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AUTOMATION OF A MANUAL PRODUCTION LINE

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Rezumat. *Subiectul principal al acestui studiu se referă la industria auto și la tehnologiile de ultimă oră din acest domeniu, special dezvoltate pentru a menține producția de autovehicule la cele mai înalte standarde și pentru a răspunde celor mai noi cerințe, cerințe ce devin din ce în ce mai riguroase. Cum aceste standarde și cerințe au atins un nivel foarte înalt, a fost nevoie de dezvoltarea unor noi tehnologii pentru ca industria să poată ține pasul cu acest trend. Standardele de calitate au atins un nivel în care resursa umană (operatorul) nu mai poate face față cerințelor. Acesta este punctul în care roboții și automatizările intervin mai mult ca oricând în industria auto, pentru o mai bună precizie și un process de fabricație mai stabil și mai eficient, ingrediente cheie pentru o fabricație de success.*

Abstract. *The main subject of this study has his roots in the automotive industry and all the cutting-edge technologies developed and available today, in order to keep the mass production of vehicles at the highest standards and to achieve all the latest requirements which are getting tougher and tougher day by day. As the standards and the requirements became higher, new manufacturing technologies were needed for the industry to keep up with the trends. The quality standards have reached a level where the human resource (operator) is not able anymore to match the requirements. This is the point where the Robots and the automations combined are introduced more than ever in the automotive industry, for a more accurate, stable and efficient manufacturing process, they key ingredients in the journey for a successful manufacturing.*

Keywords: Automation, Robots, Manufacture, Flow, Automotive industry.

1. Introduction

The performance of any successful business in the automotive segment can be reduced to one thing: stable and repeatable processes. The systems and processes in which as few variables are found are also the most secure, stable and reliable. These features are easily achieved nowadays with the help of the industrial robots, and they are essential in most industries, the automotive industry being no exception. The industrial robot is a physical, programmable system, able to perform various operations and sequences of operations for handling tools, parts or subassemblies, with a higher capacity, accuracy, speed with highest efficiency.

Due to the technological progress felt especially in the last 15 years, the automation of production processes has experienced a considerable boom,

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successfully replacing manual, slow, human-operated systems with low-cost, high-volume capacity systems managed by robots and software.

Automatic production systems successfully replace manual lines while providing stability, increased efficiency, low maintenance costs and low human resource costs.

2. Industrial robots evolution

The oldest known industrial robot, according to the ISO definition, was completed by "Bill" Griffith P. Taylor in 1937 [1] and published in Meccano magazine in March 1938. The crane-type device (Fig. 1) was built almost entirely using Meccano parts and powered by a single electric motor. Five axes of motion were possible, including gripping and gripping rotation.

The automation was done using perforated paper tape to energize the solenoids, which would make it easier to move the crane control levers. The robot could stack blocks of wood in pre-programmed patterns. The number of engine revolutions required for each desired motion was first plotted on graph paper. This information was then transferred to the paper web, which was also driven by the robot's single motor. Chris Shute built a complete replica of the robot in 1997.

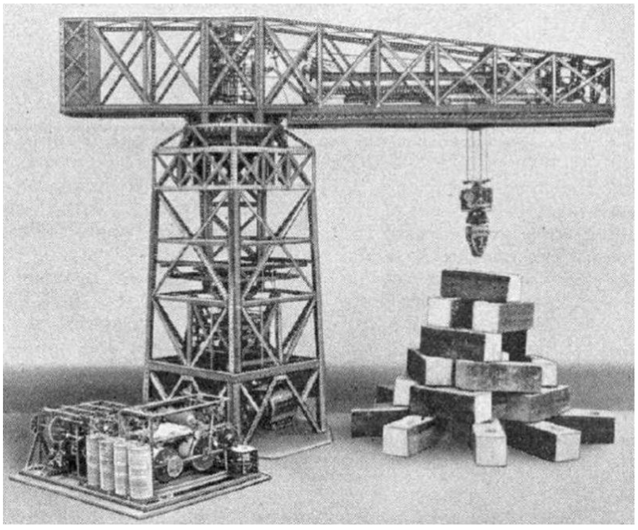

Fig. 1. First industrial robot (1937).

