An International Conference

PLASTICS INJECTION MOULDING IN THE 1990s

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RAPRA
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Plastics Injection Moulding in the 1990s

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15th and 16th November 1990

INTRODUCTION

Injection Moulding is the single most important manufacturing process in the plastics industry. It is used for the production of components for every business sector, from miniature seals for medical appliances to automotive body panels and office equipment.

Despite - or possibly because of - injection moulding's major status, it is still subject to a rapid rate of change. Both the machinery and materials used are subject to a rapid rate of development as manufacturers of both seek to gain advantage over their rivals in the hunt for market share.

The processors using injection moulding are also finding themselves under increasing pressures. As with all other plastics products, the customers' demands for high quality and rapid delivery - both, of course, at lower price - mean that they must keep abreast of new technology or lose out to their competitors.

This conference will review the various ways now being proposed to help the injection moulder become more efficient and thus more competitive. Special attention will be given to novel ways to improve productivity and quality, in particular through increased automation and statistical process control.

As ever, Rapra is pleased to place on record its gratitude to all the speakers who have put much time and effort into preparing and presenting these papers. I am confident that they will prove of great value to all those involved with injection moulding, whether as product designers, mould manufacturers or processors.

I would also like to thank all those from Rapra's Publications Group for their efforts in the typesetting, proofreading and printing of this volume, in particular, Thelma Bright, April Chow, Tim Comerford and Kay Royle.

Peter Dickin
Publications Group Head
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Modular Machine Construction and Automation

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WHAT DO WE MEAN BY A MODULE?

The central module in our discussion is the injection moulding machine, which can itself be considered a modular construction of a clamp unit and an injection unit. Hence there is a large range of injection moulding machines available with various specifications based on a central core of clamps:

- single or two stage hydraulic
- toggle
- high or low pressure

injection units:
- different sizes
- different screw geometries
- thermosetting or thermoplastic types
- single or multi-component

and control units:
- open or closed loop
- with or without memory
- high or low level

These various components then give us our basic module for automation, the injection moulding machine, to which can be added further modules such as:

- robots and handling devices
- automatic mould changing tables or vehicles
- gas injection modules
- post-finishing or printing stations
- automatic material, screw and barrel or complete injection-unit changing arrangements
- material feed systems

to produce an integrated flexible production cell.

From this palette of options the injection moulder can select his production cell to give him the required level of flexibility and automation; these two key concepts are by no means mutually exclusive. It is necessary in today's technical and commercial environment both to automate and to respond quickly to a rapidly changing market.

WHY AUTOMATE?

Quality

By automating a process a large number of random factors introduced by the human element can be eliminated. An obvious example of this is the cycle time variation in semi-automatic operation, which is completely absent when a robot is used for part removal.

In addition to this consistency of quality is the ease of monitoring it by use of weighing and measuring systems, the production of the required documentation and the possibility of batch traceability.

Productivity

By introducing automatic mould changing or material changing modules, set-up and change-over times are considerably reduced. It is possible to demonstrate increases of "up time" of 15 to 20 per cent. Moulders are very often very surprised to find out how low the actual utilisation figures are for their plant. Automated plant does not stop for meal breaks or get tired or bored (a not insignificant factor in the moulding industry).

Stock levels

We are convinced that it is a better use of capital to invest it in flexible and automated plant than to tie it up in stock. A major theme at the moment in all of industry is Just in Time production and there has been a large movement towards keeping a minimum or zero stock. To achieve this it is necessary to have a fast response to an incoming order and a guaranteed level of quality; automation offers the only solution.

WHERE TO START?

Automation is not just for the high-tech. companies with large budgets. You do not have to automate the entire factory tomorrow. But, in order to survive in the competitive market place, you do have to automate. Whether the product is coat-hangers or computer housings, only those companies which are investing in automation are going to survive.

Even if the money were available to automate everything in your factory tomorrow it would not be sensible to do so. As with most things there is a 'learning curve'. We recommend that moulders start with production cells or islands. In other words a modular approach. Having established one working production cell, the experience gained by the moulder can be used to formulate criteria for the next automation cell. In this way, as old machinery is replaced with new, so too are old-fashioned production methods replaced with modern flexible automated plant.

The island approach also has the advantage that personnel can understand and accept automation without being overwhelmed by it or seeing it as a threat.

As a corollary to the question 'where to start'?, perhaps we should ask: 'where to stop'? and the answer to this is that we don't: as technology moves on, the moulder must move with it. Automation is not a phase; it is a process of continuous evolution.

THE INTEGRATED CELL

The philosophy of automation should be to regard a production cell as an integrated whole dedicated to the manufacture of product or range of products. It is not an injection moulding machine with ancillaries tacked on.

