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THE FLEXIBLE ROBOTIZATION OF THE PRESS LINE AT THE CAR FACTORY USING THE INDUSTRIAL CONTROLLER

The basic problems of press lines robotization on the example of the factory are presented and the main solutions are shown.

Because of comparatively low level of automation of the press forming technology, the problem of press line automation becomes presently important.

The problems of vibrations at the press forming shop and its influence for robots, requirements of flexibility, output and performance as well as the control system tasks are described.

The presented solutions are taken for the medium press line 300 T in the car factory FSM–Tychy, Poland.

The paper has been prepared in April 1990.

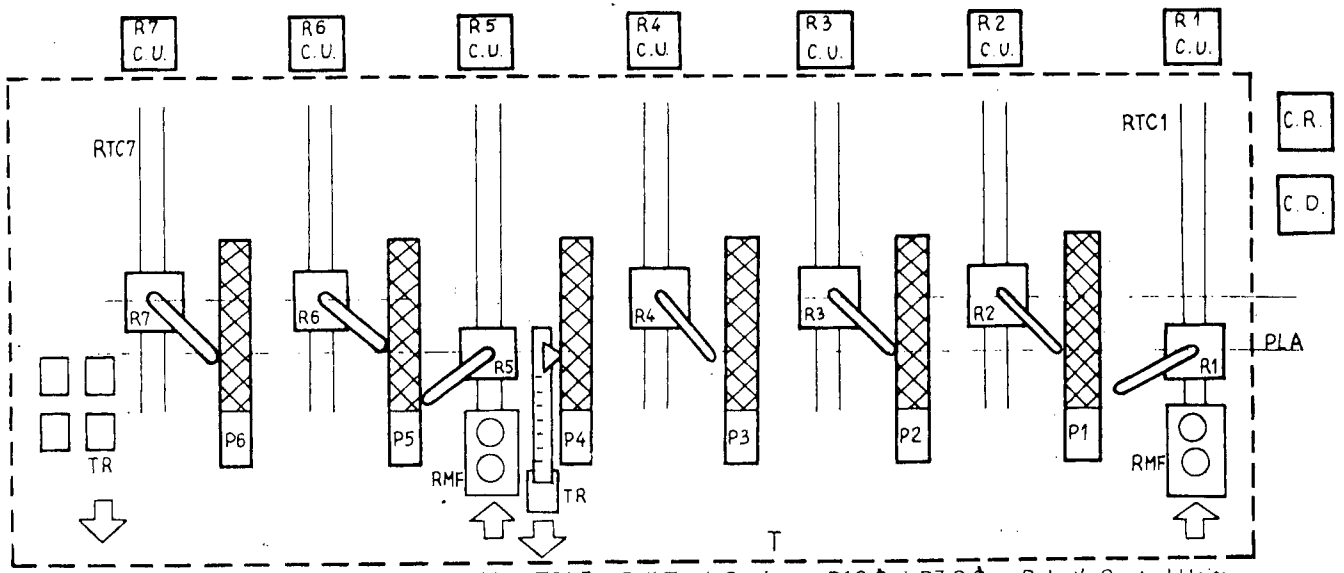
1. Introduction

In the car industry the robotization of spot welding of car bodies and other car parts is used from a long time.

As for the press forming technology, the level of automation in this technology is presently much lower and therefore the automation of this technology is very actual.

Automation in the press forming technology is necessary due to the hard and hazardous work and in order to increase and stabilize the production quality.

Presently there are known some solutions of press line robotization. One of the solution bases on the use of the specialized, quick, electrically



P1 ÷ P6 – Presses; R1 ÷ R7 – Robots – IRb–60; RTC1,7 – Rail Track Carriages; R1C.C. ÷ R7.C.C. – Robot's Control Unit; C.D. – Control Desk; C.R. – Controller Room: Display, Key–Board, Printer; PLA – Press Line Axis; RMF – Rotary Magazine–Feeder; TR – Tray; T – Truss.

Fig. 1 Press Line Schematic Diagram.

