SWEDISH IMPROVEMENTS IN CLEANING OF CASTINGS WITH REGARD TO ENVIRONMENTAL FACTORS

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ABSTRACT

The results of a number of research and development projects undertaken in Sweden during 1972-78 is reported. The major breakthrough has been the development and demonstration of mechanized manipulators and robots which separate the worker from the immediate vicinity of casting finishing operations. Automation and isolation simplify ventilation and noise and vibration control and reduce the effort while speeding up the process.

Guidelines for the use of ventilated work enclosures are also presented. Other research and development includes: substitution of hydraulic for pneumatic tools; and high velocity, low volume exhaust hoods.

INTRODUCTION

During the last decade there has been a demand made for better working conditions in foundries. In particular, the problems in today's cleaning and finishing operations are environmental, technical, and economical. Many cleaning operations are very labor-intensive and expensive. It is becoming increasingly more difficult to recruit workers for these jobs and turnover is very high. In many Swedish foundries, the turnover in the cleaning room is the highest for the whole foundry. Even in times of labor surplus in industry as a whole, it has still been very difficult to recruit workers for cleaning rooms. As a result of this, environmental improvements can be seen as essential if profitability is to be maintained.

PROBLEMS IN THE CLEANING ROOM

The environmental problem that is most often associated with the cleaning room is the high content of dust in the air breathed. Most Swedish foundries today have invested so much money in ventilation measures that, at most working places, the dust level lies well below the current limit value.

Noise is another common environmental problem in the cleaning room. There are not many foundries that are able to keep noise at the limiting level now in force in Sweden, i.e., 85 dBA.

Vibration is a third environmental problem that has attracted much attention during recent years. Above all the pneumatic chipping hammer causes high vibrations which result in "white fingers".

A fourth environmental problem in the cleaning room is back injuries due to the frequent manual lifting of heavy castings. One way of coping with this problem is to install lifting aids and other material handling provisions. Other environmental concerns in the cleaning shops are the monotonous work and bad lighting which can lead to unsafe work performance.

POSSIBLE COUNTER MEASURES

A very important question for all foundries today is, "What shall we do in order to achieve improved working conditions and reduced costs in the cleaning room?"

I think the measures to be taken first are the following (Figure 1):

1. Preventive measures to decrease or eliminate the need for casting cleaning.
2. Introduction of new and effective cleaning methods and equipment.
3. Environmental measures to decrease worker exposure to hazards.

These measures must be implemented together. If a step is taken to increase production, the environmental implications must be taken into consideration. The same type of thinking is applied when a new machine is developed: environmental and technical aspects are always taken into consideration at the same time.

PREVENTIVE MEASURES

When attempting to solve problems in the cleaning room, one should always first consider the question of whether the operation cannot be completely or partially eliminated through preventive measures. These preventive measures can be taken during casting design as well as during work preparation and production. The cleaning operations should always be taken into consideration when locating feeders and gating systems. If possible both feeders and ingates should be located on easily accessible surfaces of the casting. Another preventive measure to be taken is to make the fit between the mold and the core so tight that no fins are formed during pouring. However, this can be difficult, especially when producing castings in large quantities, as there are risks of other faults. Vacuum molding is advantageous in order to avoid fins.

The use of knock-off cores should also be considered as a measure to reduce the necessity for cleaning and finishing. Tests made in Sweden with knock-off cores of graphite and ceramic fiber materials have produced positive results. One advantage with these thin knock-off cores is that they may be given a form that corresponds completely to the casting surface. Without making the cleaning work more difficult, the feeders can be located on either flat or curved surfaces.

It should be noted that in certain cases it may be possible to decrease or entirely eliminate cleaning work. Surfaces are often cleaned by grinding

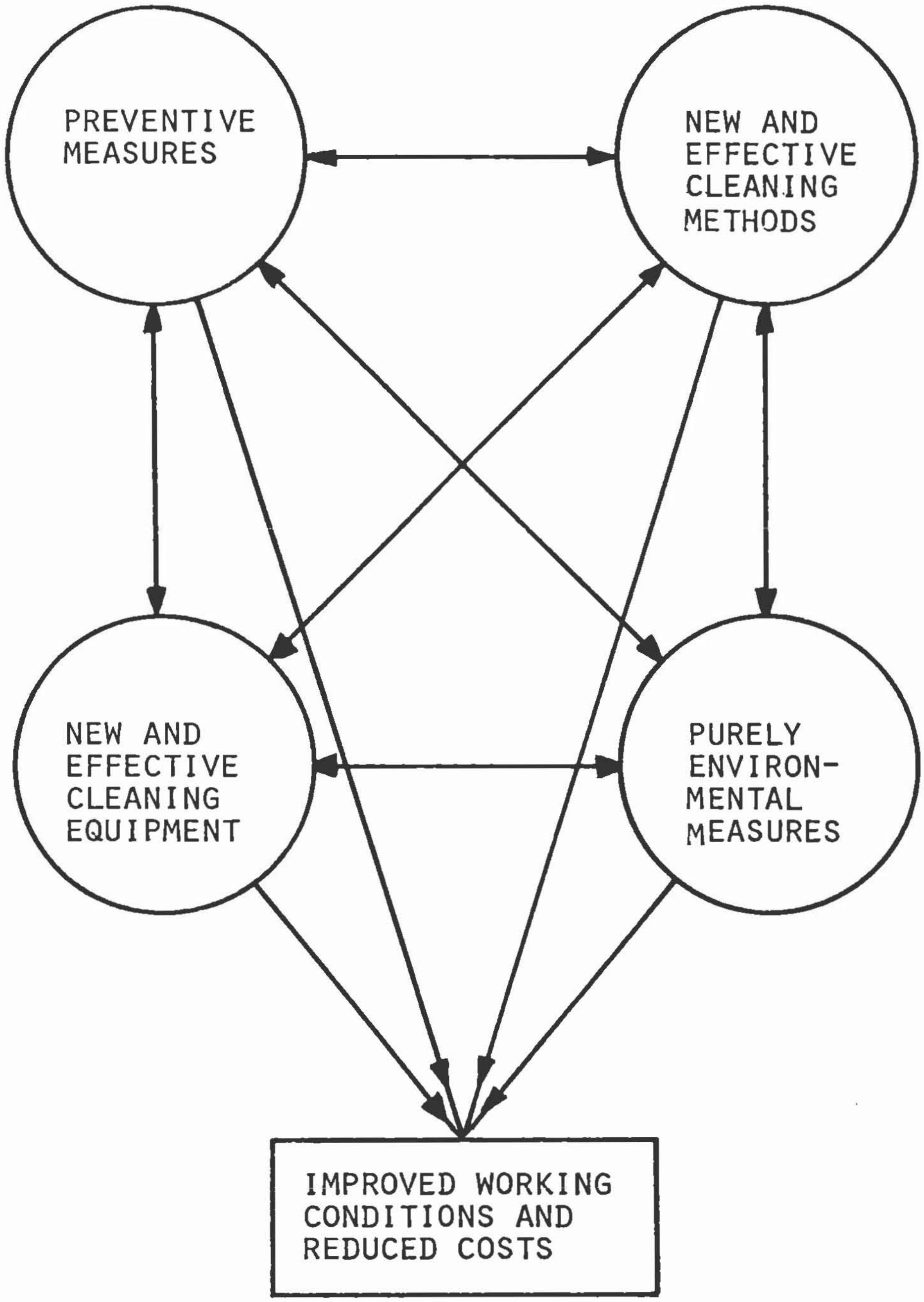


Figure 1. Measures to be taken in order to get improved working conditions and reduced costs in the cleaning room.

even if they are to be later machined. In the future more attention must be given to the relationship between casting cleaning operations and subsequent machining. Close cooperation between foundry and customer is important in this regard. Many Swedish foundries, especially jobbing foundries, have already made progress in discussions with their customers on the question of cleaning castings. Solutions have been reached that are economically and environmentally advantageous for both the foundry and the customer.

NEW AND EFFECTIVE CLEANING METHODS

An extensive development project has been carried out by Svenska Gjuteriföreningen in collaboration with several of its member companies. This development work has mainly concentrated on the use of manipulators and industrial robots and on the use of shear pressing.