Moulds and Mould Change

Essential, of course, to the moulding process is the mould. Its temperature regulation, hot runner systems and core-pulling sequences can be fully integrated into the machine control. The settings are stored and fast and efficient mould-changes can be made by means of various levels of automation:

- fast mould clamping
- mould change tables
- mould change vehicle
- complete systems including storage magazines and pre-heating stations

Robots and Handling Devices

Handling devices include simple insert loaders, sprue grabbers and pick-and-place units, all of which may find use in simple automated processes. Industrial robots will be used:

- for removal of more complex parts
- where frequent mould changes are made, when it would be integrated with a gripper change and mould change
- complex positioning, palletising, weighing or sampling
- post-finishing, e.g. printing, sprue removal, drilling etc.

Battenfeld robots are, like the machines, modular in design so that most automation requirements can be met from a standard range of modules in terms of:

- size and stroke (suitable for machines from 10 to 4,000 tonne)
- number of axes
- sequential or simultaneous movements
- speed
- type of drive
- control level

In all cases the setting and control of the robot can be integrated into that of the machine so that a complete set of data for the cell is transferred when a mould change is carried out, thus minimising set-up times.

Material Change

It may be necessary to change not only the mould and robot head, but also the material. This can be done in a number of ways:

- automatic purging
- automatic screw and barrel change
- changing the complete injection unit

The simplest option is the automatic purging. Against the relatively low level of investment must be set the disadvantages of the time taken to purge properly and to accommodate to different temperature profiles for differing materials. Some colour combinations will be more difficult to cope with.

A screw and barrel change is not a new idea, but with the advanced controls available today it is possible to arrange more efficiently, particularly in combination with mould and gripper changes. The advantages are complete security from contamination, speed and the possibility to use screws of widely differing size or geometry on the same machine. It is even possible to change from thermoplastic to thermosetting screw types on the same machine without loss of production time.

A third option is to have two complete injection units side by side which move across during the mould change. This is the fastest solution as the 'new' injection unit can be purged and brought to temperature while the 'old' one is still producing, and then as soon as the second injection unit is producing the first can be purged and switched off or even completely replaced.

Computer Integration

The demands of quality and batch traceability require good information handling capability while at the same time a modern production cell generates more data to be handled. To cope with this, not only does each injection moulding machine have its own quality control page but it is also possible to integrate each cell into a computer system which collects and processes production information and presents it in a usable form. The same computer is used for production planning. In total four software modules are offered:

- CAS computer aided setting
- ODR operation and production data acquisition
- PPS production planning and job preparation
- SPC statistical process control and quality control

CAS is a powerful archive module for storage of machine, robot and peripheral settings from any number of machines. The settings can be transferred between the computer and machine for setting jobs and for automatic mould change sequences, as well as being available as hard copies.

ODR provides an instant overview of the machine shop and indicates the status of each machine or production cell. A bidirectional data network enables communication between every machine and the host computer on a frequent scanning basis. These data are stored in the database for subsequent evaluation.

PPS includes delivery information, capacity checks, order processing, priority listing and comparison of actual and planned progress. Hence it is at any time possible to decide whether orders can be accepted with the capacity available, whether the current production can be reorganised or whether the shift pattern can be changed. Information readily available includes:

- article
- batch size
- set-up times
- capacity data i.e. machine, mould, material, robot, gripper etc.
- location of the above production components
- start times
- projected finishing time

SPC meets the requirements both of quality control and quality documentation. The system is based on the Ford Q-101 quality standard. It is possible to define which process parameters are significant, what the sampling rate should be and how the evaluation should be performed. Graphical representations of process parameters, test certificates and periodic reports are also produced.

Upstream Modules

Automation of the injection moulding machine must be complemented by automation of the processes which come before and after the moulding operation. Material storage, drying and distribution can now be fully integrated into the injection moulding shop so that raw material stock control can be matched to orders, also on the JIT principle.

Insert loading, either by robot or by a non-programmable loading device can also be considered as an upstream operation as can mould cleaning (for thermosets) or foil lamination. Addition of colorants, blowing agents etc. is now also commonly automated.

These measures have a positive effect on quality by ensuring that the additive levels are constant. In addition the hopper can be smaller so that the temperature and moisture content of the raw material are also more constant.

Downstream Modules

Downstream activity starts after the part has left the mould and can be as simple as a pulsed conveyor belt, set by the machine control, or it can include any or all of:

- orientation
- sprue cutting
- drilling
- printing (hot foil or tampon)
- assembly
- labelling
- packaging

Control System

Each of the modules making up the cell can be integrated into the control system. For automated cells this would usually be the UNILOG 4000, UNILOG 8000 or UNILOG 9000 system, all of which are capable of handling a large number of peripheral modules and of communication with the central computer.