In June, 1968, the production of first industrial robot began in Japan, the first "Kawasaki-Unimate 2000" (Fig. 2) completed in 1969 [2]. 1980 - Industrial robots are installed on car production lines. It was the carmakers who expressed a strong interest in launching the Kawasaki-Unimate model.

Since 1981, the rate of new robots has started to grow exponentially. Takeo Kanade created the first robotic arm with motors installed directly in the joint, which made it much faster and more accurate than its predecessors.

Fig. 2. Kawasaki Unimate - 2000.

Yaskawa America Inc. introduced the Motorman ERC control system in 1988. It had the power to control up to 12 axles, which was the largest possible number at the time.FANUC Robotics created the first intelligent robot prototype in 1992.

Two years later, in 1994, the ERC Motoman SK6 (Fig. 3) system was upgraded to support up to 21 axles [3]. The controller increased this to 27 axes in 1998 and added the ability to synchronize up to four robots.

Fig. 3. Motoman SK6 robot

Robots have evolved and remain on a constant evolving trend, continuing to optimize and fuel today's manufacturing lines from industrial domain, through technological progress.

3. Manual to automatic conversion

The conversion from the manual production line to the automatic one was performed on a real production flow, reducing the total headcount from 8 operators to 1.

3.1 The structure of the two lines:

Manual production line breakdown (see Table 1):

Table 1. Manual production line

Operation	Hydraulic press	Manul assy operation	Sealing operation	Rework operation	100% control operation
Quantity	4	3	2	1	1

Automatic production line breakdown (see Table 2):

Table 2. Automatic production line

Operation	Hydraulic press	Manipulating robot	Hemming robot	Assembly device	Automatic sealing system
Quantity	4	2	1	2	1

3.2 Operations sequence and description (see Table 3):

Table 3. Operations sequences

Op. no.	**Op. Description**	**No. of machines**	**Machine used**
Op. 10	Steel sheet cutting	2	Press PT1
Op. 20	Blank forming	2	Press PT2
Op. 30	Sealing	1	Sealing System
Op. 40	Hemming	2	Hemming BED

Operation 10 – Steel sheet cutting

The blank sheet is taken by the robot from destacker 1 or destacker 2, places it on a centering table, then slides it into the press. The robot is getting out of the press after placing the blank, after confirmation, the press performs the punch automatically.

Operation 20 – Blank forming

The manipulating robot takes the part from op. 10 and places it in the op. 20 press. After it clears the press barrier, the press does the punch automatically.

Operation 30 – Sealing

The manipulating robot recovers the part from op. 20, and places it into the sealing system. After the sealing system is activated, the robot follows a preset pattern and the sealant is applied on the part.

Operation 40 – Hemming [4]

The robot is placing the part with applied sealant inside the hemming bed, the interior panel is added and the clamps are closed. The hemming robot starts the hemming operations, first step with 125-degree roller, then the 90-degree head.

3.3. Cycle time and capacity study

The cycle time for each operation as follows:

Op. 10 – 7s
Op. 20 – 7s
Op. 30 – 9s
Op. 40 – 21s

Working schedule – 420 min/day
5 working days
Monthly volumes (forecast)
Cycle time measurements and improvements

