THE REINDUSTRIALISATION OF ROMANIA IN THE AREA OF EQUIPMENT FOR METAL FORMING, AN ACTION SOLVABLE ALSO THROUGH PREVIOUS ACHIEVEMENTS

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ABSTRACT: The current paper aims at presenting some of the older achievement of the Romanian industry in the domain of metal forming equipment.The Romanian equipment for metal forming produced at the beginning of the seventh decade of the past century incorporated, from the point of view of the technical level, all previous discoveries and achievements from the areas of materials and the electrical, hydraulic and pneumatic actuations and had an adequate design. Most of these equipments were made for universal usage. Then, during the following years, the equipments were endowed with numerical control actuation systems that replaced the electro-mechanical actuations, with pneumatic couplings and brakes, while the displaying of the variable parameters, displacements, forces, pressures continued to be realised with classical rigid systems. During the next decade, the spectacular achievements at world level in the domains of electronics, computer science, data processing were also applied to metal forming equipment. Important steps were taken in the area of manufacturing robots for operating these equipments so that a new generation of metal forming machines with numerical control (NC) or computerised numerical control (CNC) were developed, machines that could be programmed to work on their own, to load blanks and to evacuate the finished parts. At the beginning of the ninth decade, at world level and then also in Romania, there appeared a new concept in constructing the metal forming equipments, with introducing the flexible manufacturing cell and of the flexible manufacturing line, programmable and computer-controlled, as first steps towards flexible plants without human operators.Nowadays, the equipments manufactured in Romania a few decades ago can be found in production spaces, still in use, proving that their manufacturing could be resumed and the reindustrialisation started.

1. INTRODUCTION

The past development of the industry in Romania required the creation, in advance, of a sector dedicated to producing metal forming equipment at a higher rate than that of the sector dedicated to cutting machine tools. The old factories for producing metal forming equipment were modernized and extended and there were also created new units. In order to provide the technical documentation needed for producing new equipment, in 1979 there was founded the Sibiu branch of the Research and Design Institute for Aggregate Machine Tools – Titan Bucharest and later on similar branches in Târgu Jiu, Suceava and Braşov. There were also carried out researches on the design of metal forming equipment also by teams of specialists from the higher education and the specialized factories from Romania.

The Romanian equipment for metal forming produced at the beginning of the seventh decade of the past century incorporated, from the point of view of the technical level, all previous discoveries and achievements from the areas of materials and the electrical, hydraulic and pneumatic actuations and had an adequate design.

Then, during the following years, the equipments were endowed with numerical control actuation systems that replaced the electro-mechanical actuations (for sheet bending presses, frame shears, pipe bending machines, machines for thread rolling etc.), pneumatic couplings and brakes, while the displaying of the variable parameters, displacements, forces, pressures continued to be realized with classical rigid systems (manometers, material limiters, mechanical rotation counters etc.). Also, several specialized components for whose manufacturing in Romania there were no adequate conditions had to be imported at first. Later on, however, several of these specialized components (electronic and hydro-pneumatic systems, systems for measuring and recording, sealing rings etc.) were assimilated in the Romanian production, so that it was possible to produce any type of metal formning equipment without imports.

During the next decade, achievements at world level in the domains of electronics, computer science, data processing were also applied to metal

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forming equipment. Important steps were taken in the area of manufacturing robots for operating these equipments so that a new generation of metal forming machines with numerical control (NC) or computerized numerical control (CNC) were developed, machines that could be programmed to work on their own, to load blanks and to evacuate the finished parts.

An outstanding achievement was the application of high pressures (over 500 bar) in the construction of hydraulic presses. Thus there were obtained materials and systems capable of withstanding and working at pressures of 1000 … 4000 bar. These, combined with the realising of chassis for presse with precompressed frames with coils of high strength steel wires made it possible to realise small size hydraulic presses that were however able to develop large forces. At the beginning of the ninth decade, at world level and then also in Romania, there appeared a new concept in constructing the metal forming equipments, with introducing the flexible manufacturing cell and of the flexible manufacturing line, programmable and computer-controlled, as first steps towards flexible plants without human operators.

In the following, there are presented some of the most representative Romanian achievements in the area of metal forming equipments.

2. HYDRAULIC SHEET METAL SHEARS FHT 830 CNC

The hydraulic sheet metal shears (for sheets of up to 12 mm thickness and up to 4000 mm length) with computerised numerical control (CNC) FHT 830 is used for the automated cutting of thick sheets (made of steel or nonferrous metals) following a cutting plan. The feeding with individual sheet-type blanks is made piece by piece using a crane, after which the computerised system is initiated and everything is done in mechanised system, according to the cutting plan (movement to the designated coordinates, cutting, retraction, rotation by 90^0 in horizontal plane etc.). The cut stripes are placed on a carried where they are sorted manually.

