reasons of safety and productivity, it was only possible to manually locate 2 – 3 sleeves on the pattern plate during the moulding cycle. To manually locate sleeves on the pattern, it was necessary to open a safety gate and this process resulted in a productivity loss.

Following the 1999 GIFA exhibition the foundry decided to explore the feasibility of using an automated robot to place ram-up sleeves directly on the pattern plate. Initial discussions were held with application engineers at Motoman, Sweden. A concept was developed and an initial trial was carried out at Motoman, where cycle times were evaluated and robot movements reviewed.

A joint project was established between the foundry, the feeder sleeve supplier and the robotic supply partner early in 2001.

Technical constraints

The moulding machine has a pattern sledge accommodating 4 pairs of patterns (cope and drag); (figure 1). Patterns move in and out of the moulding machine between each moulding cycle. Cope and drag are moulded simultaneously. The patterns can be moved fully to either side of the moulding machine. The initial concept was to have a robot only on one of the side of the moulding machine. This meant that feeder sleeves could only be applied to half of all moulds produced. With a cycle time of 38 seconds, producing about 90 moulds per hour, sleeve application was therefore possible to ca. 45 moulds per hour.

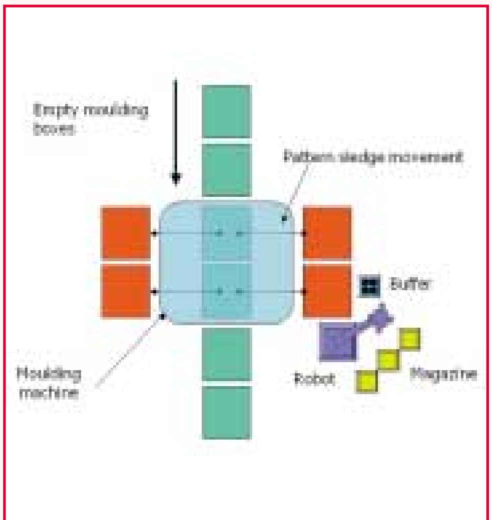

Figure 1: Robot cell layout

It is also possible to operate the moulding line so that the same pattern is moulded each cycle, in which case 60 moulds with ram-up feeder sleeves can be produced per hour.

The fundamental consideration was that the positioning of the sleeves must not increase the cycle time of the moulding machine.

A further consideration was the requirement for space and access around the pattern plate shuttle, both for manual inspection, cleaning as required, maintenance and for changing patterns using an overhead crane.

It was also a requisite that the robot cell should be able to run un-attended for extended periods, as no extra person would be employed.

The complete robot cell, including sleeve magazines and intermediate buffer station had to be removable to ensure free access for moulding machine maintenance and repair.

Technical requirements (summarised):

- Place up to 16 feeder sleeves on the pattern plate within 30 seconds. (each sleeve can weigh up to ca. 2.5kg)
- Repeat this operation every 76 seconds.
- Place up to 3 different types of sleeve in one cycle.
- Orientate the sleeves in one direction, as the breaker core or locating core can have an oval or elongated aperture.
- Pick sleeves consistently and accurately from the packaging.
- Must be compact enough to fit in the limited space adjacent to the moulding line.
- Unrestricted access to the pattern carriers for pattern plate changes.
- Possible to move the equipment away from the moulding line, in order to carry out maintenance work.

Packaging

Parallel to the engineering requirements for the robot, the feeder sleeve supplier had to develop a cost effective, bespoke packaging system capable of meeting the accuracy demands of the robot and the need for automated handling.

Initial work focused on the use of the standard packaging, however it was quickly realised that there were a number of issues, which would require the development of a specialist solution:

- In the standard packaging (a cardboard tray, ca. 400 x 600mm) sleeves are packed with the breaker core facing upwards. The robot has to position the sleeve on the pattern plate with the breaker core facing down and could not rotate the sleeve with guaranteed orientation of the breaker core.