Use of Manipulators and Industrial Robots

The word manipulator in the following section designates a remotely controlled device used to reposition a casting or a tool. An industrial robot is a manipulator which is not continuously supervised and controlled; it follows a preset program. The robot obviously cannot think but is a machine that follows relatively simple movement patterns set by a human being. In contrast to a manipulator, an industrial robot does not need an operator.

When choosing between a manipulator and an industrial robot the extent and complexity of the manipulations, as well as the weight and dimensions of the castings, are of importance. Figure 2 gives broad guidelines for the fields of application of manipulators and robots and also includes a third class of devices: specially built mechanical handling device. As the latter name implies, these devices are designed specifically for a particular handling operation. The boundaries between the application ranges for the three different types of devices are not well-defined and vary from case to case. The manipulator is normally the best alternative for short or medium runs and for large castings. With increased size of runs the robot becomes a viable alternative, provided the weights and dimensions of the castings are not too large. The programming and the necessary jigs and fixtures require that there be long runs before a robot will be feasible. It is important to note that it is not the number of castings handled at one point in time that is the determining factor for the selection of a robot but rather the total number of a casting run over a period of time. Castings may be handled on different occasions with the use of the same robot program. For really large runs, e.g., automotive castings, the robot is usually no longer the best alternative, and it is possible to design special handling equipment for the application. Special handling equipment can be designed for use both with manipulators and industrial robots. It may use a manipulator for short non-recurrent series of castings or for specialty work or it may use an industrial robot for recurrent medium sized runs.

Development work in Sweden has shown that both manipulators and industrial robots can be valuable tools for improving the working conditions in cleaning rooms. Manipulators of different types have been installed to solve problems at swing grinding operations. Three of these will be described in the following section. Industrial robots are also in use in some Swedish cleaning rooms and will be described below.

Manipulator Equipped with Force Feed-Back Coupling--
At a Swedish steel foundry, a manipulator with force feed-back (Figure 3) is used for grinding medium to large steel castings. The manipulator is of American origin and is manufactured by General Electric under the name of Man-Mate. In Europe, the manipulator is produced in France under license and called Andromat.

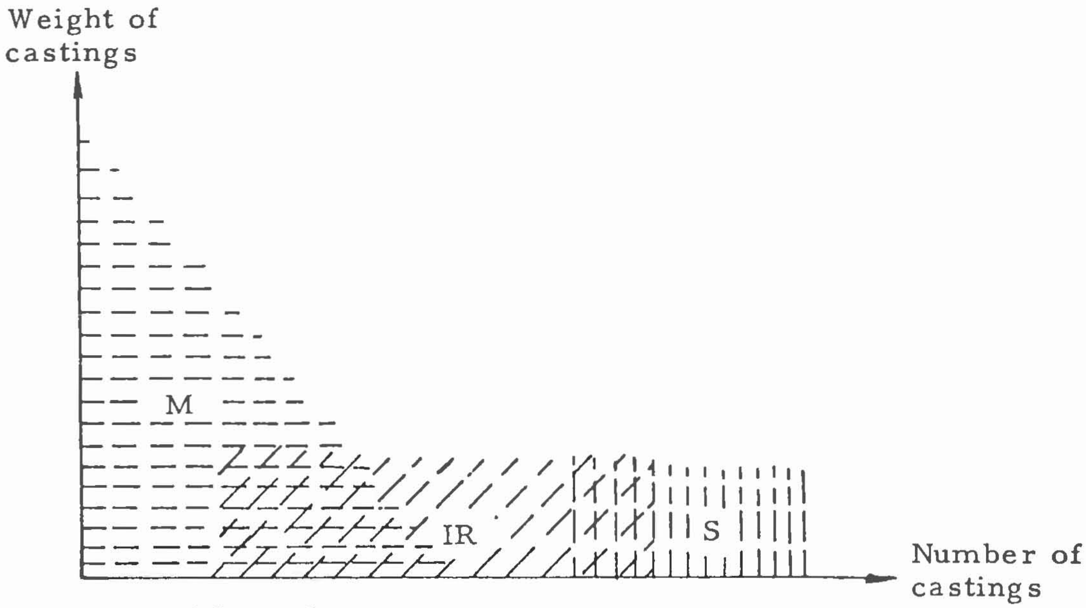
The manipulator is operated with one-hand control (compare aircraft control) and has six degrees of freedom. The operator's movements of the steering arm are amplified and duplicated by the working arm. The steering and working arms are interconnected with a servo system with force feedback which makes a two-way communication between operator and work possible. This means that the operator continuously feels the weight of a load or the resistance of the grinding tool on a reduced scale, about 1:100. The manipulator has a lifting capacity of 270 kg and a lifting radius of 5m. Force feedback is used on three of the six degrees of freedom, i.e., rotary movement of the manipulator and the radial and vertical movement of the arm.

The movements of the tool head in the other three degrees of freedom are controlled by different pushbutton controls on the steering arm handle. These movements include rotation, bending, and side tilting.

An hydraulic motor with a grinding wheel and a grinding casing has been installed into the tool head of the manipulator. The casing is designed to prevent flying debris if the wheel should burst. The hydraulic motor develops 30 kW of power and is run by a separate hydraulic pumping system. The hydraulic motor of the grinding machine is started and stopped from the control station on the manipulator. It is also stopped automatically when the operator leaves the control seat.

Because a force of up to 10,000 N may be applied to the grinding wheel, a grinding wheel of very high quality, i.e., hot-pressed and very hard, must be used. The peripheral speed of the wheel is 45 m/s and its dimensions are about 50mm wide x 300mm in diameter. The rotation of the wheel is such that the material removed is thrown forward and is captured by a ventilation hood. The grinding pressure is easily felt at the control handle and may be varied as required. It is also easy for the operator to tell by feel when the grinding wheel has gone past the edge of the casting. The hydraulic motor of the grinding wheel is powerful enough to maintain a constant number of revolutions, irrespective of grinding pressure.

Figure 3 shows the grinding of a casting weighing about 400 kg. The manipulator is being used for grinding away the remainders of feeders and gating systems and fins. Due to the high grinding pressure the grinding time was decreased to a third or a fourth of the time required previously. The learning time was also short; after not more than one or two hours, full production speed was attained.



M = Manipulators
IR = Industrial robots
S = Specially designed mechanical handling equipment

Figure 2. Application fields for manipulators, industrial robots, and specially designed mechanical handling equipment.

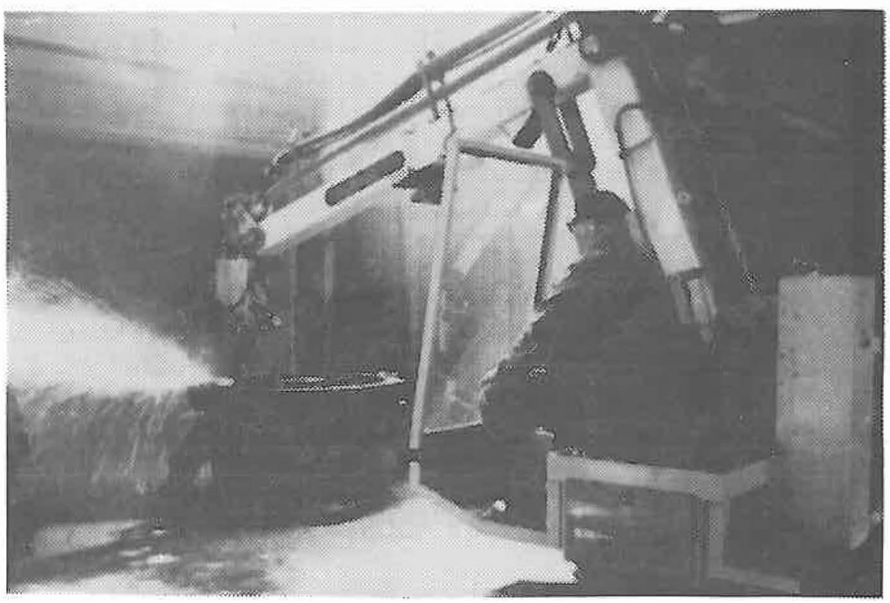


Figure 3. The Andromat manipulator.

