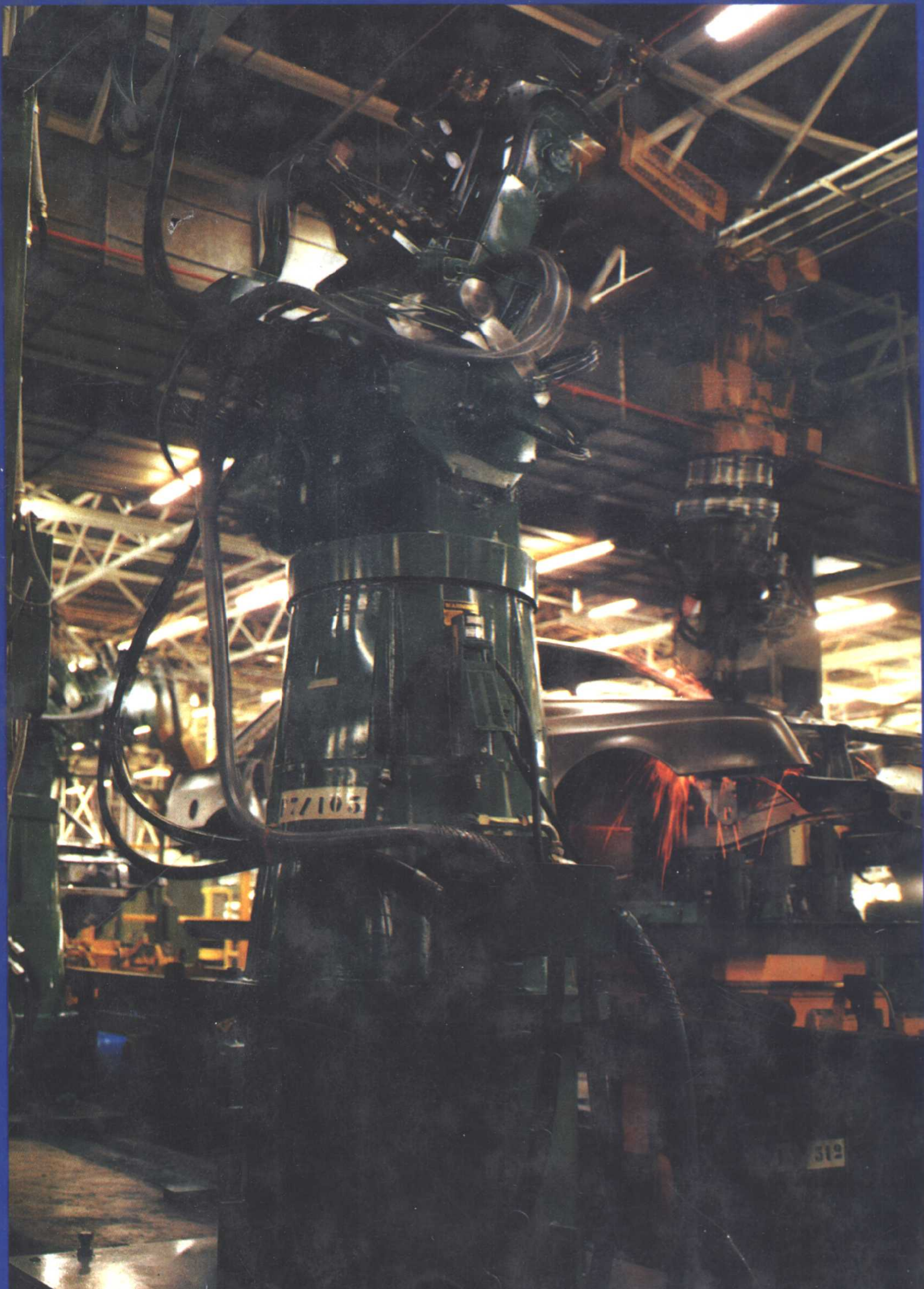
Developments in Robotics 1983



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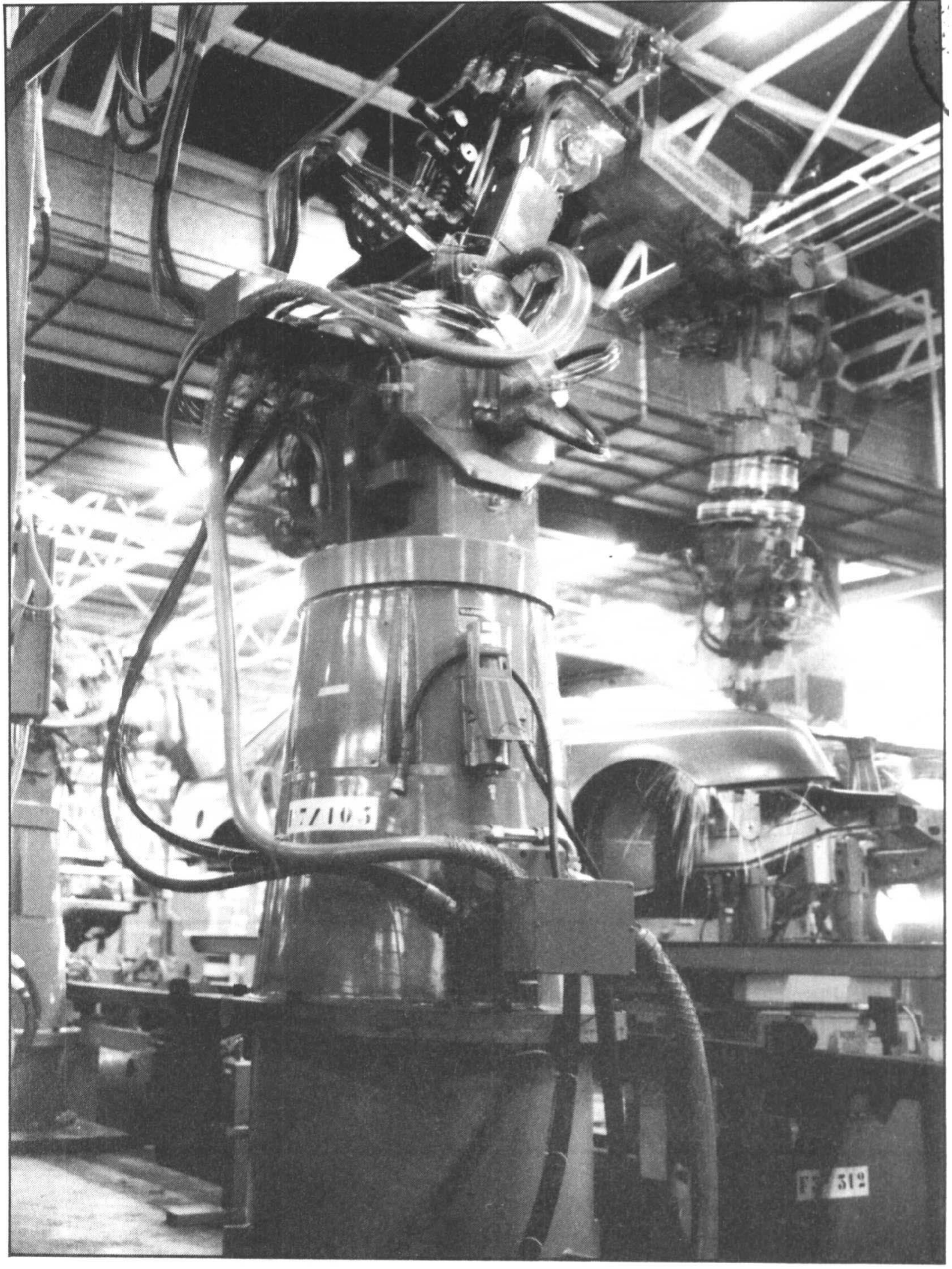

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FOREWORD

ROBOT is now the 'buzz' word, not only for manufacturing engineers but for the public at large. Whilst some may decry this development, I for one welcome the fact that through this more and more people have become aware of the needs and problems of automating manufacturing industry. It has also helped in attracting the attention of government and other funding bodies so that now money is being diverted into robotics, both for application studies and research.