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driven, cartesian coordinates, robots, placed on traverses between the presses, above the level of press tools. The main movement of these robots is linear one, along the axis of the press line.

Such automation developped by Mecfond, Italy works now at the heavy press line in FSM–Tychy car factory, which produces the cars under the licence to the Fiat.

The another solution bases on the use of universal robots positioned on the level of the press base and on the press line axis. It is known also in such solution the use of the special, additional and quick rotation of the whole robots.

Such automation proposes the Comau of Italy, which is the producer of the robots for car industry and in that for press forming.

The additional, quick rotating drive of the robots is introduced in order to meet the requirement of the press line output.

Generally, the special solutions are necesarry when the use of the robots with the main rotation speed of the order of 90^{o} per sec. is planned.

The factory FSM–Tychy introduces automation and robotization of production in the different technologies and in that in the press forming technology.

The factory press forming department consists of some medium press lines with the presses of 300 T capacity and also the heavy press lines with the pressure capacity up to 1000 T.

The medium press lines consists of 6 and 10 presses and are served directly by 6 and 10 workers.

The heavy presses are served by four workers per press due to the dimensions of drawpieces.

There are then being introduced the different variants of robotization of press lines in the FSM car factory.

The project of medium press line robotization, is being performed by Industrial Institute of Automation and Measurements, MERA–PIAP, Warsaw, with the cooperation of the factory staff. The project has been included into and is financed by the Governmental R & D Programme „Industrial Robots". Some support for project is granted by UNIDO, which founded the short bilateral project for that purpose.