Electro-Hydraulically Controlled Manipulator for Swing Grinding--
Figure 4 shows an electro-hydraulically controlled manipulator used for grinding of a plane surface. The operator controls the manipulator from an enclosed, ventilated, and acoustically lined booth. All controls in the booth are located on two consoles to the right and left of the operator. The manipulator can also be operated from a mobile control unit outside the booth.

The castings to be ground are placed on an electrically driven truck and transported onto a rotating table in the grinding room. Truck and casting can thus be rotated in the horizontal plane to the desired position.

During grinding the pressure may vary from 300 to 3000 N (30 - 300 kp) regulated through electronic conversion of the applied power of the grinding motor. The grinding unit is suspended in similar fashion to an overhead crane. During grinding work the unit performs a pendulating movement whose maximum angular displacement is $\pm 45^{o}$. The rotational speed of the grinding wheel is 1870 rpm which corresponds to a peripherical speed of 60 m/s when using a new grinding wheel. The unit can be inclined 45^{o} in one direction and be turned maximally $\pm 45^{o}$ for the pendulating movement.

Complicated, curved, spherical, and cylindrical surfaces can be ground while maintaining constant pressure of the grinding wheel against the workpiece. The grinding wheel follows the outline of the workpiece during the pendulating movement. Figure 5 shows the difficult grinding of turbine blades with the manipulator.

When grinding is finished, the truck with the workpiece is taken out of the room and unloaded. Changeover time for castings is about 15 minutes.

A heavy turntable is built into the floor under the manipulator. It is dimensioned for a maximum point load of 100 kN (10 Mp) and a total bearing strength of 200 kN (20 Mp). It is driven by two motors at 0.5 r/min corresponding to a peripherical speed of 6 m/min. with a table diameter of 4000mm.

The machine is provided with equipment that minimizes the risks involved in wheel breakage. If the grinding wheel slips over the ends of the casting during the work, the load on the wheel is immediately lowered by the built-in control of wheel pressure. If the pressure controls do not function or if the wheel were to be exposed to a higher load than intended, operation will be automatically shut down.

An exhaust hood, located adjacent to the manipulator removes dust in an exhaust flow of $10,000 m^3/h$. Another exhaust hood with a capacity of $5000 m^3/h$ is located at the grinding wheel head and is connected to a wet scrubber. Makeup air is introduced through inlets located above the door of the grinding room. In the operator booth there is a separate intake of fresh air with temperature regulation.

Heavy manual work has been eliminated by using the manipulator. It is possible today to employ women and handicapped workers for the operation.

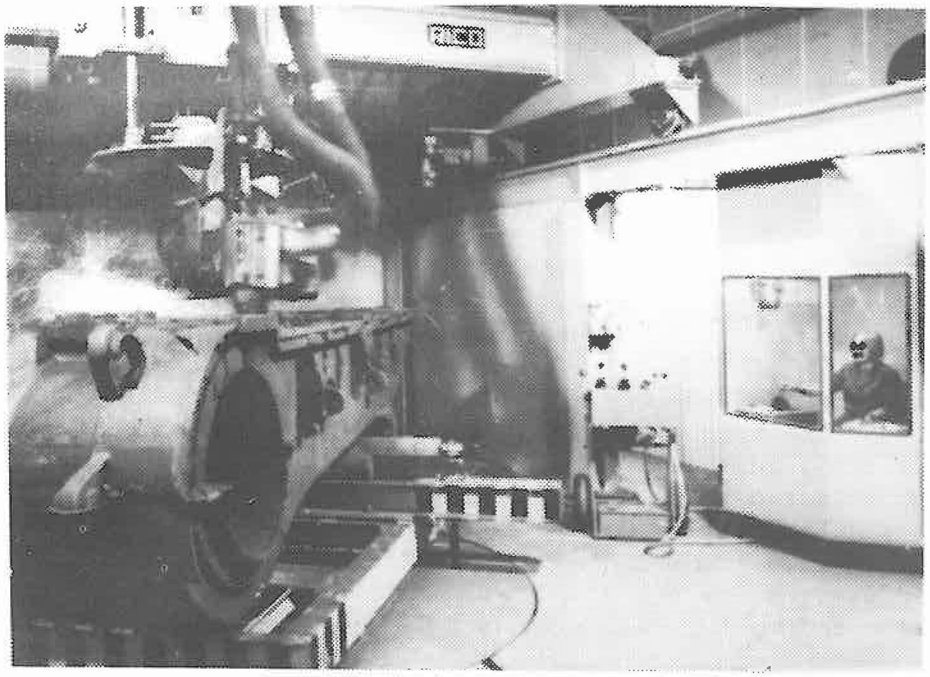


Figure 4. Grinding of flat surfaces with an electro-hydraulically controlled manipulator.

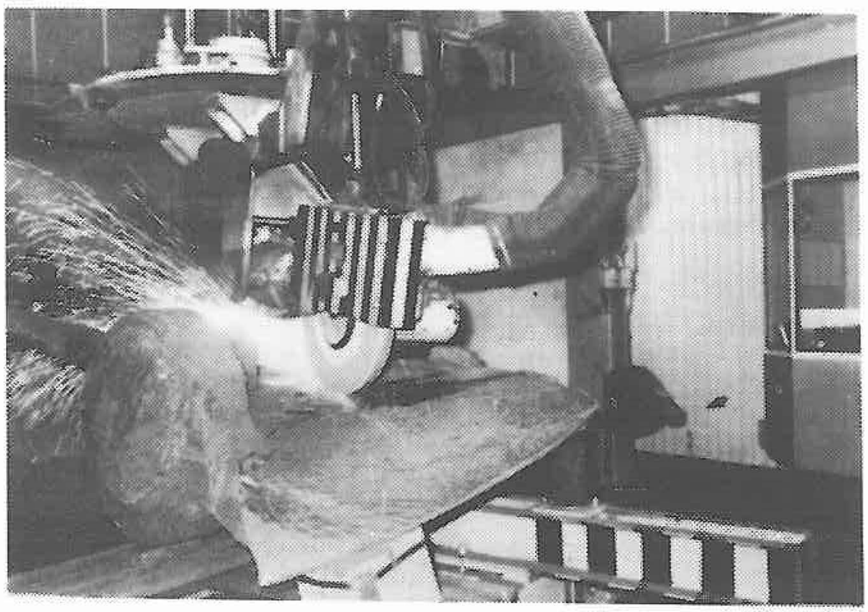


Figure 5. Grinding of turbine blades with the electro-hydraulically controlled manipulator.

Pneumatically Controlled Manipulator for Swing Grinding--
As in the case of the electro-hydraulic manipulator, the pneumatically controlled manipulator is also suspended like a travelling crane (Figure 6). The grinding unit of the manipulator can move horizontally in cross movements as well as up and down. It can also be given a bevelled movement and can move around a horizontal axis, making possible the grinding of curved surfaces. The working area of the manipulator is about 1x1m.

Movements in two horizontal directions as well as the bevelled movement are achieved by pneumatic motors in chain drive systems. Vertical movement is accomplished through a combined hydraulic-pneumatic system. The speed of all movements can be varied continuously within high and low speed ranges. The controls are located on a panel.

A considerably higher pressure can be attained than during manual swing grinding. As the grinding wheel travels over the surface of the casting, constant pressure is applied while variations in height up to about 100mm are accommodated.

The grinding machine requires 15 kW (20 hp) of power and operates at 2820 rpm. The grinding capacity of the manipulator is greater than that of a manual grinding machine.

In order to protect the operator from noise and dust, a small booth has been erected beside the manipulator. From this booth the whole process is remote-controlled. It is provided with an inlet of pre-heated fresh air.

During grinding the castings are located on a truck on rails on a turntable. It would be comparatively easy to provide the truck with a motor to achieve the back and forth and turning movements. The truck could also be provided with a lifting device for the raising and lowering of the work table.

Robots for Grinding and Pneumatic Chipping--
In order to determine the feasibility of using industrial robots for the grinding of castings, a Trallfa robot was tested in a large iron foundry in southern Sweden in the spring of 1974. The results of the test were promising. Further tests were performed with a more rigid robot made by ASEA. These latter results were so satisfactory that this robot is now being used in production cleaning operations in some Swedish foundries.