Thus, more and more companies and institutes are carrying out developments on this topic. We, at IFS (Publications) Ltd., see this from the increasing number of papers submitted to ourselves and to our sister company IFS (Conferences) Ltd., for publication. This presents a problem since it is only possible to accommodate a fraction in our two programmes. This is not because of the poor content of those not published, on the contrary, it is due to the sheer volume of work being done on the subject.

To overcome this problem we have decided to provide a vehicle for previously unpublished papers to be made available to the robot community at large. Starting with this one we shall publish annually a selection of papers with the emphasis on the latest developments and research in robotics.

I have selected the papers, previously unpublished and submitted within the last six months, to represent current trends. The four chapters cover those areas which I think are of most importance. The first on applications selects three contrasting areas. The second chapter covers not only the latest commercial developments but also new techniques and research. The third chapter on sensors demonstrates the wide range of activities on both visual and non-visual techniques. Finally, the all-important question of controlling, driving and simulating robots is covered.

I hope you like my selection and trust you will find the information of value whether you are a user, designer or researcher.

Brian Rooks,
Bedford.
November 1982.

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Chapter One
Robot Applications

ROBOTICS AND PLASTIC INJECTION – FROM MANIPULATOR TO PROGRAMMABLE ROBOT

Jean-Louis Moreau – Technical Manager of SEPRO – La Roche S/Yon – France

Unloading of Plastic injection presses is one of the fields in which the use of manipulators is very developped. Without starting a vocabulary fight, it must be admitted that most of these systems should not be called Robots. The customers seem to ask more from these machines, waiting for further possibilities. A french manufacturer, starting from the general architecture of speciallized manipulators, by the use of a microprocessor and numerical control on one axis offers a new range of equipment, still very low in price, but able of a lot of possibilities. An important work has been developped to make it as easy as possible to use and program . It is a good example of the technical improvement of simple robots, needed by the user demand and enabled by technological development.

INTRODUCTION

It is almost impossible to touch to the Robot field without being involved in a vocabulary problem. Any study can be debatable because the bases are not equivalent from one country to the other.

A great amount of work is developped to try to find a universal definition and classification, based essentially on the possibilities of the electronic system driving the machine.

This work is absolutely needed, but should not leave behind the user point of view, which is to compare the possibilities of systems in the field of a specific range of application.

This is why one will find on the market another type of classification based on the application ; thus inciting manufacturers to design specialised architectural system : Painting robots, welding robots, robots for machining machines etc...

We are going to study one of the more numerous family : Robots for automatic unloading of horizontal plastic injection presses.

.../...

GENERAL DESIGN

The mechanical design of these manipulators is in most of the time a 3 axis cartesian coordinates system extended with a wrist motion and speciallised gripping system.

It is installed above the press and allows to operate with lateral screens closed.

The particularity of these machines is the length of the strokes which must be achieved. On medium size presses, vertical strokes of 1200 mm and horizontal stroke of carriage of more than 2000 mm are often needed. Compared with universal industrial robots, we would be in the field of big and expensive systems.

Another technical requirement is that the unloading cycle time should be as short as possible, needing to operate the vertical motion at very high linear speed (1200 to 1500 mm/second).

The work cycle is more or less the same from one application to the other. The typical sequence can be discribed as follow :

- Robot waiting above press axis, for the press to open
- Down stroke of arm Z
- Horizontal stroke of slide Y) associated with press ejectors
- Seizing of component (
- Retract motion of slide Y
- Up stroke of arm Z
- Translation of carriage X   While starting a new press cycle
- Wrist orientation W
- Down motion of arm Z
- Component release
- Up motion of arm Z
- Return motion on wrist and carriage.