All three systems offer closed loop control of all important moulding parameters and their own individual memory and diagnostic functions.

THE FUTURE

This paper gives a necessarily superficial view of the possibilities of automation with modular design but it illustrates the major trends:

- automation
- JIT
- quality control
- traceability
- flexible production
- production cells
- manless production

In which direction will the automated mould shop go now?

A few years ago it seemed impossible that the control systems would run out of capacity, but we find this happening at an even greater rate than expected, hence we are already working on control systems with greater capacity.

Two developments which will become important are in adaptive control and multi-tasking processors. Adaptive control has already started with PVT optimisation of holding pressure and other programs are foreseen, while multi-tasking processors will be essential for handling the volume of information to be evaluated without jamming the system.

It is certain that new materials and processes will continue to make new demands on the machine manufacturer and that manufacturers such as Battenfeld will meet the challenge.

Highest Productivity with Best Quality

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INTRODUCTION

As injection moulding has become fully integrated into large-scale industrial manufacturing, such as in the appliance, automotive industries, and other market segments, the promise for higher productivity has all too often evaporated in production bottlenecks and cost over-runs.

What is productivity?

Is it just a shorter cycle ?

A better definition would be "more good quality parts per hour". However this cannot be achieved just by turning a knob. It requires a systematic approach, to analyse every step of the manufacturing process to identify potential problem areas and create solutions. This of course has to be completed at the beginning of the project with good record keeping, good housekeeping, deep knowledge of materials and good technical preparation. The moulding machine, the material to be used, the ancillary equipment, and the mould all must work together so that the best quality/productivity can be obtained. This highlights the point that productivity does not begin and end at the injection moulding machine. Everyone involved, part and mould designer, material specifier, moulder, and automation robot/pick-up, control, assembly-line employees, contributes directly for obtaining the quality level that productivity requires. But often none of these persons has a global overview of the total manufacturing process and therefore is unable to asses, how their actions affect subsequent steps in the production cycle. The aim of this article is to show by the use of a "case history" how better project co-ordination using a - Total Process Concept- (Global View) can lead to a manufacturing operation with the highest combination of quality/productivity.

CASE HISTORY

An important appliances manufacturer spent a great deal of time and devoted considerable resources to the development of a new complete series of fluorescent lamp holders. It was decided to mould in-house the complete product line, consisting of models of different lengths for either one or two fluorescent tubes. For this production the company decided to build a completely new moulding assembling plant. The latest state-of-the-art equipment, needed for the production and assembly of these parts, was selected.

This plant was conceived with:

- automated materials handling
- dehumidifying dryers
- first class moulds, previously studied by simulation (very long and balanced flows channels) and equipped with high-quality runnerless systems
- several oil and water mould temperature controllers
- latest on the market moulding machine equipped with the most advanced Automatic Process Controls and Statistical Process Control (SPC).
- automatic mould changers with pre-heating for runnerless
- robots for pick-up, positioning and automatic boxing
- in line quality controls

Everything apparently had to be taken into consideration in order to achieve the best productivity. But shortly after start-up, the results, in-terms of moulded quality/ production parts/shift, were not acceptable. First analysis of the poor productivity showed that as soon the moulding cycle was reduced, as it should have been, the reject rate increased.

The high reject rates were identified as being due to distinct defects:

- unacceptable flashing at the middle of the part.
- when the flashing could be almost solved, the parts were often un-filled at the same corner.

How could this have happened after all the resources that had been used in setting-up this new facility?

Simply because the plant had not been conceived with a " Global Process Concept".

Whilst the different areas concerning the moulding operation had been carefully selected and then installed by the relevant specialists from competent equipment manufacturers, there had been a lack of co-ordination by Plastics Technical Experience (Plastics Technologist) with an overview of the complete moulding manufacturing process. Planning ahead, analysing and anticipating possible "Quality" problems, be prepared for solutions in having a global experience of the all process before the final selection as starting to cut steel, choose the moulding machine and the ancillary equipment, that's what productivity is all about . Just installing high-speed sophisticated injection moulding machine equipped with the latest state-of-the-art equipment, will not give the desired results, if, as in this case, an hygroscopic resin is used but not properly dried. Only for this the reject rate may be extremely high. The remainder of this article will examine systematically, those areas which directly contributed to "boosting" productivity. This needed an overview using the "Global Process Concept"

MATERIAL SELECTION

The material, for moulding these fluorescent tube holders, was initially chosen with the help of a very sophisticated software but user-friendly (1a), today in the market. The material was better confirmed by direct discussion with the material supplier's technical service. The material had to withstand the severe working conditions found in this application and conform to the rigorous flammability and electrical properties demanded by the international organization homologating this type of electrical equipment e.g.. Underwriters Laboratories (USA). The material finally selected was a flame retarded and very fluid Polycarbonate The material supplier gave many helpful suggestions on how to mould this special Polycarbonate particularly sensitive to:

- the Hold Up Time on the barrel of the injection moulding machine mainly because of the flame retardant additive.
- moisture

These special characteristics of the material are strictly related to two main types of resin degradation:

- Thermal
- Hydrolytic.