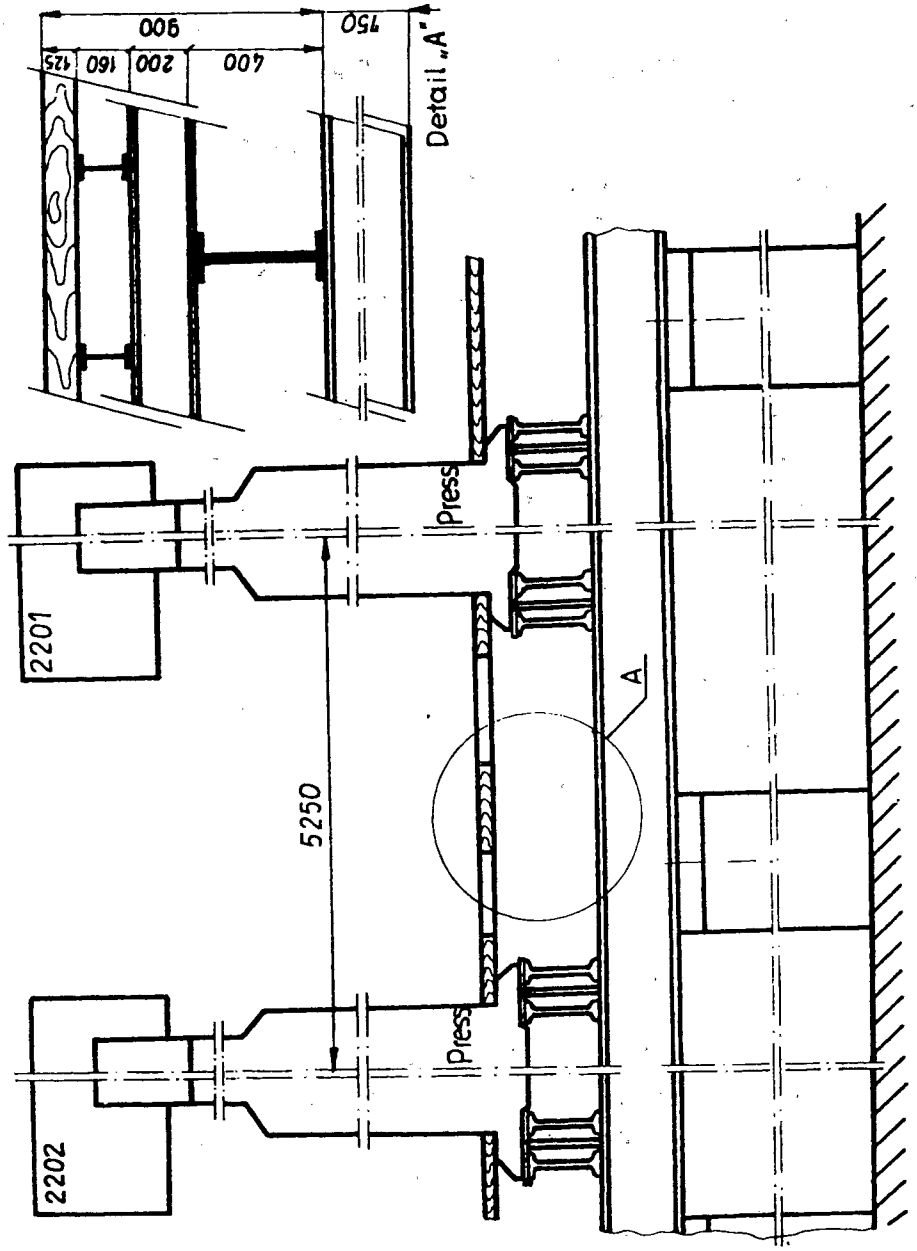

Fig. 2 The truss

2. Description of medium press line 300 T

The press line is equipped with:

- 6 crank presses, type E2–300 with pressure 300 T,
- drawpieces transporters,
- shutes,
- rack shedders,
- palletes for drawpieces.

The lay–out of the press–line – see Fig. 1.

The presses foundation on the truss and truss structure is shown on Fig. 2.

The press line produces mainly the brake disks, oil sumps and the bottom side parts of seats.

The shape of drawpieces is shown on Fig. 3.

3. The main requirements for press line automation

The robotized line has to meet the following main requirements:

- instantaneous output – min. 8 pcs/min,
- flexibility – production of 1 ÷ 3 different drawpieces at same time,
- the time of changing the production (beside the press tools) – max. 1 hour,
- robots availability – min. 0.82,
- working staff – max. 2 persons,
- positioning accuracy in x, y, z axis – max. ± 1 mm,
- control system:
  - easy reprogrammable,
  - providing flexibility and diagnostics,
  - counting the output per shift, day, mounth,
  - calculating the performance.
- during the changing of the press tools, the robots have to be retracted from working area of press line – into the parking positions.

Because of the requirements and the fact, that presses are founded on the truss, which conducts the vibration to the robot manipulators, it was

decided to built the test cell to examine the vibrations and other problems.

The test cell had to allow checking of:

- the robots shock–resistance,
- the positioning accuracy in the vibrations presence,
- the attainable output.