The ASEA robot has a lifting capacity of 60 kg and 5 degrees of freedom of motion. The robot has a separate programming unit with a memory capacity of four programs. The programming capacity is normally 250 position instructions; programs are easily modified. The robot moves in straight line patterns through a series of preprogrammed motions. Practical experience has shown that the distance between the points should not exceed 40mm, otherwise the deviation from the ideal straight line will be too great. The program capacity permits steering both from point to point and in a curved line. The programming unit itself is portable in order to facilitate the programming of the robot. The unit may be used for several robots and also for manual operation of robots.

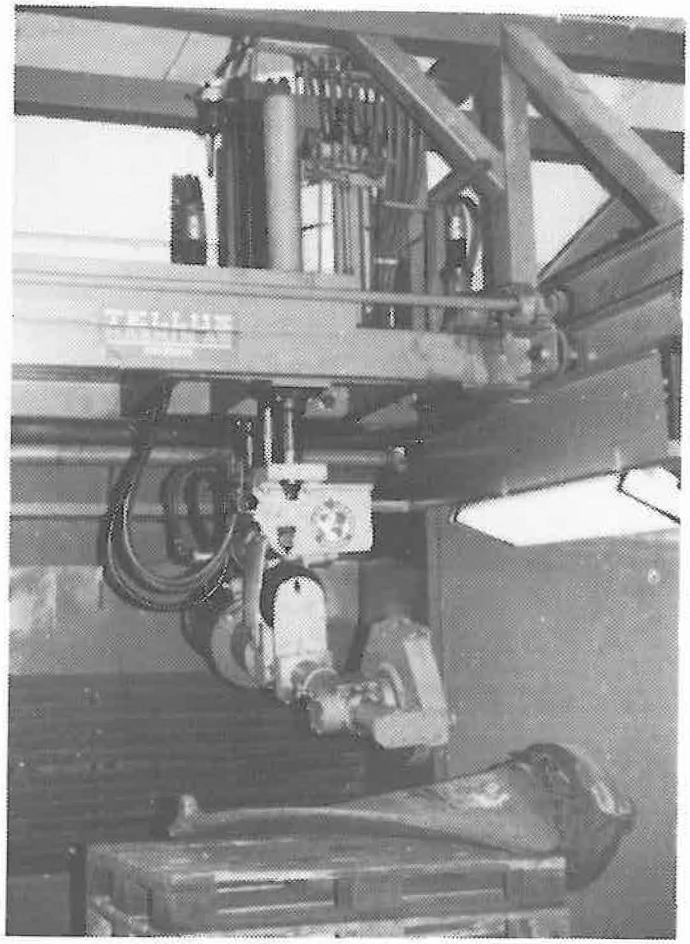


Figure 6. Pneumatically controlled manipulator for grinding of castings.

At the foundry where the development work took place, special equipment was designed for the robot: a revolving work table, a holder for the work piece, and a holder for the tools. In order to protect the operator against grit, dust, and sparks, a shield of transparent plastic has been inserted between the working area of the robot and the work station of the operator. The table is provided with a slotted exhaust located under the table.

For straight grinding a grinding wheel is attached to a separately built holder which is, in turn, attached to the robot arm (Figure 7).

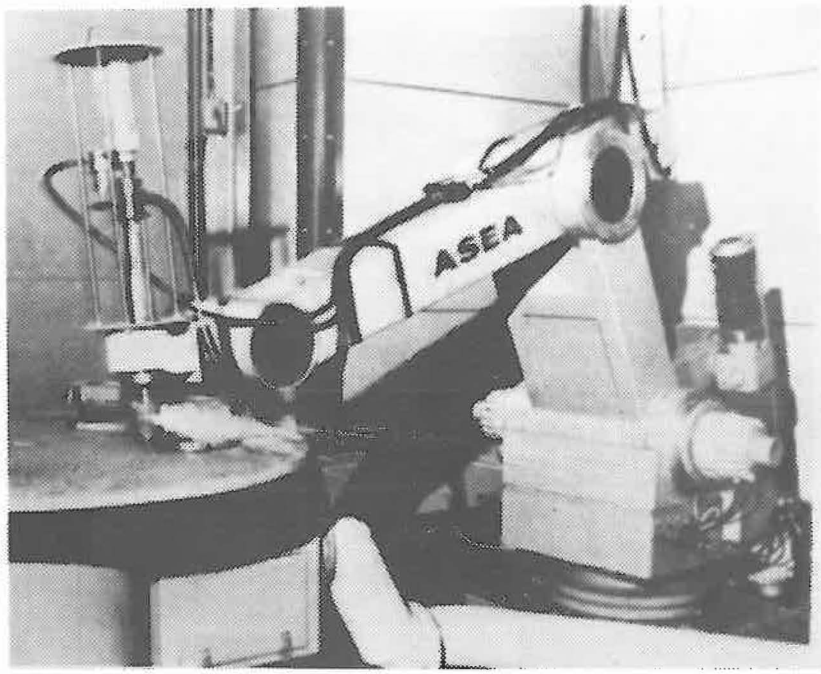


Figure 7. Use of industrial robot for straight grinding of castings.

When setting up the machine's program, a grinding wheel with a diameter of 40mm was used, while during actual work the diameter was 50mm. The difference in diameters plus the elastic holder resulted in an adequate grinding pressure against the work piece. The life of the grinding wheel is calculated to be two hours efficient grinding time, which corresponds to 50-80 castings.

Cup grinders could also be inserted into the specially designed holder. The grinding machine travels in two guides and the necessary pressure is achieved with the aid of a pressure cylinder. The pressure in the air cylinder is set to a level which provides sufficient force to ensure that the wheel always cuts, and its force is constant. As the robot advances the wheel to the casting and begins its pattern of movement, any variations in size and position of the component from what may be termed "nominal" are taken up by the compound slide, which is free to back the wheel off, or advance it, while still maintaining thrust for the cut. Figure 8 shows the machine at work.

Some ASEA robots are also used in the cleaning room of a Swedish steel foundry. Here one of the two robots is used for cutting off risers, and one for grinding. For removing risers (Figure 9) the robot applies a powerful spindle with a large diameter cut off wheel driven by an hydraulic motor. In this application, the robot incorporates a sensor which detects the moment when the cut off disc touches the casting, an event which obviously can vary from work piece to work piece. As soon as contact is "felt", the cycle of the robot is initiated.

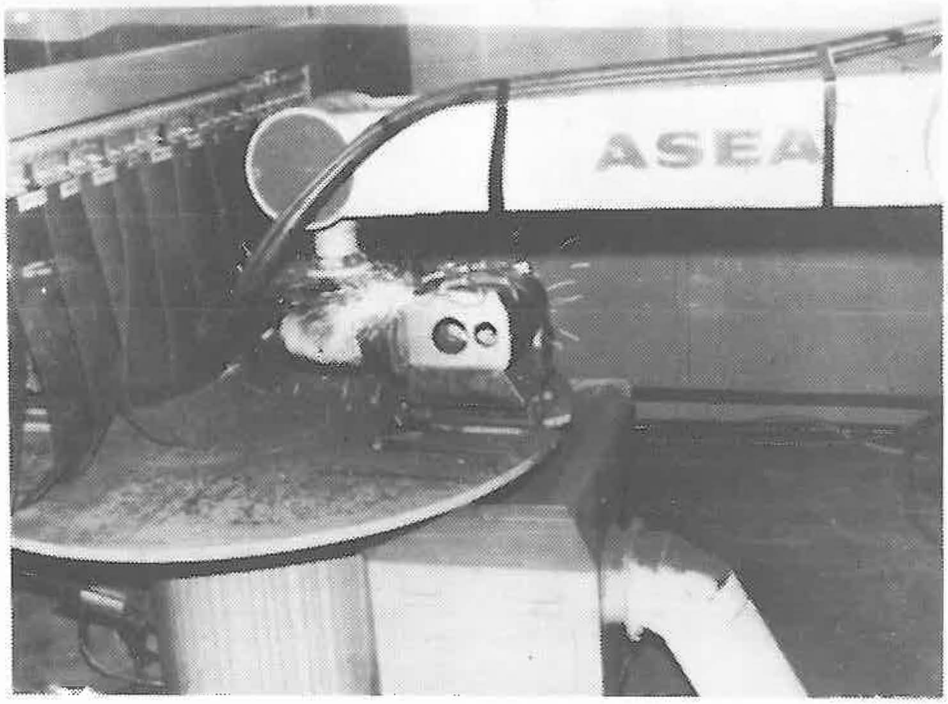


Figure 8. Robot grinding with a cup
grinding machine.