- Thermal degradation results from either using normal moulding temperatures over a long time or from excessively high temperatures for a short time. This can result from a non-optimum compromise between shot weight/shot capacity/cycle that gives that well known parameter the Hold Up Time (HUT). To take account of this, the material supplier recommended the use of a smaller injection unit than the standard one that would normally fit in this Moulding Machine. This special set-up assumed that the injection unit and or the runnerless mould did not present any hold up spots where small amount of material may be trapped for long periods and slowly undergo thermal degradations. This partial thermal degradation gives rise to moulded parts defects like: brown streaks, black spots, nozzles drooling, splays, flash, etc..
- Hydrolytic degradation is caused by high moisture levels in the resin, which at the melt temperature results in a breaking of the polymer chains. This reduction of the polymer molecular weight leads to brittleness and increased melt flow giving possibly un-expected flash and dimensional variation from shot to shot. These two common types of degradation will be discussed and reviewed in the subsequent section of this article.

MATERIAL HANDLING

Trials were initially made with a dehumidifying dryer/hopper, of a limited capacity, that was automatically pumping pellets from a completely open one ton container. The container was kept open in such a way that the pellets could not only be contaminated by all possible flying air/dust and create contamination (transparent cover for the tubes) but also and more important the pellets were widely absorbing the air moisture. This would have meant increased drying times, but the dryer was already of limited capacity for standard drying time. Not to forget that drying is an energy-intensive operation.

Adequate precautions have to be taken in the initial moulding trials, especially where the "prototypes" are being used to demonstrate to the market, the quality and performances of the new product.

Material handling should be a well planned, in advance, as the rest of the Global manufacturing cycle, not just to eliminate or improve a last minute problem, on any particular area. This material, transparent Polycarbonate, is very sensitive to moisture, contamination, constant viscosity etc., and as such it requires a sealed automated handling system from a properly closed container to the moulding machine hopper. This system that would unload, store in a special moisture proof silo, feed a right capacity dehumidifier dryer and from there to a moisture proof small hopper of the moulding machine is now in function at the moulding plant. The system is equipped with sophisticated controls to measure moisture, dew-points, air flow, feed rate and keep track of resin inventory. This advanced manufacturers (2), may even combine the entire Material Handling System with a tailored Data Management Information System to keep track of material and energy consumption, drying and maintenance conditions etc.

MOULD DESIGN

During the initial moulding trials a question was asked about the mould temperature and the answer was: 90°C as recommended by the material supplier. But when checked, using a touch pyrometer, along the all length of the cavity a difference of greater than 15°C was found between the centre and the extremities of the cavity.

This could have accounted for the part being unfilled in one corner.

It is well know that the mould design has a direct influence to boost those two important criterions "Quality and Productivity". The tool maker and the runnerless manufacturer (3 & 3a) invested considerable resources and used their collective experience in order to avoid or get minimum re-cutting and refitting. The moulds for the different tubes holder lengths had to be studied for automatic mounting, clamping on the machine platen together with a pre-heating of the runnerless.

This simulation software (1) one of the most advanced has a unique possibilities for complete moulding and tooling studies, has been thoroughly used. The flow analysis (1b) has been extensively used for designing the runnerless channels size and layout; the number, dimensions and location of the gates (direct sub-nozzles with and without shut-off). The tool designers (3) spent a considerable amount of their time with simulation experts, not only for flow analysis (1b), but also for designing the mould conditioning temperature channel system (1c). Together with the channels another important study, for getting a more uniform cavity temperature, revealed that the very thin long and high blades, forming the all contour of the holder, would have given better results when made in CuBe. But even more in sectors in such a way that each of them were separately water cooled for obtaining the most flexible, efficient and rapid heat exchange. For fulfilling this latter thermal exchange tasks, they used a special software (1c) designed for this particular purpose.

Based on the very efficient channels layout of the "cavities" it was then possible ,by re-arranging few pipe connections, to obtain a uniform temperature of about 90 ±2°C on both cavities and, very important, over the total length . This more uniform cavity temperature has been a decisive factor in getting easier filling, shorter cycles, better flatness and a more uniform surface aspect (transparency).