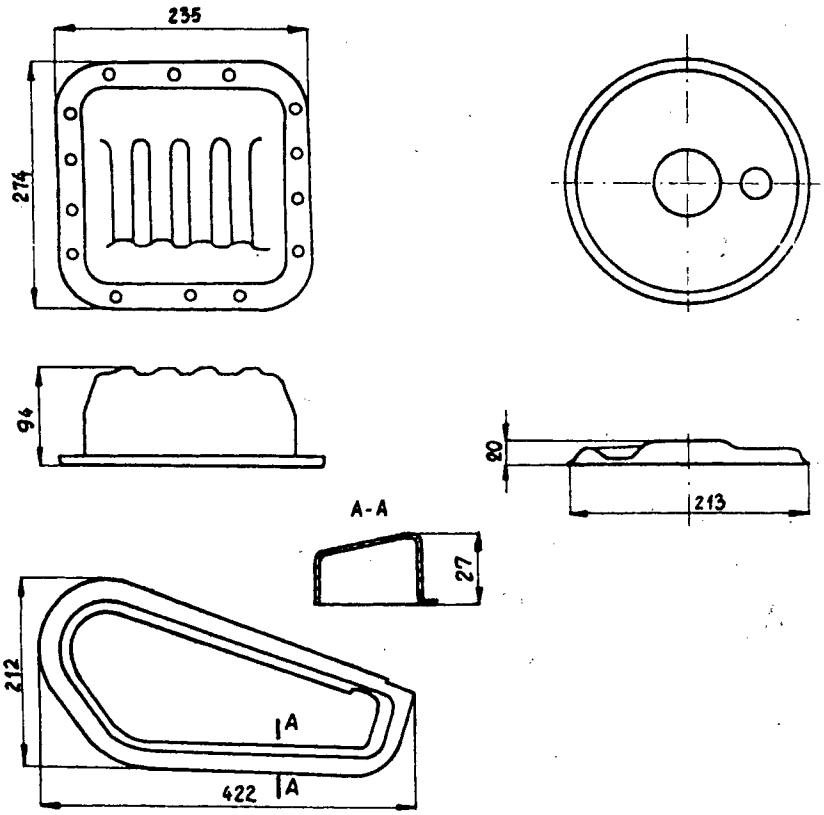

Fig. 3 Drawpieces

4. The investigations in the test cell

The test cell consisted of:

- 2 presses, first and second in the line,

- input module with the magazine–feeder of blanks and IRb–6 robot,
- robot IRb–60, between the presses,
- the rack shedder and shute on the press 2,
- safety barriers,
- control desk.

The robots were putted on the driven rail–tracks on the rubber cushion. The lay–out of the test cell is shown on Fig. 4. The robots IRb are produced by MERA–PIAP.

The robots assigned to test cell were equipment with the shakeproof lock–washers.

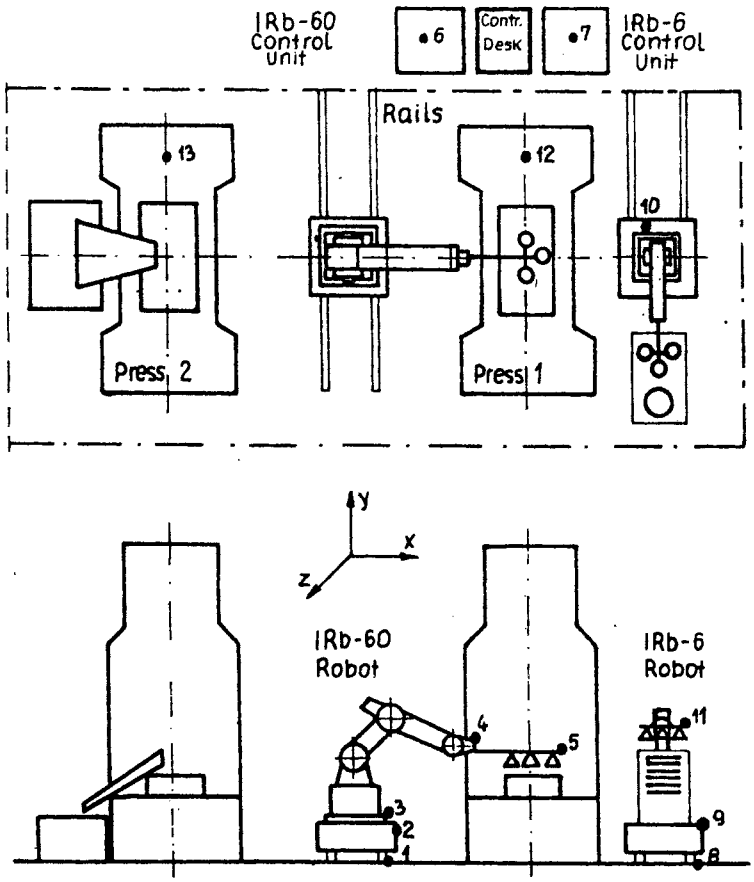

Fig. 4 Test Cell

The vibrations in the test cell were measured in the 13 points in x, y, z axis as it is shown also on Fig. 4.

There were measured during the press work: the vibration frequency, effective acceleration and displacement values and acceleration amplitude values.

The maximum acceleration amplitude value is for press No 2 – 6.8 g and for press No 1 – 2.5 g. On the next presses these values are lower.