The actual shearing device is a normal hydraulic shear for which the blank limiting device from behind the cutter was eliminated and replaced with a blank positioning system in front of the cutter and the stripe evacuation system behind the cutter. The angle between cutters can be varied on the vertical axis using the CNC system. The main technical characteristics of the family that includes this shearing equipment are presented in table 1. This equipment was manufactured at the "Mecanica" plant of Sibiu.

Table 1

Parameters	Unit	Machine type		
		FHT 830 CNC	FHT 1230 CNC	FHT 1240 CNC
Maximal sheet thickness (for R_m = 450 MPa)	mm	8	12	12
Nominal cutting length	mm	3000	3000	4000
Angle between blades (Z axis)	°	0.5 - 2.5	0.5 - 3	0.5 - 3
Work pressure	bar	250	250	250
Blank size: - maximal - minimal	 mm mm	 3000x3000x8 1000x300x3	 3000x3000x12 1000x300x5	 4000x4000x12 1000x300x5
Programmable increment	mm	0.1	0.1	0.1
Installed power	kW	17	29	29
Dimensions (length x width x height)	m	39.4 x 2.33 x 2.12	13.1 x 5.5 x 2.9	16.5 x 6.0 x 2.9
Mass	kg	17200	21000	22000

3. HYDRAULIC SHEET BENDING PRESS PHT 63-30 CNC

The hydraulic sheet bending press PHT 63-30 CNC is used for the cold bending of sheets of steel and of nonferrous metals, by means of a single operation or of multiple operations, in a semiautomated cycle, the succession of operations being unfolded according to the routine stored in the memory of the CNC equipment. If equipped with adequate devices, the press can be used also for perforating, sheet cutting, executing various metallic profiles for metallic structures, shipbuilding, rolling equipment, cars, in medium-scale and large-scale production.

The press consists of an open, C-shape, welded chassis consisting of columns stiffened at their base by means of a fixed beam (the press table) and at their upper parts by means of a girder beam which supports the hydraulic installation with the oil tank. On the press table, which has T-shaped grooves, there are fastened the bending die and consoles for supporting the sheets. In vertical plane, on the

chassis the mobile beam is moving guided by column ways, actuated by the hydraulic installation by means of two double-effect hydraulic cylinders. Each cylinder can be actuated individually, the mobile beam being able to work in sloped position, in order to realize bendings with various angles. A micrometric setup system allows the execution of bendings while maintaining the parallelism of displacement and the accuracy of positioning the beam within the indicated tolerance limits. Also, on the mobile beam, actuated by hydraulic cylinders, there is fastened the punch that bends the sheets.

The measurement of the mobile beam's movement on vertical direction is done using two displacement transducers fastened at its end. The plan-parallel motion of the mobile beam is maintained with the help of an electrohydraulic balancing system equipped with proportional hydraulic distributors. The positioning of the sheets that are to be bent is realized using a complex limiting system that is able to move the sheet limiting devices on five axes, their movements being controlled electromechanically.

Blank limiting devices are fastened on two carriages that can move independently from each other along the limiting device's beam (on vertical direction), the measurement of displacements being done with a rotational incremental transducer.

The press has protection screens on the machine's sides and in the area of the cylinders. They are basically articulated screens, the machine's functioning being allowed only in the *closed* position, confirmed by an electrical limiting device.

The main technical characteristics of the family that includes this press are presented in table 2. This equipment was manufactured at the "Mecanica" plant of Sibiu.

Table 2

Technical Parameters	Unit	Machine type			
		PHT 63-30 CNC	**PHT 63-40 CNC**	**PHT 100-40 CNC**	**PHT 100-50 CNC**
Nominal force	kN	630	630	1000	1000
Distance between columns	mm	2580	3250	3250	4120
Maximal bending length	mm	3150	4000	4000	5000
Distance from bending plane at the column	mm	250	250	250	250
Hub of the mobile beam (y axis)	mm	160	160	160	160
Work speeds of the beam					
- fast descent	mm/s	75	75	75	75
- slow pressing	mm/s	9	9	9	9
- ascent	mm/s	70	70	70	70
Height of the table from the ground	mm	800	800	800	800
Maximal pressure	MPa	21	21	25	25
Main engine power	kW	75	75	75	75
Number of axes controlled by CNC	-	7	7	7	7
Positioning precision					
- x axis	mm	± 0.1	± 0.1	± 0.1	± 0.1
- y axis	mm	± 0.05	± 0.05	± 0.05	± 0.05
Dimensions					
- length	mm	3650	4500	4420	5420
- width	mm	2090	2090	1375	1375
- height	mm	2400	2400	2485	2575
Mass	kg	7100	8150	9200	10800

4. UNIVERSAL THREAD ROLLING MACHINE MURF 32

The universal thread rolling machine MURF 32, with a pressing force of 315 kN is used for the realising, through metal forming procedures, of threads with diameters between 5 and 100 mm for screws and other machine parts. Also, it can be used for the obtaining of worms, gears or for surface hardening, surface smoothing, grooving etc.