INJECTION MOULDING PRODUCTION

For the moulding of this thermal sensitive grade of Polycarbonate, both the material supplier and the flow simulation (1a) studies had recommended the use of the following two key moulding parameters:

- short Hold Up Time
- very high injection speed

In order to fulfil these two parameters with the large platen required because of the part size, the machine manufacturer (4) had to study a very special injection unit. This unit had to be much smaller than the minimum size normally used for a machine with this clamp. The best choice for reaching the best compromise of polymer residence time and fast injection speed required the use of a specially made 105mm dia. screw .

Not to forget that the smallest standard screw for this machine is a 135mm dia. This machine manufacturer (4) people had few meetings with the end-user-moulder, material supplier, tool maker, runnerless designer, software people, for determining the characteristics of the machine, for tool fixing, robot etc..

The screw was specially designed for Polycarbonate as the hydraulic pumps with maximum power for reaching the requested injection speed. The moulding machine (4) was also equipped with the latest microproccessing features, of which few are unique from this builder like PVT, Logifeed, along with the robot with motor in each axis for faster and more flexible palletisation.

To "avoid flashing and /or to completely fill the parts", a considerable amount of the moulding technicians time was spent in trying to find the best switching-time speed-pressure. A very important point, which they had forgotten, was that the profile temperature and the stroke had been calculated and set-up based on the use of the larger barrel of 13mm and not for the specially made one of 105mm. The micro-processor could not have known about this very instrumental change. Did they ever check whether the material was properly dry (viscosity?) Did they ever investigated whether the mould was not only at the required mould temperature but very important uniformly heated?

AUTOMATION

In virtually every injection moulding operation, many opportunities exist to increase productivity via better "Quality" obtained by more dedicated labour and automated equipment. It is well known that automation can lead to higher labour productivity levels provided it is first carefully planned and implemented as part of the global engineering production process.

In this particular case, a much longer time was needed for getting the parts automatically palletised because the tuning of the robot with the moulding machine became very difficult in not being able to obtain shot after shot acceptable parts for extraction and pick-up procedures.

Automation can improve "Quality-Productivity" but it is not the only way. Outside automation may start only when the moulding operation is systematically giving a 100% of good "Quality" parts.

OPTIMIZING "QUALITY AND PRODUCTIVITY"

After having discussed and gathered the pertinent and necessary informations from the above mentioned areas in the moulding manufacturing process, with each area's responsible and having in the mean time analysed the problem, it has been possible to decide the following steps:

Main considerations

- Problem - "Part have flashing or/and get unfilled"
- Every step from the Material Selection to the assembled parts are equally important.

Material Handling

- Keep closed the big container (was open to the air and dust)
- Let some material drying properly for trials (Small dryer, longer time)
- Select a machine/hopper that contains no more than one shot of material.
- Assure that material is pulled into the hopper with dried air

Mould

- Once the operation had reach the equilibrium of the moulding conditions the cavity temperature had been checked and the cooling lay-out re-arranged together with few oil instead of water controllers all, for a uniform cavity temperature. Measured temperatures on surface cavity with a touch pyrometer were 88°C ± 2°C.
- Suggested to regularly control, during production, in the same way. In case some fluid channels would block.

Runnerless

- Once in production slowly decreased one by one each temperature controller in order to avoid any over heated spot.
- Cooling around the gate was also finely tuned.

Machine

- Entered the correct temperature profile as a function of the true hold-up-time. This had been completely changed from actual increasing (from the hopper) to a decreasing profile.
  Microprocessor gave 52X as reading stroke, but it was still reading the 135mm setup, when the effective stroke of the 105mm. screw dia. was effectively of 82X (Calculated). It was reminded to the operators that the temperature profile of the barrel is a direct function of the stroke.
- The water circuit into the hopper throat had to be a little modified for improving the conditioning effect on the temperature of this area while in production.
- Once the machine reached the moulding conditions equilibrium the melt temperature was checked and at the same time discussed and demonstrated to the operators how and when they regularly had to check it with a pre-heated needle pyrometer. This measurement found the need to increase the new temperature profile of 5°C.
- The adapter and nozzle (kept constantly against the mould) temperatures were also properly adapted to the cycle.

These changes resulted in a more "uniform melt" through the complete shot with the effect of an easier flow at the same suggested melt temperature of 290 °C. The parts after several shots started to consistently be very good and total cycle could then be reduced

CONCLUSIONS

How could it happen that after more than one week's production, there was still an unacceptably high reject rate after all the investment made in such a modern and up-dated moulding operation? For sure the end-user/moulder had invested for this facility the best equipment available on the market but at the production start-up the various representative of each area like, dryer, mould, runnerless, moulding machine, material and why not the operator, they were all separately checking to ensure that their equipment functioned properly! This had been done without considering the impact that each other step and condition, from a different area, would have had on the final product. They did not had the "total finest tuning" experience approach for a global productivity process as for this injection moulding operation.