The vibrations are efficiently damped by the basement and under robots rubber cushion and are equal correspondingly on the robots: 0.7 and 0.12 g.

The measurements proved that the vibration acceleration did not exceed the values permissible for IRb robots.

The displacements of the vacuum cap–litter gripper ends being 0.05 mm for IRb–60 and 0.04 mm for IRb–6, are for an order less than the requirements for positioning repeatability of these robots.

The vibrations didn't have the negative influence for the correctness positioning accuracy of robots.

The control units of robots were positioned outside of the truss, on the steady basement. The operation of test cell proved also the satisfactory stability and production reliability of robots under the vibration conditions.

At the beginning of the test cell operation the output was attained equal to 4 pieces per minut, that is much less than required.

In order to increase the output, there were made the investigations in three steps, see Fig. 5:

- Optimization of the robots user work programmes. For decreasing the press serving time by robots, there were also made some changes in the presses. As the examples the next changes may by cited:
  - taking away some bars, which strongly complicated the robots trajectory,
  - equilizing the level of the tools in the both presses.

  After that the output of 6 pcs/min was attained.
- Increasing of the maximal speed of robots. The control program of the robots was chanped so, that the desired positions delivery speed for the

servos was increased for the maksimum. Also the power suppliers of the servos were forced. All this was made after the calculation and practical analysis of the static and dynamic load of robots. Analysis proved that forcing the servos was permissible comparising the results of the analysis against the constraints given by robots design. These changes enabled to increase of the maximum speed of robots: IRb–6 by 15% and IRb–60 by 10%. The resulting output of 6.6 pcs/min was attained.

- Decreasing of the angle of the main rotating drive of robot was performed.

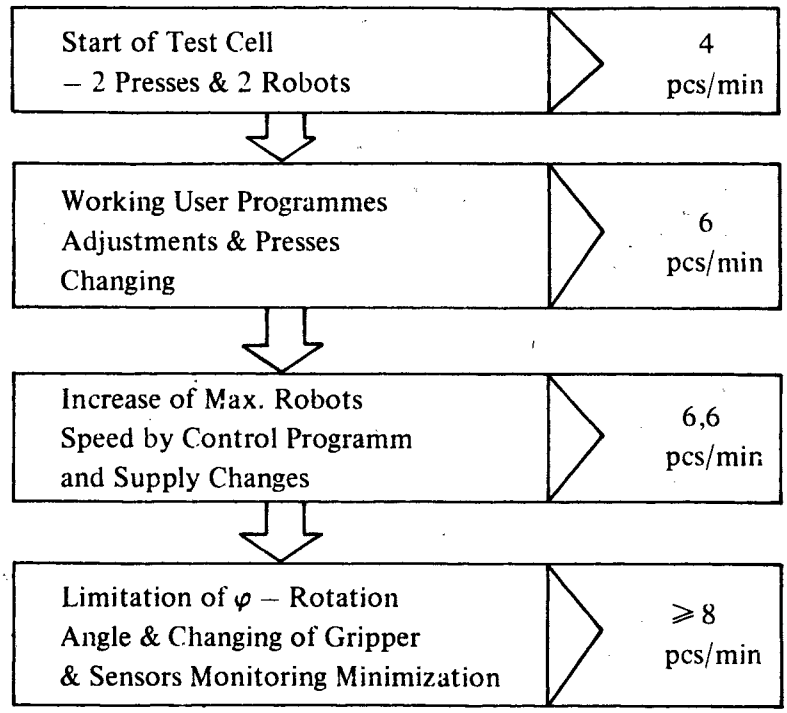

Fig. 5. The Instantaneous output

The limitation of this angle was achieved by retracting the robot IRb–60 manipulator from the press line axis and using the gripper equipped with the pneumatic cylinder and rotating motor. The solution is shown on Fig. 6.

The limitation of the robot rotation angle from 180^{o} to 130^{o} was

introduced. Also the limitation of sensors manitoring by robots was introduced as a factor of robot serving time consumption.

As a result, the instantaneous output higher than 8 pcs/min has been achieved.