- Sleeves are normally packed to maximum density and are frequently touching one another. The sleeves may therefore move slightly as they are picked, causing problems of misalignment.

- Certain designs of sleeve are fitted with an oval aperture breaker core. It is vital, in order to locate the sleeve on an oval support pin, that the robot always knows the orientation of the breaker core aperture.

The robot handling therefore placed a number of new requirements on the sleeve packaging, as summarised below:

- ❑ The sleeve must be packed with the cap (closed end) facing upwards, i.e. the breaker core facing downwards.

- ❑ The sleeves must be positioned so as to allow the robot gripper fingers access between them.

- ❑ Furthermore, the sleeve has to be delivered to the robot pick-up position with small tolerances in the X- and Y-axis coordinates.

A number of alternative packaging arrangements were discussed and evaluated at length. Full Euro pallets for the three sleeve types were supplied for trials. Various systems were examined to present the sleeves to the robot, however most failed due to their inability to provide sufficient accuracy in the X- and Y- coordinates.

In order to obtain the required accuracy in X- and Y-axes, and to resolve the issue of breaker core aperture alignment, a novel packaging solution was developed, based upon the standard 400 x 600mm cardboard tray, (figure 2).

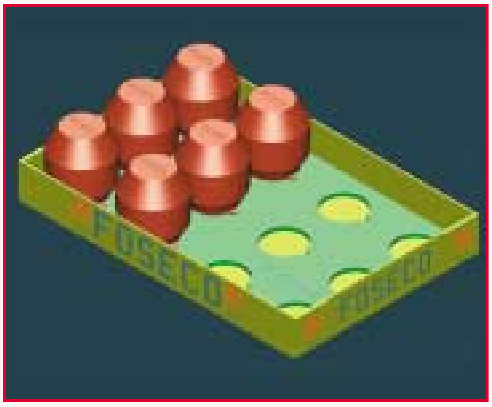

Figure 2: Feeder sleeves located in a cardboard tray, with wooden insert

Several types of packaging were investigated and tested, amongst them corrugated cardboard trays with cardboard inserts, to stabilise and orientate the sleeves. This concept was rejected as it did not locate the sleeves with sufficient accuracy for the robot. It also proved to be expensive and difficult to recycle.

Finally a workable packaging solution was developed, based upon cardboard trays containing a plywood insert.

The Robot Gripper Head.

The gripping device fitted to the head of the robot, is pneumatically actuated, as opposed to the standard electrical motor design, which would probably not withstand the demands of the harsh foundry environment. Another consideration was weight, as a pneumatically operated gripper system is much lighter than the electrical motor system, whilst achieving the same gripping force.

One limitation of the pneumatically operated gripper, is that it is only available with two opening ranges, described as ‘large’ or ‘small’. This means that the feeder sleeves must be spaced in the patterns / lines that enable the fingers of the gripper to move down into the spaces between the sleeves, without disturbing the adjacent sleeves. This is achievable, however it reduces the packing density of the sleeves in the tray, compared to the standard packaging.

The Sleeve Storage Magazines.

In order to reduce the requirement for manual handling, and to allow the robot to run for extended periods of time unattended, it was necessary to devise a system capable of storing large quantities of sleeves adjacent to the robot. The sleeve magazine was developed, which accepts a standard stack of trays, which are presented sequentially to the robot.

The magazines, of which there are 3, can be loaded directly from the Euro pallet (each contains 4 tray stacks).

A special mini forklift truck was designed to load the stacks from the pallet into the magazine, (figure 3).

Figure 3: Forklift device with trays to be loaded into a sleeve magazine

To summarise, the sleeves are packed in special trays, the cap facing up, with accurately defined positioning in X- and Y-axes. These trays are then packed in stacks on a 'mini' quarter pallet, of which there are 4 located on each Euro pallet.

Proposed solution

Various engineering solutions were considered and evaluated, but eventually it was decided to install a 6-axis robot with four pneumatically operated gripping units located at 90° to each other. This gave a very flexible and compact unit, capable of dealing with a broad range of sleeve products (with and without breaker cores) and all pattern plate layouts.