COMPANIES THAT PARTICIPATED TO THIS SUCCESSFUL PRODUCTION:

1) Software for CAE: Plastic and Computer - Milano, Italy
   a. MS package for Material Selection
   b. faBest soft for finite element flow analysis and cooling
   c. MTA program for Mould Thermal Analysis
2) Material handling systems: PIOVAN Srl - Venezia,Italy a. Automatic dryer
3) Tool design/maker BVA Srl of Annovi, Quarto Inferiore BO, I. a. Runnerless type Comat-DME studied by CM-Calderara BO, I.
4) Moulding machine: Sandretto Industrie Srl - Torino Italy

"HIGHEST PRODUCTIVITY WITH BEST QUALITY BY GLOBAL DESIGN"

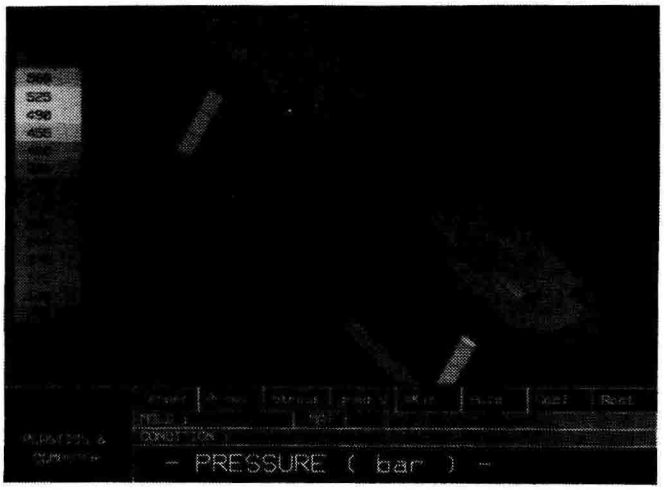

Photo 1

On this photo it is possible to see a partial study of the flow analysis simulation with the faBest, from P&C, of only the half of the runnerless and cavity. The pressure drop clearly shows the weld line area and also that the extreme corners of the cavity are the last to be filled. This simulation is taking in consideration the same uniform temperature through the all cavity.

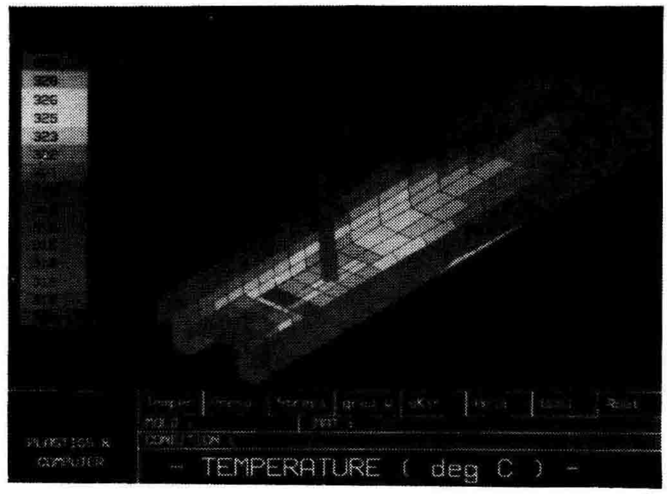

Photo 3

In this simulation it is visible that the hottest melt easily flow toward the centre gates of the cavity. Easy flashing?

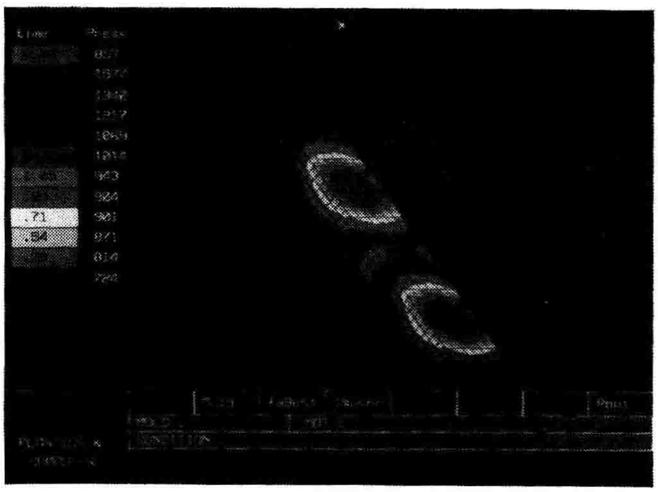

Photo 2

This one shows the requested filling times/pressures requested for filling the cavity in a two cavity runnerless (Incoe system) mould. Only half of one cavity of the mould is here simulated.