The roll-shaped active elements are put in a rotation motion by a common actuation system placed in the chassis. The force cylinder receives pressure from a hydraulic unit, the machine functioning with manual feeding in semiautomated and automated regime. In the first case, the blank is positioned on its support, a control pedal is pushed and the mobile forming roll (the tool) closes in on the fixed roll (both being in rotation motion), the forming action is carried out, after which the mobile roll retreats, awaiting a new command.

In the second case, the blank is placed on the support, the mobile roll closes in and carries out the forming, after which it retreats for a short break, after which the next closing in movement is done without any further command. During the break, the human operator removes the finished part and introduces a new blank.

The main technical characteristics of the family that includes this machine are presented in table 3. This equipment was manufactured at the Machine-Tools Plant of Suceava.

Table 3

Parameters	Unit	Machine type			
		MURF 6	**MURF 12**	**MURF 32**	**MRF 63**
Nominal pressing force	kN	63	125	315	630
Thread diameter	mm	2-12	2-50	5-100	42-120
Maximal thread pitch	mm	15	4	8	8
Rotation speed of the rolls	rot/min	40;60;80;100;120;200	20-120	20;30;40;50;60;100	20;30;40;60
Angle between tool-carrying shafts	°	0	0-20	0-20	0-20
Distance between rolls	mm	90-170	125-250	140-315	
Roll diameter	mm	95-150	125-200	140-225	16-300
Diameter of tool-carrying shaft	mm	54h7	63h7	80h7	110h7
Height of rolls over the chassis	mm	130	160	200	315
Installed power	kW	4	7	18	45
Dimensions (length x width x height)	m	1.6x1.1x1.3	1.5x1.3x1.6	1.8x1.2x1.9	2.93x1.85x2.3
Mass	kg	1100	2100	3400	6800

5. MULTIPOSITIONAL HORIZONTAL PRESS PMPO 200

The 2000 kN automated multipositional horizontal press PMPO 200 is a mechanical press with five workstations, used especially for cold extrusion. The press has a horizontal unactuated unfolder, a guiding-straightening device and a mechanism for cutting and transfer.

The chassis with its annexes is the base on which all other component parts of the machine are assembled. The actual chassis is a cast O-shaped structure in horizontal position. At the upper part there is a welded subassembly with a trough for evacuating the tools' cooling oil. The chassis' annexes consist of protection screens, lids, part collector, troughs etc.

The pressing unit consists of a crank shaft, connecting rod, double-bar link, die support plates, punch supports and guiding wedges for the punches.

Table 4

Parameters	Unit	Machine type			
		PMPO-40	**PMPO-120**	**PMPO-200**	**PMPO-315**
M nut	mm	-	6	10	18
Diameter of wire to be cut	mm	7	11	18	27
Cutting length	mm	40	12	20	30
Hub of the pressing unit	mm	250	80	130	200
Hub of the eliminator	mm	100	15	25	45
Pressing force	kN	400	1250	2000	3150
Number of workstations	-	11	1+5	1+5	1+5
Die diameter	mm	40	60	73.02	120
Dimensions (length x width x height)	m	3.2x1.7x2.3	3.7x2.6x1.6	5.2x3.1x1.8	6.1x3.8x2.1
Mass	kg	10500	10000	18800	42000
Installed power	kW	21.8	21	27	

The actuation mechanism is put in motion by a direct current electric engine with variable rotation speed; from here, the motion is transmitted by means of belts to the flywheel located on the main shaft of the press. The mechanism also contains a pneumatic coupling with frontal disks for driving the main shaft of the press by the flywheel and a braking disk for the automated braking if the coupling is open.

The transfer mechanism provides the processed part's movement from one workstation to the next one, the motion being taken from the main shaft by means of a cam.

The extractor mechanism ensures on the one hand the part's evacuation from the die-block, being controlled via an eccentric mechanism or a cam mechanism and on the other hand the guidance of the bar to the cutting stamp.

The blank consists of a wire coil, placed on an unfolding mechanism after which it passes through a straightening and feeding mechanism. At each machine cycle, following operations are executed: cutting the material, transfer of the intermediate blank from one workstation to the next one, actual pressing, evacuation of the finished part. Some operations overlap, others are separate in time. All mechanisms are controlled by means of cams located on the main shaft. It is possible to vary the feeding speed and the length of the eliminator hub, the other hubs being constant.