Figure 9. Removing of risers on steel castings
by an industrial robot.

The point of contact is also used as a means of monitoring the reduction in diameter of the disc as wear takes place. As the disc reduces in diameter the cut off stroke of the robot is automatically extended. The controller also recognizes the minimum diameter below which it is not safe to use the wheel, and withdraws the robot to an idle position when this point is reached. For the grinding application with this robot, a spindle and burr is substituted for the cut off wheel, and a fresh program is inserted into the controller. The complete installation is housed in a cubicle, and a 180^{o} indexing table is provided for loading and unloading.

Tests have also been made with the ASEA robot on chipping. A chipping hammer (Atlas Copco RRC 33) was elastically attached to the robot arm with a special holder (Figure 10). During chipping the casting was held in a jig. The tests showed that chipping, too, can be satisfactorily performed with an industrial robot. This application, however, has not yet been used in real working conditions.

As a result of this development work it is possible to state that the use of industrial robots during certain cleaning jobs is a practical proposition, with an increase in production of 20 to 40 percent possible. An important advantage is the obvious improvement of the working environment when the worker is removed from the immediate vicinity of the dust source and when the main part of the heavy and monotonous work is relieved.

Manipulators and Industrial Robots from an Economic Point of View

It is difficult to evaluate manipulators and industrial robots economically because of the large number of factors involved. It is evident, however, that a normal investment calculation does not show that the installation of a robot is always profitable. One should not, however, always adhere strictly to economic assessments when investments of this sort are discussed. Often it is of paramount interest to solve difficult environmental problems. Due to stringent governmental regulations concerning the environment and shortness of labor in some countries, installations of robots and manipulators may be the only way of getting a certain type of work done. Another factor to remember when evaluating economic feasibility of using robots and manipulators is the ever-increasing cost of ventilation. If, for instance, a dusty operation can be performed by remote control with a manipulator, the need for ventilation will be reduced. The cost to temper makeup air will also be reduced.

When estimating the costs of a manipulator or robot installation, the costs of the necessary accessories must be taken into account. Often these costs are as great as the cost of the manipulator or the robot itself. The cheapest robot or manipulator does not always produce the most cost-effective system when everything is considered.

A further cost item that must not be forgotten is the cost for service and maintenance and, owing to the advanced electric and pneumatic equipment involved, it may be necessary to give the workers special training.

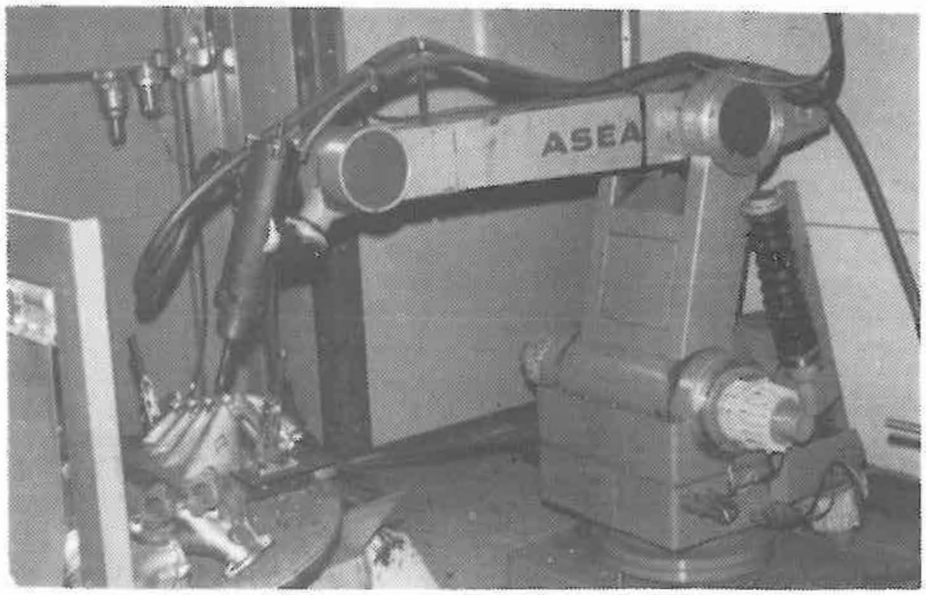


Figure 10. Pneumatic chipping with an industrial robot.

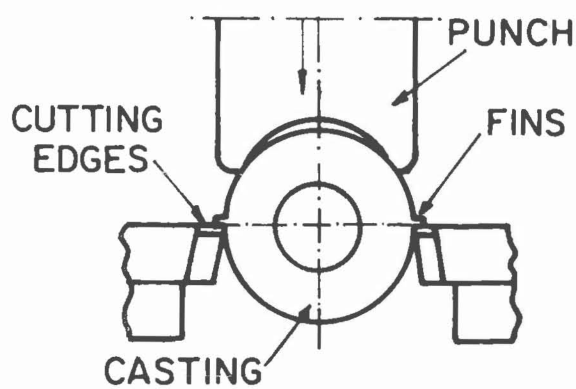


Figure 11. Shear pressing of flash on a simply shaped casting.

Shear Pressing

Shear pressing signifies the removal in a press of flash, feeders, and ingate rests. Up to now, the method has been used by foundries primarily for the cleaning of die castings.

For castings of simple geometric design a process such as shown in Figure 11 may be used. A punch fixed to the runner of the press moves the casting past the cutting edge, which shears away the flash. It is also possible to locate the cutting edges on the runner. The latter technique is used in Figure 12, showing the cleaning of a gear case. This method has turned out to be the most efficient method of cleaning castings with complicated geometry. The casting is located in a fixture on the pressing table and is held in place with the aid of an extra cylinder in the runner.

When geometry is complicated, it is generally impossible to perform all the deflashing with one single tool in one direction of movement; several tools in several directions must be used. Only flash that is projected in the direction of the tool can be removed.

During development and testing of the shear pressing technique, the following advantages have been identified.

1. Less dust formation, noise, and exposure to vibrations, and improved ergonomic conditions compared with conventional cleaning methods.

2. Increased productivity resulting in lower cleaning costs.

3. Insensitivity variations in the amount and size of flashes.

4. Better quality of work.

5. Less energy consumption than conventional cleaning due to lower ventilation demands.

6. Easy process to mechanize.

Measurements of the work environment before and after introduction of shear pressing have shown very drastic reductions in the amount of dust produced at shear pressing and reductions of 20-25 dBA in noise level.

High cost reductions have also been achieved. For long runs the costs have in some cases been reduced to one fourth of that for conventional cleaning.

Of course, shear pressing also suffers from certain disadvantages. The following are the most important:

1. The relatively high investment cost demands a certain minimum length of the production run to justify the tool cost. When cleaning not too complicated castings, a number of 1500-2000 per year will represent the lowest limit.

2. The demand placed on the tools is high.

3. Placing the casting in a press may be felt as a monotonous job, justifying further automation.

4. Interior cleaning is difficult to perform.

NEW AND EFFECTIVE CLEANING EQUIPMENT

Very few other innovations have been developed during recent years. Instead, already existing equipment is steadily being further developed and improved.

Hydraulic Grinding

Manual grinding machines are good examples of cleaning equipment that has not changed very much over the years. In Sweden, hand grinders are as a rule driven by compressed air; electric grinders are an exception. A power source that is expected to be more widely used in the future is hydraulic power. Tests done in Sweden with this sort of equipment have shown positive results. A hydraulic grinder would have considerable advantages over a pneumatic tool, particularly in that the hydraulic tool is more powerful and the speed is not effected by load. Cutting times may therefore be reduced and longer life of the grinding wheels may be expected. Another essential advantage is that the hydraulic tools get somewhat warm when used in contrast to the pneumatic ones, which grow cold. Operators who have been testing hydraulic grinders have said that they like them just for this reason. From the point of view of vibration it is medically advantageous that the machines are warm; the risk of injury is lower.

Casting Fixtures

When cleaning castings it is important to be able to hold the casting firmly and handle it efficiently. In Sweden a machine has been developed for fastening and handling castings during cleaning (Figure 13). The castings are held between movable pegs which are locked in a special patented way. Development of this type of tool is ongoing.