Other cycles are a slight variation of this sequence and the automatic control is made by a simple wired logic system, with eventually one or two selectors for variation.

This description shows that each motion is achieved between two stops (in fixed or adjustable location), typical application for pneumatic actuation most of the times associated with shock absorbers.

These types of machines should be classified in the range of fixed sequence manipulators. The normal utilization is limited to the unloading and positionning of parts, with a possibility of a stop during cycle to achieve an auxilary operation (gate cutting for example).

This application seems very simple and limited, it has thus allowed an important developpment on the market.

JAPAN is onee again the leader in this field, 80 to 90 % of new injection presses being equiped with manipulators.

One among the Japanese manufacturers sells more than 1500 manipulators per year. This level is made possible by the low cost of equipment (approx. 80 000 to 200 000 FF according to dimensions) and by a rather easy pay-back possibility on labour saving, most of the presses working in three shifts.

MARKET DEVELOPMENT

Market studies show a wide possibility of development for this range of product in EUROPE and specially in FRANCE. However it appeared that eventual customers, already familiar with Japanese techniques, are not very satisfied with the fixed sequence principle. A lot of new applications require supplementary auxilary motions on gripping elements to be programmed at various steps in cycle according to the very application.

Thus appears the need for the move from the fixed sequence to the programmable system, that is to say from the wired control to the electronic control.

In parallel, the simple unloading operation is considered as too limited, most of operators achieving other works on parts. Many requirements have been made to increase the possibilities : unload one type of part on one side of the press, another type on the other side ; load the parts on stations where other operations are achieved, arrange the parts in row etc...

.../...

These new requirements, thus allowing to stay with the same architecture as for manipulators, need to study an horizontal motion of main carriage with stop positions able of being multiplied and programmed, and a vertical motion with at least 2 different down levels.

TECHNICAL REALIZATION

A french company, already very familiar and experienced in the field of automatic loading and unloading of drawing presses for metal has developped a new range of equipment trying to offer the best performance/price compromise but still affordable compared with overseas competitors.

We shall not insist on the mechanical design, which is using the experience and technological components of system for the drawing presses application, with a guarantee of liability and efficiency.

The real work in research and studies has essentially been made on the electronic control of cycles and of the carriage actuation.

The programmable side of the problem could have been solved by the use of a standard programmable logic Controller. But the experience has shown a certain number of practical problems in application :

- These systems are delivered with a separated programming console ; the price of which is usually much higher than the price of the control circuitry itself. And the use of the console in production shops does not appear to be well adapted to the precise problem.
- The programming languages are universal to be able to meet as many requirements in application as possible. They need for the operator to attend to a special technical teaching course, which is not in the sight of the simplicity aimed for this range of products, accepting very easily a step to step sequence mode from which any technician is able to programm without special teaching.
- The possibilities of choice are very numerous in this range of equipment. But the manufacturer has to choose one supplier, which is sometimes unknown or not agreed in the final customer specifications. When the robot manufacturer has to install a different type of programmer, a new programming console must be purchased and a new language must be learnt...

The programmation of carriage motions calls for numerical control technics. But here too, standard systems offered on the market do not appear to be well adapted. The cost is too high because the technical possibilities are far above the requirements for the precise application, both in case of self contained systems or in case of using programmable controlers able of sequence monitoring and numerical work in the same time.

It was thus needed to develop a specific circuitry monitoring both the sequences of the programmed cycle and the motion of the carriage. This circuitry has been built around a 8 bits microprocessor.

The sequences are driven step by step. Several actuations can be programmed at the same step : the respecting outputs are all actuated in the same time. Incrementation to the next step is automatically monitored as soon as control informations have been collected on the sensors checking the end of motion of programmed actuations. Digits on a display show in continuous the address of the step and, in case of a stop in the cycle, allow to find instantaneously the motion which has not been actuated or controlled.