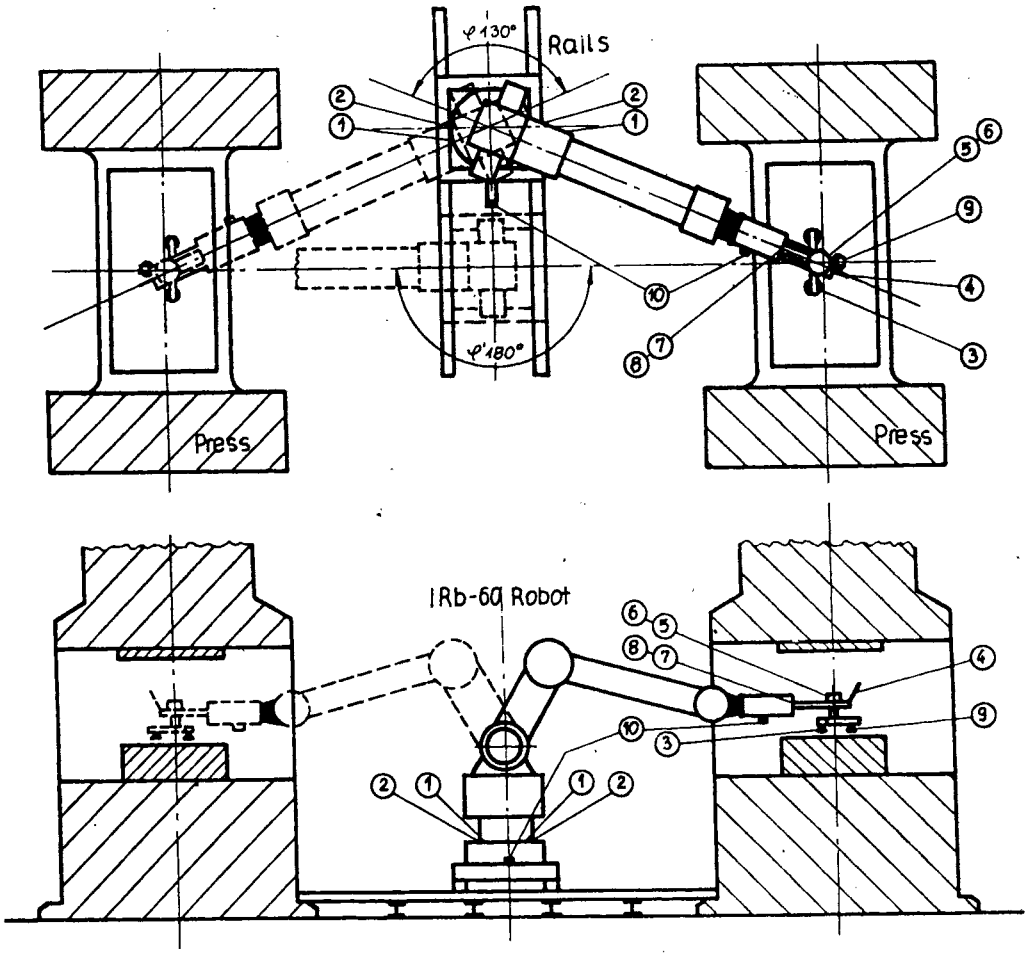

Fig. 6 Gripper Solution & Sensors. 1. Anti–Colision Sensor ($\varphi \leqslant 130^{o}$); 2. Anti–Colision Sensor ($\varphi \leqslant 180^{o}$); 3. Vacuum Caplifter Anti–Colision Sensor; 4. Gripper Anti–Colision Sensor; 5. Turn–Right Gripper Sensor; 6. Turn–Left Gripper Sensor; 7. Cylinder–Out Gripper Sensor; 8. Cylinder–in Gripper Sensor; 9. Drawpiece Presence Sensor; 10. Master–Position Sensor.

5. The equipment and lay–out of the line

The equipment for robotization of the medium press line 300 T is as on already shown Fig. 1.