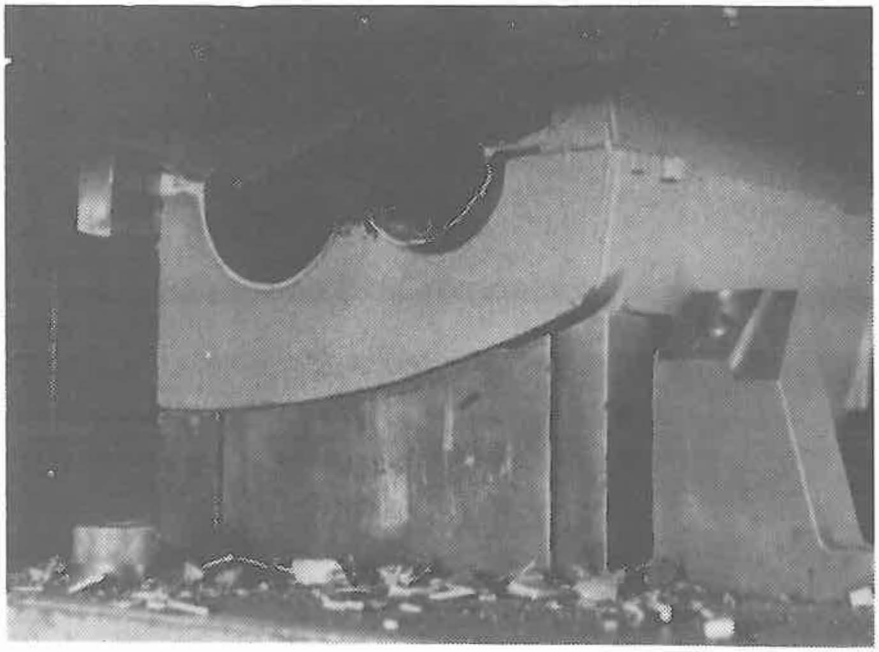


Figure 12. Shear pressing of a gear case.

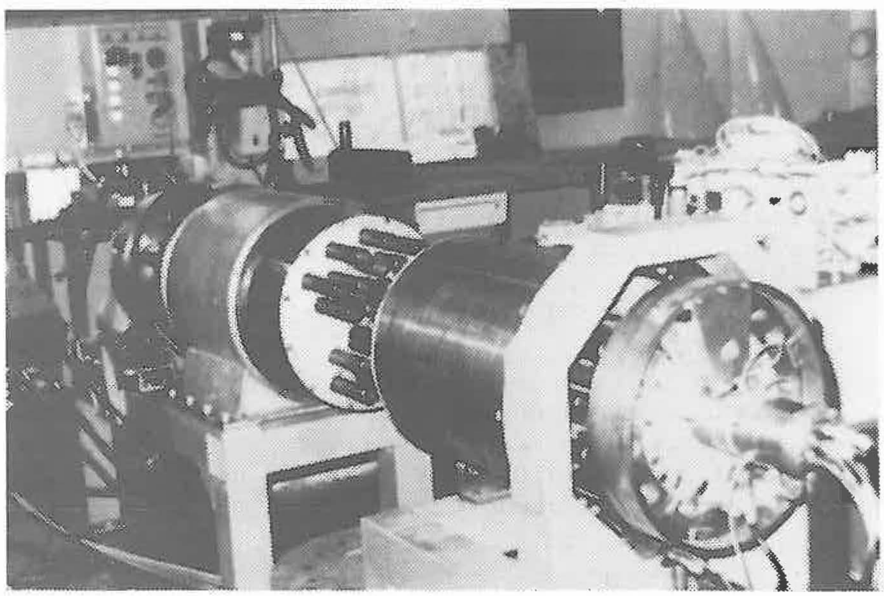


Figure 13. Fastening and handling equipment for castings during cleaning.

Cleaning Booths

Many Swedish foundries have installed enclosed booths during recent years, resulting in a considerable improvement of working conditions. Figures 14-18 show some examples of cleaning booths in use. The hexagon booth in Figures 17 and 18 was introduced first. Experience with this method and other development work have resulted in other types of cleaning booths. Experience has shown that the following requirements should be taken into consideration when designing a satisfactory cleaning booth.

1. Cleaning booths must provide sufficient ventilation so that dust concentrations are well below the hygienic limit value. The supplier should be asked to show test results from dust measurements made in the booth on similar work, thus demonstrating that dust concentrations should be sufficiently low.

2. The booth must be built in such a way that noise from surrounding processes does not cause levels in the cabin to rise above 85 dBA and preferably not above 80 dBA.

3. The worker in the cleaning booth must not feel locked up or isolated but should have a chance to contact and collaborate with his fellow-workers. Methods of booth surveillance for accident detection should be implemented.

4. The dimensions of the booth must allow the worker to move around freely. The floor surface must be at least $15m^2$. The booth should be furnished with a drop-leaf table and chair. The height of the booth should be at least 2.4m.

5. The booth must be equipped with satisfactory non-glaring lighting. The luminance should be maintained at least at 700 lux. The electrical fittings must be equipped with protective plates made of a material which grinding debris cannot damage.

6. It must be possible to transport castings in and out of the booth in an efficient way.

7. The booth must be rugged and suitable for a foundry environment.

8. Color, light reflectivity, and perforation of the walls must not irritate the eyes or cause glare. It must also be easy to clean the wall material.

9. If fresh air is brought in through the ceiling, the downward speed should not be less than 0.25m/s and not more than 0.5m/s. With lower speed air dust removal is insufficient and with higher speeds, drafts on workers is the result. If air is drawn in from surrounding space, the air velocity should be about 0.5m/s through the cabin door. A separate intake for air is desirable. The operator should be able to regulate the temperature from inside his booth.

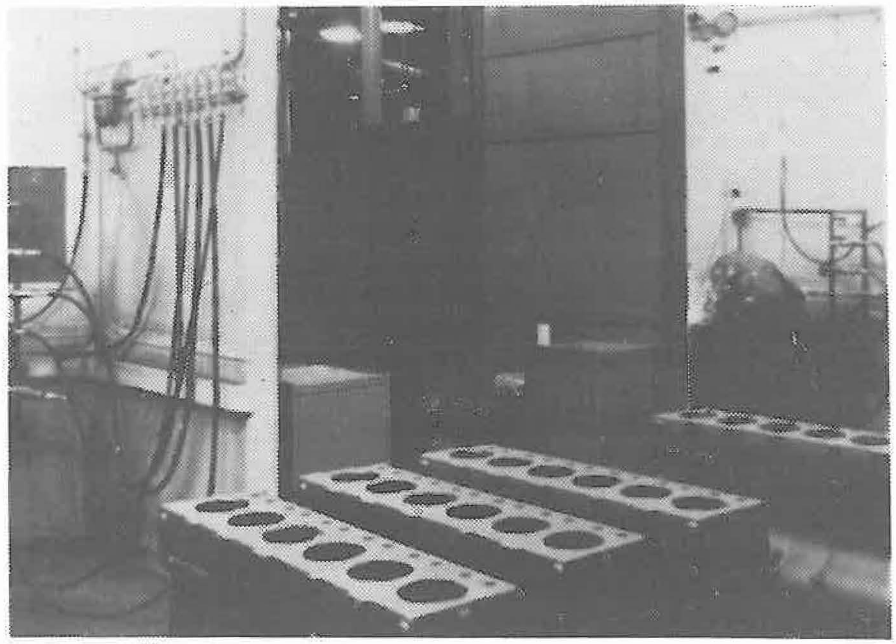


Figure 14. Hexagonal cleaning booth for cleaning of castings such as diesel engine blocks.