Programming is possible without using a special logic or data-processing language, with a key board allowing to increment the program steps, and to select the needed actuations at each step. Modifications in sequence are easily made by inserting or erasing one or several steps.

The exchange of informations with other machines or equipments are made by programming inputs and/or outputs in steps of program as needed.

In a way to simplify the programmation, the possibility of using subprograms has been added. It is specially interesting for arrangement of parts in several rows.

.../...

The linear motions on carriage are actuated by an electric motor with electronic speed control, and measured by an incremental encoder. The micro-processor calculates continuously the difference between the actual position of the carriage and the aimed stop position, and sends orders for speed variation and stop to the speed control console. An automatic correction of the stop position is monitored in case of a stop out of tolerance. The stop positions can be entered in the system either in numerical dimensions by a direct addressing with the key-board, or by registration in memory of the position of the carriage adjusted by actuation on inching buttons (direct teaching method). The abscissas of stops are displayed, in millimetres, on digits.

The possibilities are well known and universal. They have been extended by special internal programs specially adapted to the application. They are specially established to increase the safety in interlocking with the press and they allow to perform special sequences in motions when special informations occur (for example component lost during unloading ; special travel back to origin in case of problems on auxiliary stations etc...)

It is the most important part of the study. We are not so far from the concept of the "Intelligent Robot" modifying by itself its basic cycle according to the state of some sensors or other inputs.

The elements of program on which the operator has the possibility of access are stored in RAM memory with battery safe-keeping. It is studied to operate in industrial application without any problem. It is very usefull especially during fittings, commissionning and adjustments of both the program and the gripping elements, because it remains permanently and instantaneously modifiable.

For the succession of small or medium series, it is possible to store the programs in ROM memories, and to call them back by a simple coded commutation. This addressing is made in practice by a special wiring in the socket of a multi plug connector installed on the mould. When the operator plugs in the connector, the selection of the program specially established for the injected part is automatically made.

This programmable robot with one axis in N.C control stays however very simple and robust. Except the microprocessor card, it is built with classic and well known components, and can be run and maintain by a normal technical team without special training.

Its price for a medium size robot is only 10 to 15 % higher than the price of an equivalent fixed sequence manipulator. Its possibilities in application on press are widely improved. The following examples will give some better ideas.

EXAMPLES OF APPLICATION

1 - Press unloading and arranging of parts, side by side, in rows on a belt conveyor actuating step by step. This application is well adapted for the production of parts with surface requirements needing a visual inspection.

One operator is able to control and pack the production of several presses.

The total cycle of the robot includes as many press cycles as the number of rows on the conveyor.

2 - Press unloading, gate cutting on part, loading and unloading of an assembly or a marking machine.

These operations may be followed by arranging as in example 1, the conveyor being installed either on the same side or on the other side of the press.

3 - Press unloading, carott cutting, carott machining with a milling head, arrangement.

This application shows the possibility of program interlocking with several machines having each their own control system.

4 - Press unloading, loading and unloading of rotating table for cooling and shape correction, loading and unloading of a mechanical press for further cuttings, arrangement on belt conveyor.

.../...

5 - Robot with 2 associated gripping elements in same vertical axis on vertical arm.
Taking in charge of inserts with the upper grippers, on a distributing device installed on one side of the press.
When press cycle ended, unloading of injected part with lower gripper, then second down vertical stroke and loading of inserts in mould, retraction of vertical arm and arrangement of parts on conveyor installed on the other side of the press.

CONCLUSION

Through these examples, we have tried to show the technical possibilities of an equipment, universal in its applications in one special range of industrial field.
It is well possible that further technical improvements, or even further commercial development open to this type of equipment new possibilities of market in other fields than injection presses, as for example loading and unloading of lathes, milling machines or machining centers, or palettization work.
But we shall have to stay very carefully in our state of manufacturer of industrial devices, trying to forget if needed the technical performance as itself, and working hard to go on with our close contacts and discussions with customers and eventual users.
We have the feeling that if we wish that technics help us to sell robots, we must try to use technics to build the robots that the customers require.