The robot cell also included 3 integrated magazines as described above.

As it was planned to apply sleeves only to every second mould, the robot would essentially have one moulding cycle available to prepare the sleeves for location. This time was used to move sleeves from the transport packaging to the intermediate buffer plate, where the sleeves were orientated on special pins.

As the pattern plate, onto which the sleeves were to be placed, is indexed out of the moulding machine, the robot stands ready with four sleeves in the gripping unit. 12 sleeves have already been located on the support pegs of the intermediate buffer plate. Sleeves are then located in their programmed positions, (figure 4). The robot returns to the buffer plate and picks up four new sleeves, then repeats the cycle three more times.

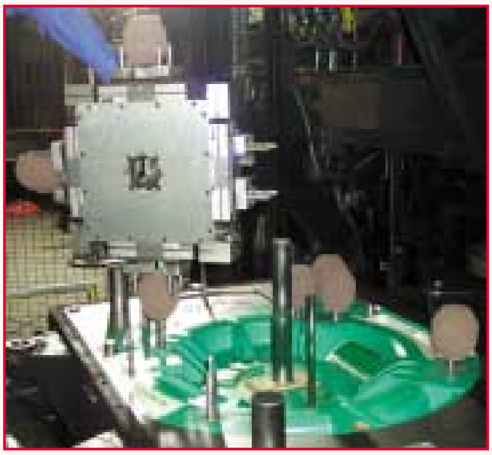

Figure 4: Robot locating ram-up sleeves on the pattern plate

The following examples illustrate how the robot and application of ram-up sleeve technology have allowed the foundry to improve their commercial competitiveness.

Installation

The complete robot cell was successfully installed during one weekend 7-9 June 2002.

Casting example 1

Figure 5 illustrates a casting produced before the robot installation, with 2 traditional sand feeders per casting and an additional core to accommodate the sand feeders. Poured weight for this conventional method, 530kg.

Figure 5: Casting example 1 using traditional sand feeders

Figure 6 provides the comparison after robot installation, using one ram-up sleeve per casting. Casting yield has improved from 48% (sand feeders), to 78% using the ram-up sleeve. Pouring time also reduced by 20%, one core per casting was eliminated and fettling cost reduced by 10%.

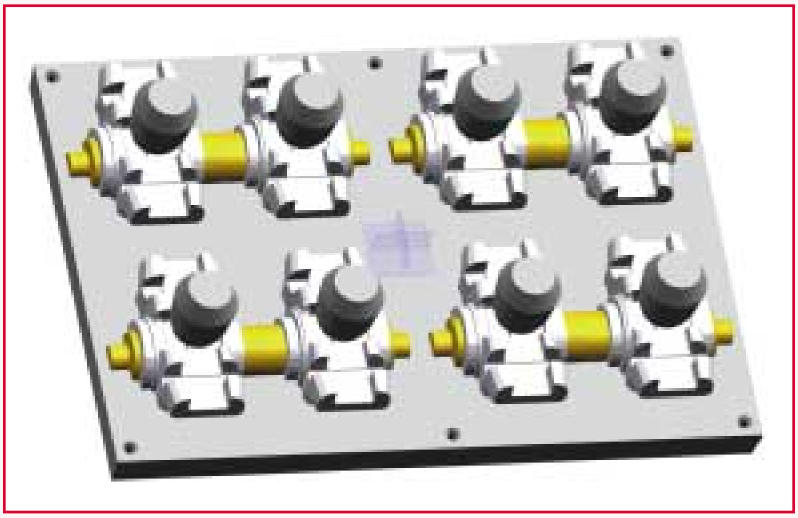

Figure 6: Casting example 1 using ram-up sleeves

Casting example 2

Figure 7 shows a casting that utilises the available pattern plate area to the maximum. Previously it would have been difficult to feed this casting economically, without the use of ram-up sleeves. The casting has several isolated sections, which require feed metal, and these would be impossible to reach with conventional sand side feeders. Casting yield in this example is 78%.