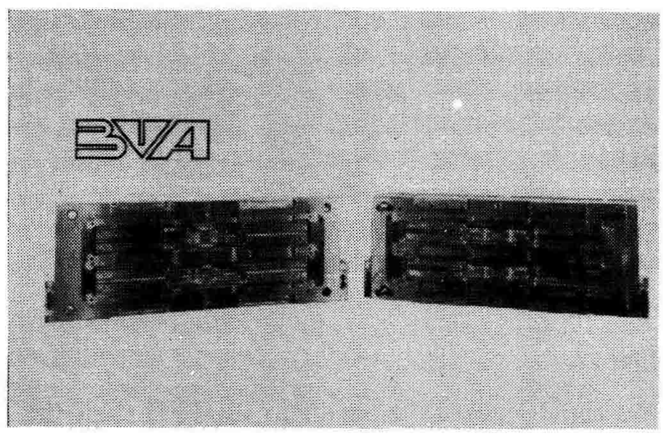

Photo 4

This view of an open mould clearly show the Copper-Beryllium (Cu-Be) block-inserts that create the all contour with a thin blade. These are of paramount importance for flatness at very short cycles.

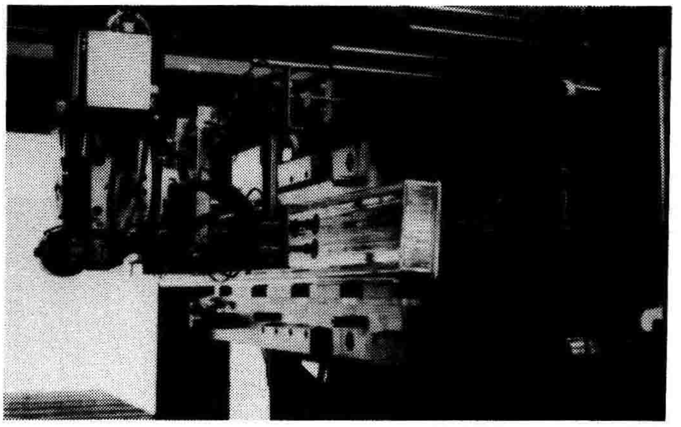

Photo 5

The double head of the robot is visible while picking-out in one cavity mould a transparent cover of the lamp-holder. Another visible detail are the quantity of hoses necessary for a very flexible and effective cavity temperature control.

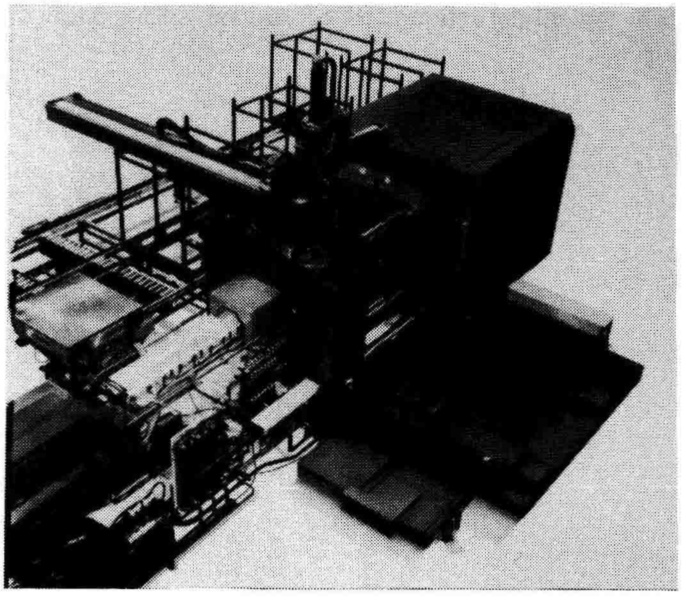

Photo 6

This aerial view of the Sandretto 1800 LH show the mould charger and the automatic robot-palletiser system installed for this special production and already pre-set for all moulds for the complete series of lamp-holders.