TOWARDS THE AUTOMATED FACTORY: ADVANCED ROBOTISED LINES IN FORGING PLANTS

By Dott. Ing. Alessandro Ferloni, General Manager, CAMEL ROBOT S.R.L., Italy and Dott. Ing. Giovanni Pontini, Production Manager, TEKSID FUCINE S.P.A., Italy

ABSTRACT

Here is the first description of the automated production line of: connecting-rods - suspension arms - rollers - flanges, performed by robots.
This paper describes the lines and mainly the application of the robots in some technical, social, economical aspects.

INTRODUCTION

The operation of a forge, in a typical instance, requires personnel to feed the furnaces, manoeuvre the incandescent billets, feed the presses and remove the finished parts.

Now completely robotized forging lines are growing up very rapidly in Europe and in particularly in Italy.

Automation by means of dedicated robots for forging operations is attractive since it allows existing machinery to be completely utilised, overall productivity to be encreased and personnel to be freed from working in what are, frequently, unpleasant conditions.

One of the most important forging industry in Italy, Teksid Company, has already about 15 robots working in Turin forging plants.

Completely automated hot forging line need no people to keep it running; computer controlled robots completely eliminate manpower in moving materials and decision making providing a large increasing production gains, without great capital expenditures.

Flexible high production capacity lines are composed of robots, steel bins, conveyors, billets heaters, traditional forging and trimming presses. Different presses position in the plant suggests different solutions.

The robots used are hydraulically or pneumatically powered at modular structure with carthesians axes and movements of:

traversing : the carriage carrying the robot can slide on two columns blocked at their extremities by floor-mounted pedestals, traversing stroke can reach 2500mm.

rotation : obtained from a rotating table fixed to the traversing carriage; the maximum angle of rotation is 180°.

vertical : the robot carriage slides on two columns with a maximum stroke of 500mm.

horizontal : a second carriage, carrying the robot ram and grippers slides on two horizontal columns, the ram stroke has a maximum value of 1000mm.

The maximum weight which can be manipulated is 100 kg.

The modular construction of this robot means that only the axes which provide the movements necessary for a given application needed be supplied, giving therefore obvious economic benefits.

The control system of the robot is comprised of a microcomputer which gives the robot all working flexibility i.e. intelligence, needed for carrying out the tasks entrusted to it. Both the microcomputer and associated software have been specifically developed from the CAMEL ROBOT.

Now follows the description of three most representative forging lines.

<u>CONNECTING-RODS FORGING LINE</u> (or in general flat parts) (See figures 1 and 2)

A steel bins conveyor moves one steel bin to the position where ORCA robot loads the billets conveyor in the electric billet heater, replacing former manual loading or very noisy automatic loading equipment.

Orientating robot ORCA loads the billet magazine in the electric billet heater. It takes one billet at time directly from the steel bin, where the billets are collected, orientates it, and places it on the magazine or on walkingbeam feeder.
Steel bin is scanned until empty; a warning signal is given to provide bin replacement.

Cycle-time is 6 sec.

Operations are computer controlled, rugged and depenable, and completely unmanned.
Billets are positioned at one end of a conveyor: positionning is mechanically adjusted time by time, according to the billets length.

CARICATORE robot takes the billet from the input conveyor one at time and provides to position them on the first die of the forging press, and in the same time it provides lubrication of the die by means of suitable jets mounted on the gripper.
An optical temperature sensor provides to checking the temperature of billet.

Then the robot commands the press descent; after the first stroke of the press, the two robots SPECCHIO , placed one in front and the other behind the press, transfer the forging from the first to the second die.

Then they send the signal to operate the press. Now again they transfer the piece on the third die and command the descent of the press. Now the forged connecting-rod is unloaded from the press and transferred to the trimming press.