- The IRb–60 robots control units, the industrial host controller with display, key–board and printer and the control desk consisting of only the push–buttons and lights, are positioned out of vibrating truss.
- The robot manipulators are retracted from the press line axis in order to provide the required output by limiting the angle of main rotation. Only the press line input robots are positioned in the press line axis as the ones which do not limit the working cycle. All the manipulators are positioned on the rail–tracks with use of the rubber cushion. Rail tracks enable the quick change of tools on the press line by quick moving the robots out of working area to the parking position.
- The flexibility of the line is provided by the additional material inputs and outputs as shown on Fig. 1, between the presses 4 and 5.
  One type of draw piece is moved out by transporter and the blanks for another type is taken by the robot No 5 from the magazine–feeder.

6. The controller tasks

The chosen controller – Simatic 155–U of Siemens, provides:

- the coordination of presses–robots cooperation, including the press starting and the robot movement clearance,
- the diagnostics of the line with emergency stopping of the presses and robots as well as the host controle of the testing programmes of the robots,
- the technological data processing and in it mainly: supervision of the instantaneous output, counting the output per different time–periods and calculating the performance.

The main tasks of controller are shown on Fig. 7.

Because of automatic mode of line work and restricted visibility, the controller has also to provide the visualization of the line work.

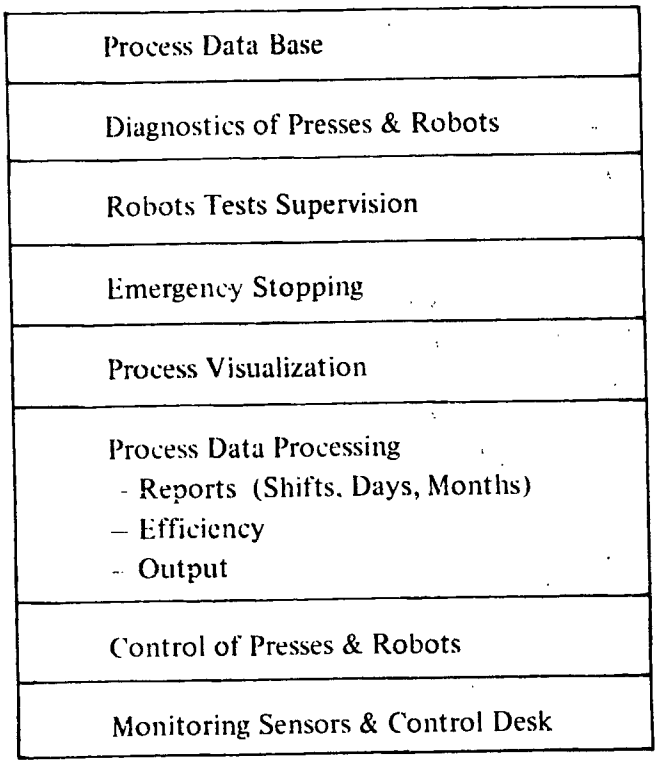

Fig. 7 Controller Tasks

All these tasks the controller does considering the production flexibility of the line.

It is necessary to put on the press line with such requirements the controller with rather big capacities.

The factory is planning in the future, after the some press lines automation, the introduction of the higher level of automation with the data processing and production planning for the press forming department.

In such case it is advisable to have the technological data base in this higher level equipment.

Due to the necessity of providing the required output and the diagnostics, the sensors of drawpiece presence are monitored by controller.

7. The constitution of robots programmes

The user programmes of the robots consist of the 3 main parts:

- the tests of robot, robot input/output and cooperation with controller,
- the service tests – specific programmes enabling finding the failure during service work,
- the user working programme built identically for every robot, with the differences between robots only in positioning points.

The composition of robots user programmes is shown on Fig. 8.

A. Testing Programmes
1. Robot/Controller I/O/ Exchange
2. Gripper Test
3. Manipulator Master Position Test
4. Test of Working Programme & Drawpiece Number
5. Test of Vacuum Caplifters & Drawpiece Presence
6. Press Tool Position Test
B. Service Programmes
C. Working User Programme

Fig. 8 Robots Programmes

The necessity to equippe the robots with different types of sensors is caused by small room inside and nearby the presses and due to the

requirement of the very quick movement between the presses. The sensorics should protect the robots against the hard possibly collisions caused during programming and work.