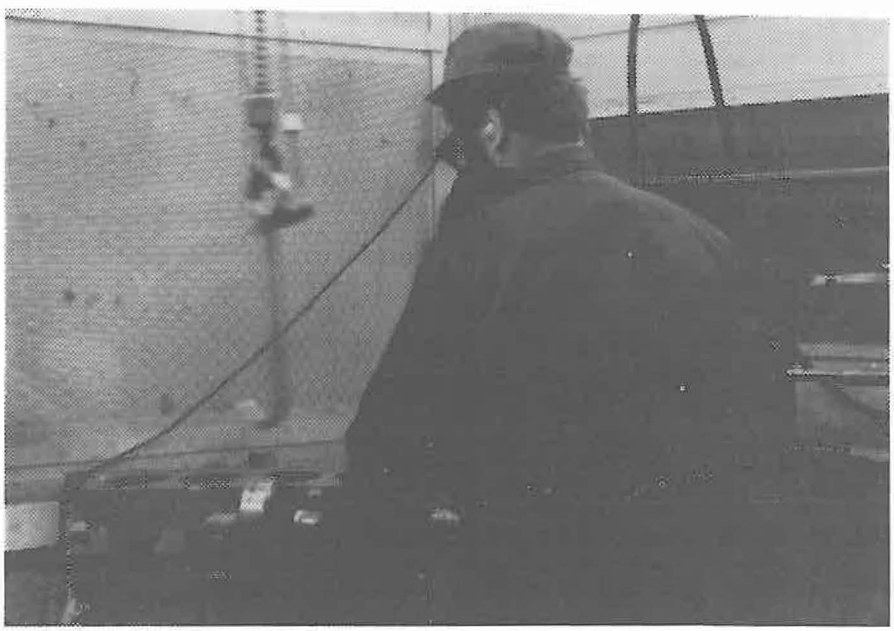


Figure 15. Interior of the cleaning booth in Figure 14.

Figure 16. Cleaning booth for smaller castings.

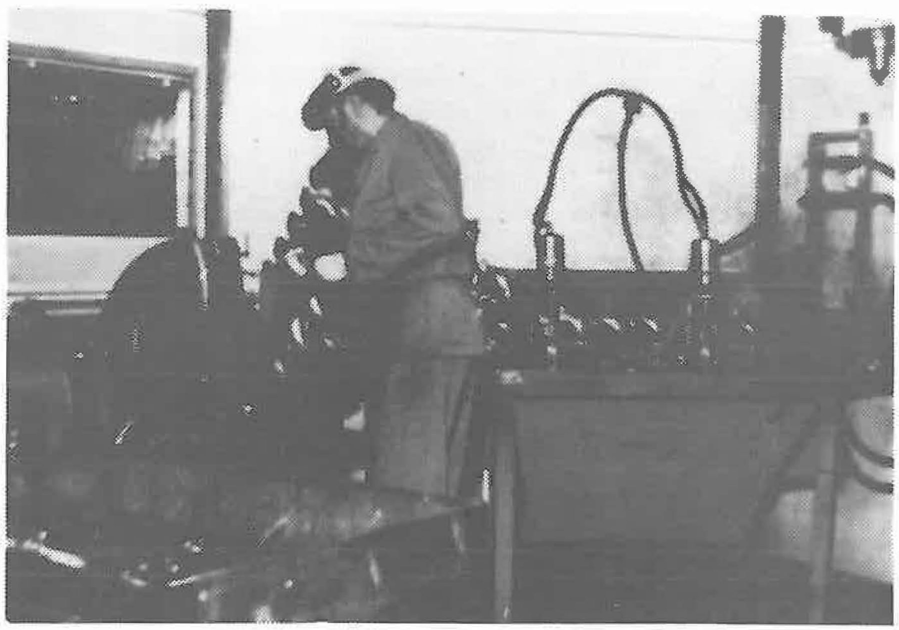


Figure 17. Interior of the cleaning booth in Figure 16.

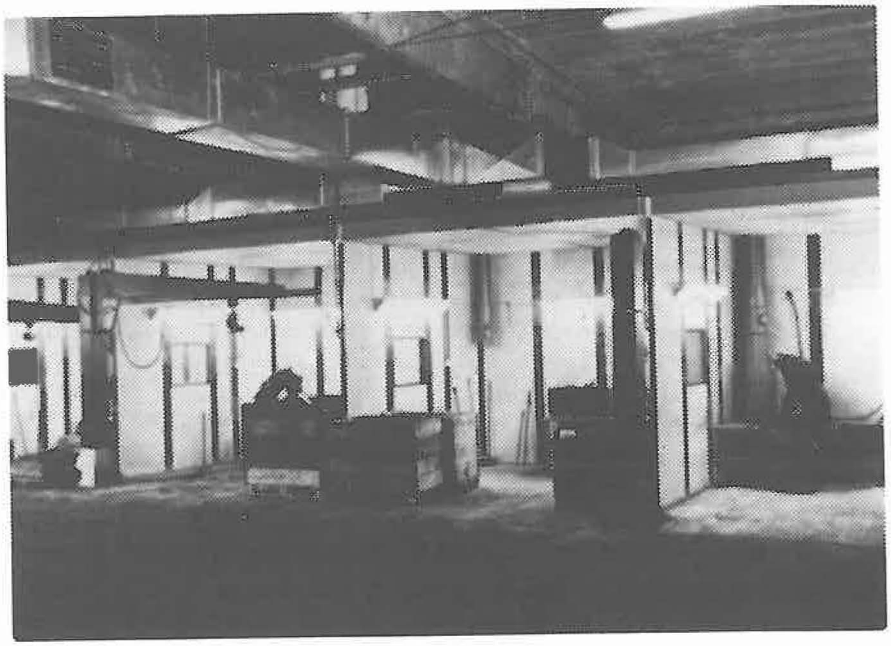


Figure 18. Another type of cleaning booth.

10. A working bench or table should be fixed onto or located near a wall with an exhaust hood. Close proximity between bench and wall is important to prevent work from being done between the exhaust hood and the table, in which case the dust produced must travel through the breathing zone before entering the hood.

11. The space under the cleaning bench and the cleaning table should be large enough to allow large pieces of iron to be collected there.

The cleaning booth in Figure 14 and 15 consists of a framework of steel, to which wall units are attached. The frame consists of six corner posts held together by transverse members. The walls are noise-absorbing and are built of prefabricated module panels consisting of 1.5mm of sheet steel, 80mm of noise absorbing glass fiber wool, and 1.5mm perforated plate on the inside. In one of the walls there is a window of tempered glass. The roof of the enclosure is similarly built of prefabricated panels.

Ventilation is provided by fresh air blown in through the perforated ceiling of the enclosure. The air is distributed in such a way that an almost laminar flow passes the breathing zone of the worker. The air is exhausted through the work bench.

Castings are transported in and out of the booth using a pneumatic hoist on a monorail. Compressed air lines are supported at head level from behind the operator for ease of movement (Figure 15). In the cabin there is a seat and a small folding table, both fixed to the wall. The light directed on the castings is about 1000 lux. The amount of dust in the cabin has been measured and it has been shown that the respirable percentage of quartz in the worker's breathing zone is about one sixth of the limit value now in effect. Before the reconstruction of the work station, when ventilation was arranged with exhaust in the walls but without a controlled supply of fresh air, the respirable percentage of quartz was so high that a respirator had to be worn by the worker.

The general noise level in the part of the cleaning department where the new cleaning booth has been installed has been reduced by about 20 dBA. The noise level in an unused booth from work carried out in neighboring enclosures is about 75-80 dBA. Thus it is possible for the worker to take off the hearing protection during work pauses without risk of hearing damage. When he is working, however, the ear protectors must be used.

Exhaust Hoods on Hand Grinding Machines

In dust control design the general rule is that dust should be collected as near the source as possible. This is especially important for hand grinding machines, which are very difficult from the point of view of ventilation. During grinding, air currents which can disperse dust are caused by release of heavy particles and by the rotation of the grinding wheel. With pneumatic tools the exhaust air from the tool makes the situation even worse. Extensive development work has been carried out with hand grinders in order to collect the dust as close to the source as possible by applying ventilation to the tool itself. This is difficult because good flexibility and lightness are necessary while, at the same time, the worker must be able to see the grinding area easily.

When collecting dust from hand grinding tools through source ventilation the so-called high velocity, low volume (HVLV) system is the best. The tools are fitted with hoods around the grinding wheels. A comparatively powerful exhaust system is connected to the hood demanding the use of special fans or ejectors. The power increase needed is comparatively small because the air flow rates are small and the total cost of heating fresh air is reduced.

Svenska Gjuteriföreningen,in collaboration with a member company and a supplier company, recently carried out a development program during which efficient exhaust hoods for different types of hand grinding tools were developed and tested (Figures 19-21).