Transferring operation to the trimming press is carried out by SARACINO robot which picks up the part from the forging press third die with one ram while with the other unloads the trimming press. It turns 180° and loads the trimming press, sends the signal to operate the trimming press and then removes any flash and unloads it on a conveyor.

The finished connecting-rods are collected by a special device into a bin.

During trimming operations the CARICATORE provides to place a new billet on forging press first die, beginning a new cycle.

At each trasferring, special jets mounted on SPECCHIO rams extremities provide local lubrication of the next die.

Forging lines as this just described double production in respect to manual running, and with a low investement cost.

Only one man controls the whole line.

Lines as this just described can forge, only changing the fingers in the grippers, also suspension-arms, crankshafts, mower blades, link chains and generally all flat parts.

MULTIDIE PRESS: PREFORMING-FORGING AND TRIMMING OF ROUND PARTS (See Fig. 3 and 4)

Multigrip robot POLIPO moves parts from a die to the other in succession or altoghether; in the same time provides dies lubrication control, as programmed.

The robot is equipped with four indipendent sensitive grippers.

Providing that hot billets feeding, is properly done first grip of the POLIPO robot takes the hot billet from feeding conveyor; rotates the billet and places it on the first die.
Second grip moves the preformed part in the second die. Third grip moves the forged part in the third die. Last grip moves the trimmed part from trimming die to the output conveyor that carries it to proper steel bin.
Flashes are automatically collected in a steel bin.
Lubrication of dies is performed during transfer moving, when the dies are "free".
Sensitive grippers assure reliable operations; equipped with several grippers, which can rotate indipendently, the robot can manipulate simultaneously up to four differently shaped parts moving each of them sideways with a stroke equal to the distance between the dies.
Robot's computer controls conveyors, press and lubrication system.

A forging line equipped with this robot can triplicate production in respect to a manual production and with a very low investement cost.

This is the enormous advantage of this application; and simply changing the fingers of the grippers it is possible to forge a lot of round parts such as hubs, bearing rings, drive train joints, spiders, gears and so on.

The robot is completely pneumatically powered and microcomputer controlled.

The microcomppputer controls also the press, the heating furnace, the superior and inferior ejectors of the press, and the dies lubrication.

One man is dedicated to surveillance.

Cycle-time is 5 sec.

HEAVY PARTS FORGING LINE (See Fig. 5 and 6)

The line composition is as follows:

- ORCA robot to load the billets from the bin
- feeding systems of furnace
- electric or gas furnace
- outlet sustem of furnace
- loading robot
- forging press
- transferring robot
- trimming robot
- trimming press

In this line the billets are heavy (up to 100 kg.) and operations are relatively slow; the cycle-time is about 12 sec.

The robots are hydraulically powered and robot's microcomputer controls as for what described in the previous lines:

- furnace
- feeding systems
- press dies lubrication
- presses
- correct positioning of parts in the die.

The operations performed in this line are:
The first robot H01 takes one billet from the chute and places it in the die of the forming press. The second robot H01 trasnfers the piece on the second die and the third robot transfers the forged piece in the trimming press, then unloading this trimming press collecting the pieces in a steel bin.

This automatic handling line brings a significant decrease in work injuries and compensation costs. This line normally forges with few fingers modifications: rollers, flanges, tranck links, crankshafts.

In the near future probably this line will be an obliged step to achieve in all forging plants as it performs really a hard jobs in unpleasent environmental conditions.

CONCLUSIONS

Production capacity

Connecting-rods forging line: 500 forging pieces/hour as 1000 connecting-rods/hour.
Weight from 750g. to 1230g.
Round parts forging line : 700 pieces/hour.

Efficiency computed over one year is 70% for the connecting-rods forging line (18% of the total losses is unputable to robots).

Efficiency computed over one year for the round parts forging line is 80% (6% of total losses is imputable to POLIPO robot).