8. The automatization state and other proposals

Now there is going -on the final stage of setting–up of the equipment on the medium press line 300 T. The starting–up is planned for october this year.

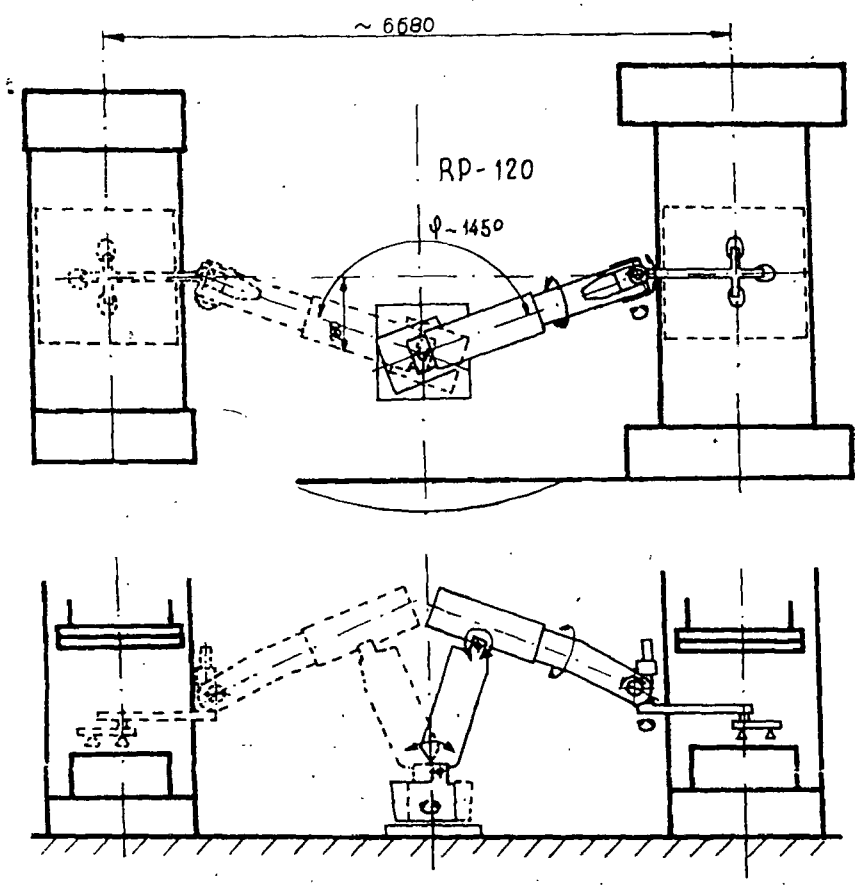

Fig. 9 The RP–120 and heavy presses

Independently of robotization of the first medium press line with the IRb–60 robots and possibly the robotization of the next lines, there are plans of use the new designed at MERA–PIAP the heavy, 120 load capacity robots RP–120 with the big radius approx. 3 m. This robot, having 6 axes, enables to robotize the heavy press lines without prolonging it's arm and without putting the rotation into the gripper. It is also possible to position this robot out of press line axis in order to decrease the necessary angle of main rotation.
The Fig. 9 shows approximatively the kinematics of this robot and rotation radius in comparison with the heavy press distance.

9. Conclusions

- The vibrations of the truss, on which the robots manipulators are positioned do not jeopardize the robots operation.
- The most difficult requirement to meet for robots application in the press forming technology, especially lines, is the line output requirement.
- In order to meet this requirement it is necessary to use the specific solutions in the line technological equipment.
- Robotizing the press lines it is necessary to provide the robots manipulators with different type of sensors in order to enable the preliminary tests and proper movement control, diagnostics and emergencies.
- The accomplished robotization of the 6 press line is a good base for the next works to achieve the realization of the fully automatic flexible line with the fully robotized inputs and outputs.

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