The main technical characteristics of the family that includes this press are presented in table 4. This equipment was manufactured at the "Mecanica" plant of Sibiu.

6. FINE STAMPING PRESS PDF 100/50/25

The fine stamping press PDF 100/50/25 is a metal forming equipment for cutting, perforating or imprinting of blanks in the shape of bands, stripes or sheets made of ferrous or nonferrous metals. The main subassembly of the press, which connects the other component parts is the chassis. It has a high stiffness, having to withstand high forces while providing a high work accuracy.

The chassis contains three hydraulic cylinders: the main cylinder providing the cutting force and placed in the lower part of the chassis, the cylinder producing the counter pressure force and actuates the evacuation system, placed co-axially with the main cylinder and the cylinder actuating the pressing element with protruding edge, placed in the upper part.

The fine stamping tool is fastened on the fixed upper table, its mobile part being solidar to the rod of the main cylinder.

The blank's feed is realized by means of a feeding mechanism, while the waste material is eliminated by the pulling mechanism. The press also has a shear for segmenting the waste material after a preselected number of steps of the pulling mechanism.

In order to facilitate the fastening of the stamp on the press, at the upper part of the chassis there is a pivoting crane.

The hydraulic pumping group is placed a top the oil container, while the electric installation is placed in a separate box. The electric control is realised from a panel ergonomically placed on the chassis.

The finished parts and the waste materials are removed from the work area by means of a compressed air.

The main technical characteristics of the family that includes this fine stamping press are presented in table 5. This equipment was manufactured at the "Mecanica" plant of Sibiu.

Table 5

Technical Parameters	Unit	Machine type			
		PDF 100/50/25	**PDF 160/80/40**	**PDF 250/125/63**	**PDF 400/200/100**
Force at the main cylinder	kN	1000	1600	2500	4000
Force at the pressing element	kN	0-500	0-800	0-1250	0-2000
Counter pressure force	kN	0-250	0-400	0-630	0-1000
Height of stamp fastening	mm	165-240	220-295	265-340	340-415
Table dimensions	mm	400x400	450x450	500x500	650x650
Hub of the slide-block	mm	30-150	30-125	30-200	30-225
Setup hub of the slide-block	mm	75	75	75	75
Maximal hub pressing element	mm	30	30	30	40
Maximal hub counter pressure	mm	30	30	30	40
Size of the centering hole	mm	Φ300	Φ380	Φ450	Φ550
Number of empty hubs	hubs/min	30	30	30	30
Maximal work pressure	bar	275	250	275	250
Maximal band width	mm	150	275	275	400
Material feeding hub	mm	0-150	0-220	0-220	0-300
Maximal band thickness	mm	10	5	10	5
Cutting force at the shear	kN	120	200	200	500
Dimensions - length	m	3.500	4.120	4.000	5.160
- width	m	1.270	2.310	2.525	1.750
- height	m	2.135	2.310	2.300	3.620
Mass	kg	5885	8600	12300	18800

These are only a few notable Romanian achievements in the domain of manufacturing metal forming equipment. The list of such equipments could continue, however, with many more, such as:

machine for realising outer grooves MCE 20 (Sibiu), rotative machine for longitudinal drawing MRAL 250 CNC (Sibiu), machine for profile drawing MTPC 100 (Tg. Jiu), machine for sheet drawing MTTC 250 (Tg. Jiu), machine for rail and fittings profiling (Timişoara), mechanical press PM 30 CNC (Sibiu), mechanical press PMC 16 (Sibiu, Tg. Jiu), machine for step forming MAP 16 (Sibiu), press with hydraulic cell PCH 1250 (Tg. Jiu), automated stamping line (Sibiu), automated angle steel cutting and perforating line LDPC 20 CNC (Sibiu), flexible cutting cell (Sibiu) etc.

Many of these equipments are no longer manufactured today, while the others have been improved. In Romania, the production volume has decreased, including in the area of manufacturing of metal forming equipment. In Romania, as in the European Union in general, the GDP has decreased with the reduction of the industry.

Therefore, there are numerous debates regarding the relaunching of the economy through reindustrialisation. The reindustrialisation of member states is the solution proposed by the EU so that Europe can have a sustainable future. Moreover, by increasing the role of industry, new workplaces will be created, with a high value in the GDP, thus solving a part of the existing social problems.

The EU's vision is that the strategy for a competitive and sustainable industry must be based on integration and solidarity, in a climate of cooperation for implementing investments with beneficial effects for all parts involved.

The examples given above strenghten the conviction that Romania can go through actions that target reindustrialisation in general and especially in the domain of manufacturing metal forming equipment.

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