For surface grinders (not shown) an exhaust hood is used consisting of a plastic case which surrounds the grinding wheel and rotates with it. Air is exhausted between the case and the grinding wheel.

An exhaust hood has also been developed for a chipping hammer (Figure 22). It consists of a suction nozzle with provisions for preventing large particles to be sucked into the exhaust tube. The nozzle is positioned by a figure "8" device consisting of two steel rings welded together. The chisel is inserted through one of the rings and the nozzle hood through the other.

A special swinging arm to support the suction tube and the compressed air line has been developed within this project. A vacuum valve has also been developed which shuts off the suction to the machine when it is not in use.

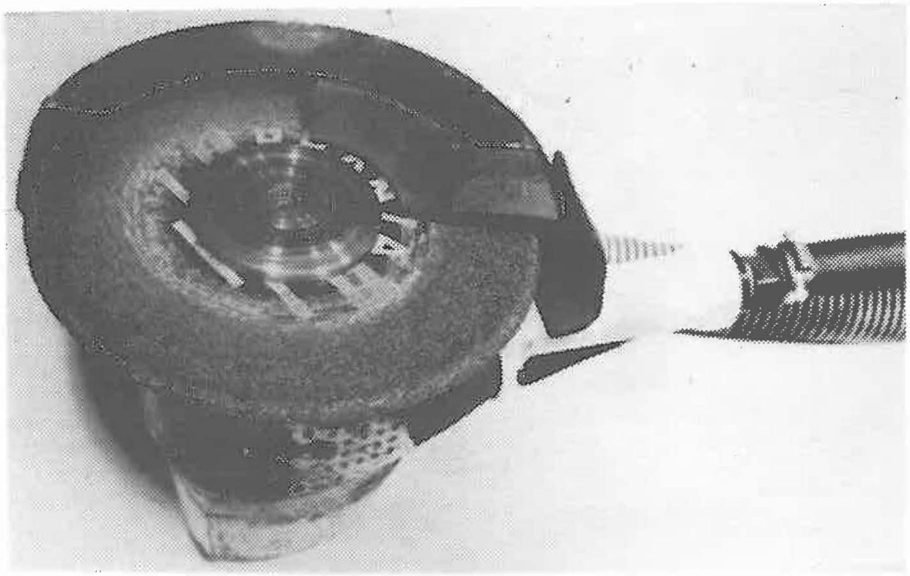


Figure 19. A cutting wheel equipped with an exhaust hood inside the shield.

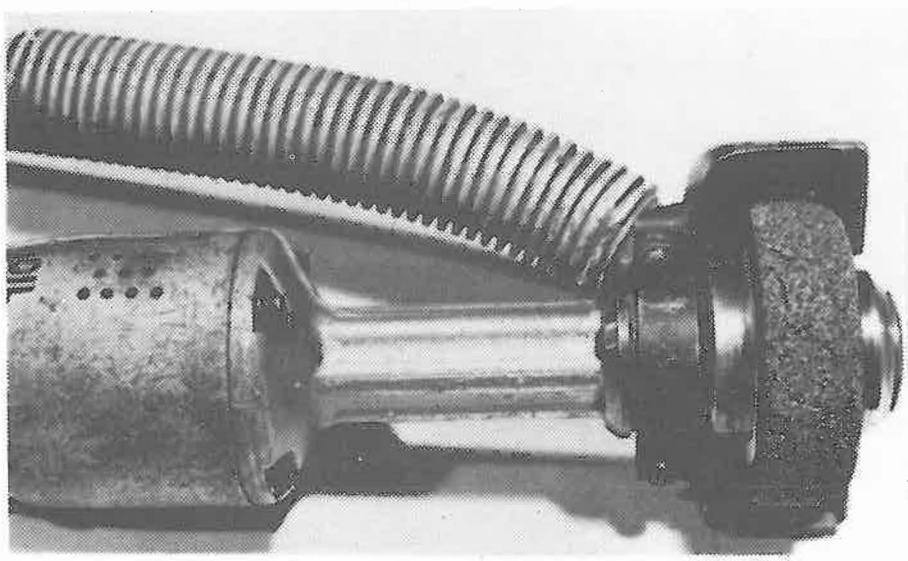


Figure 20. Straight grinding machine equipped with an exhaust hood.

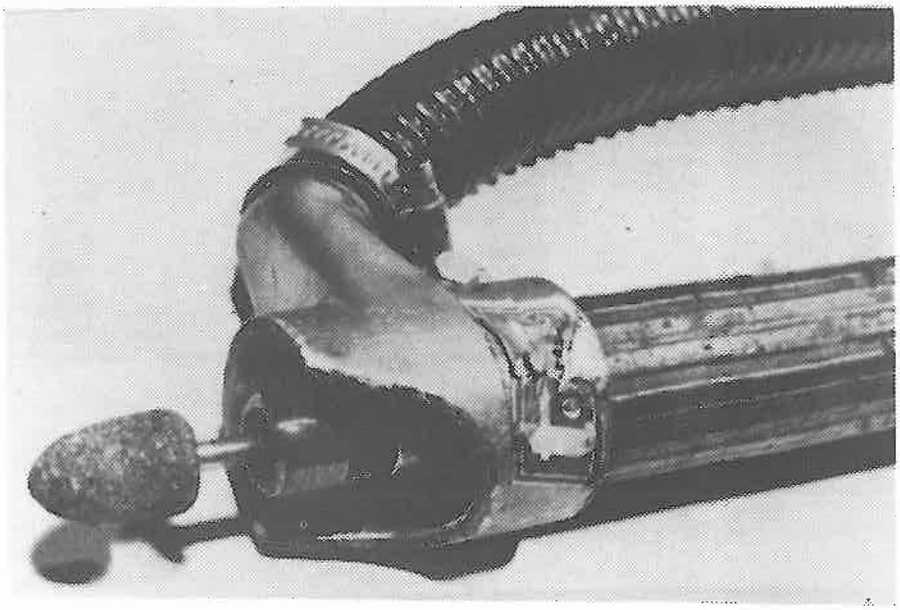


Figure 21. Straight grinding machine equipped with an exhaust hood.

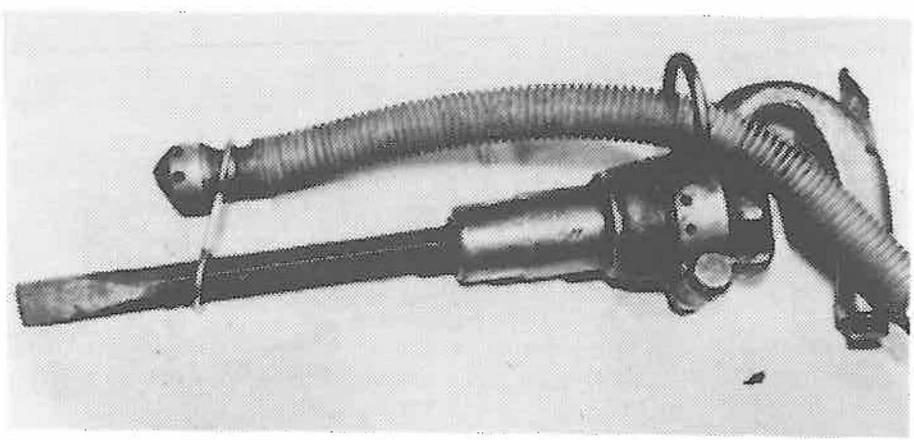


Figure 22. Chipping hammer equipped with an exhaust device.

Tests during actual cleaning operations showed that the use of the spot suction devices reduced dust concentration considerably.

Prospective Developments for the Future

Continued development is expected in the field of manipulators and industrial robots. In the future, many manipulators will probably be equipped with force feedback. Developmental work on industrial robots is continuing in many parts of the world. For the foundry industry a robot with a capacity for "recognizing" is desired for handling castings after the shakeout operation on automatic molding lines and transporting them to an appropriate automatic cleaning machine. Robots are needed that are able to lift heavy weights, perform work more accurately, and have a larger programming capacity, which will certainly be possible with new computer techniques. With a better programming capacity it will be possible to have the robot perform a number of tasks simultaneously.

New and effective cleaning equipment is sought which can reduce the need for specialized work booth enclosures.

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