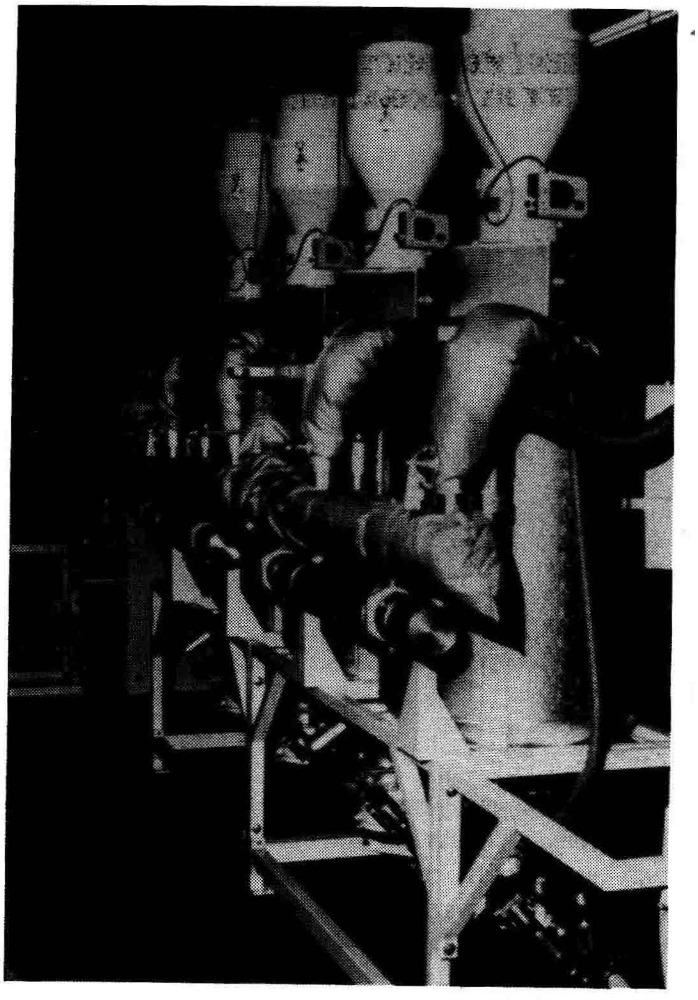

Photo 7

The complete automatic material handling and drying equipment, from Piovan, is here installed for the all plant (15 moulding machines). All the operations are pre-set from a central microprocessor that is connected with the molding machine, the mould changer and robot-palletiser. Soon, the cavity temperature cabinets will also be connected via cavity/thermocouples to the same central computer.

No Man Operation and the Reduction of Man Power

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INTRODUCTION

The development of the 'F' series machines was prompted by the following thoughts on the future of machine control:

1. The procedure of starting up or operating injection moulding machines, can it be done by man? Does it have to be done by man? Or can it be done by machine, and its controller?
2. Can the machine recognise faults, and take the necessary action?
   Is the machine capable of changing the mould, and starting up production with minimum supervision?
3. Can you have security of mind that once the above has happened, it will operate without supervision?
4. Is it safe?

If the answer to the above questions is 'YES', then we have a basis for No Man Operation.

THE 'NO MAN PACKAGE'

The first element in reducing manpower costs is to enable any task to be undertaken by anyone in the plant.

It is not always essential to employ skilled persons to do observation tasks. For example when the machine is set up in the automatic heat up mode, there has got to be clarification that the material has reached working temperature. This is done by:

1. 'Screw Cold Start Prevent'

We have to ensure that the machine cannot be started up below set and confirmed resin temperature. This is to prevent damage to screw head and check ring.

2. Hydraulic Oil Warm-Up Device

To increase oil temperature up to 40°C and to obtain stable temperature, but do this function by loading/unloading the pumps, not by oil heaters which causes localised burning of the oil, destroying its lubricating properties.

Although these are minor tasks, and don't require a skilled person, without this procedure we cannot expect easy start-up.

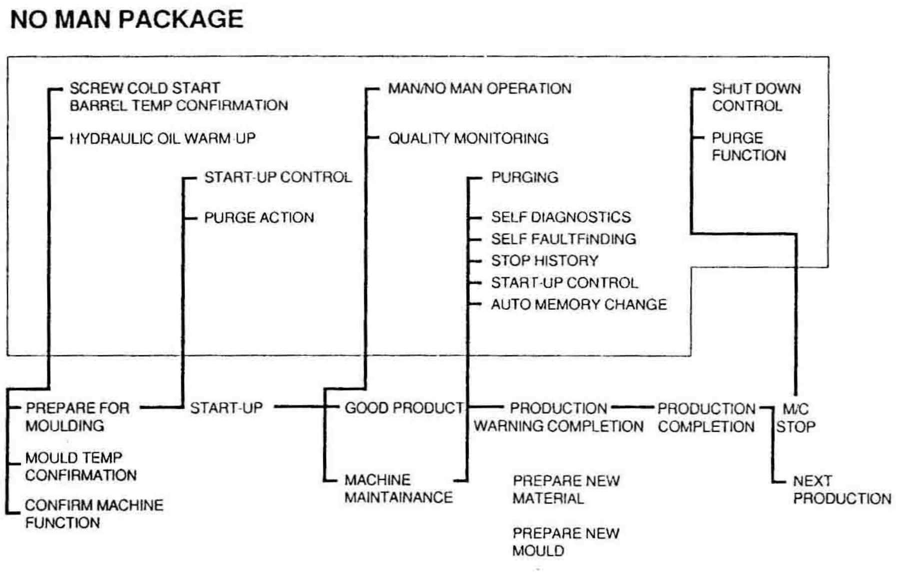

Figure 1