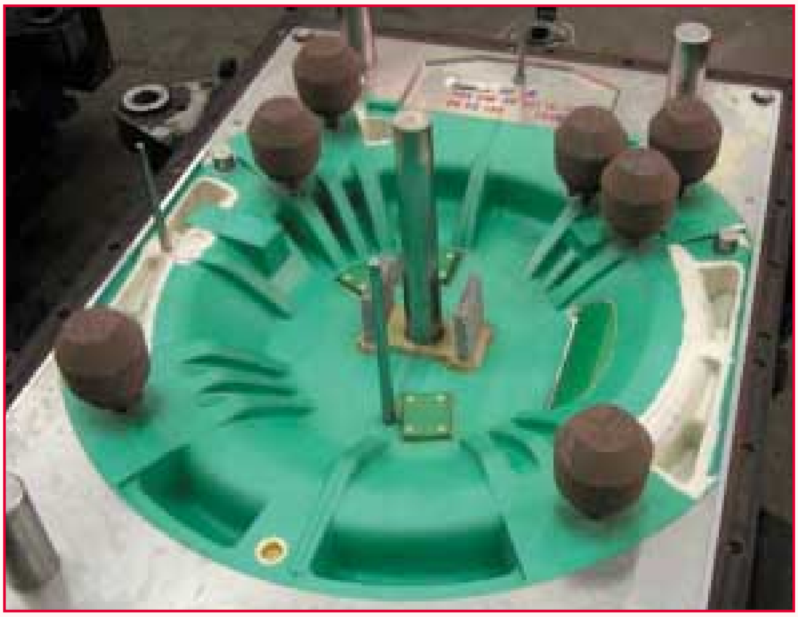

Figure 7: Casting example 2 using 7 ram-up sleeves

Casting example 3
This is a casting, where the use of ram-up sleeves effectively increases the number of castings produced per mould.

With traditional side feeding it would be difficult to locate 3 castings in the mould and the yield would typically be around 60%. The use of ram-up sleeves increases the yield to 79%. Cleaning costs are also reduced by about 20%, compared with the use of traditional side feeders (figure 8).

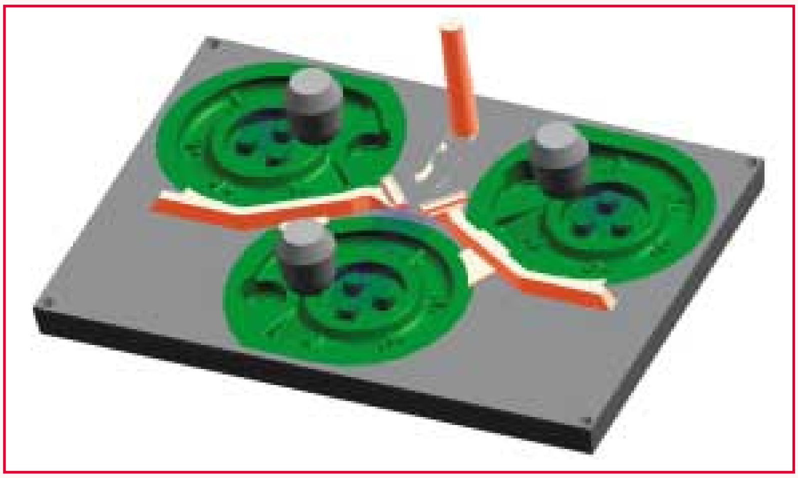

Figure 8: Casting example 3 (CAD model of a Forest Machinery Casting)

Conclusion
The robot cell is in successful operation and has handled more than 50,000 sleeves since August 2002.

The ability to use ram-up feeder sleeves has improved the commercial and technical competitiveness of the foundry. In some cases, a reduction of up to 25% in the total manufactured cost of a casting could be achieved by elimination of a core, increasing yield and reducing fettling cost.