3.4 Process simulation and layout (Fig. 4)

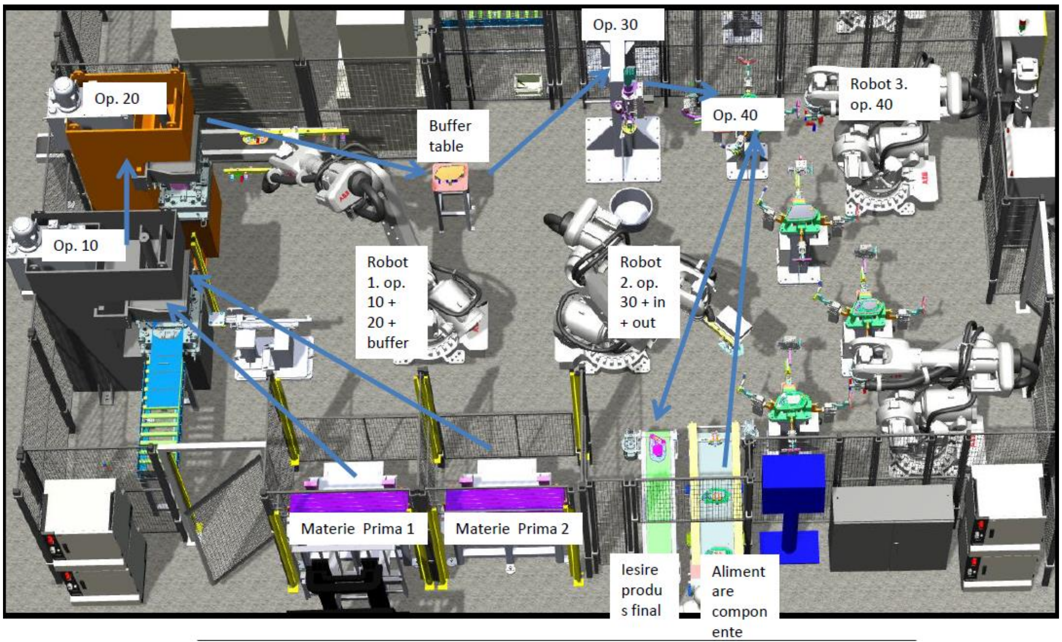

Fig. 4. Process simulation

<u>3.5 Implementation phases - Gantt</u> (Fig. 5)

- Simulation
- Supplier nomination and contract
- Installation and comissioning
- Part validation
- Capacity confirmation + process capability

	Simulare	**66 days**	**Wed 11/18/20**	**Wed 2/17/21**		
	efectuarea studiilor de fezabilitate	40 days	Wed 11/18/20	Tue 1/12/21		Inginer Proiectant,Manager Proiect
	stabilirea layout-ului de post	5 days	Wed 1/13/21	Tue 1/19/21	2	Inginer Proiectant
	stabilire Flow Chart	7 days	Wed 1/20/21	Thu 1/28/21	3	Inginer Proces
	simulare procesului	14 days	Fri 1/29/21	Wed 2/17/21	4	Inginer Proiectant
	Manufacturare	**33 days**	**Thu 2/18/21**	**Mon 4/5/21**		
	Pregatire Documentatie si lansare RFQ	3 days	Thu 2/18/21	Mon 2/22/21	5	Manager Proiect
	Manufacturarea Robotilor	27 days	Tue 2/23/21	Wed 3/31/21	7	Furnizor
	Pre buy-off furnizor	3 days	Thu 4/1/21	Mon 4/5/21	8	Manager Proiect
	Instalare si punere in functiune	**18 days**	**Tue 4/6/21**	**Thu 4/29/21**		
	Instalarea Robotilor in locatia definitiva	4 days	Tue 4/6/21	Fri 4/9/21	9	Furnizor
	Punerea in functiune	2 days	Mon 4/12/21	Tue 4/13/21	11	Furnizor
	Programare, parametrizare	4 days	Wed 4/14/21	Mon 4/19/21	12	Furnizor
	Cicluri Proba (Trial Runs)	3 days	Tue 4/20/21	Thu 4/22/21	13	Furnizor
	Training Tehnicieni	2 days	Fri 4/23/21	Mon 4/26/21	14	Furnizor
	Training Operatori	3 days	Tue 4/27/21	Thu 4/29/21	15	Furnizor
	Validare proces	**5 days**	**Fri 4/30/21**	**Thu 5/6/21**		
	Ajustari initiale	2 days	Fri 4/30/21	Mon 5/3/21	16	Furnizor
	Validare 1	1 day	Tue 5/4/21	Tue 5/4/21	18	Specialist Calitate
	Ajustari Finale	1 day	Wed 5/5/21	Wed 5/5/21	19	Tehnician Proces
	Validare Finala	1 day	Thu 5/6/21	Thu 5/6/21	20	Manager Calitate
	Confirmare capacitate + capabilitate proces	**8 days**	**Fri 5/7/21**	**Tue 5/18/21**		
	Run@Rate	1 day	Fri 5/7/21	Fri 5/7/21	21	Operator
	Studiu capabilitati	3 days	Mon 5/10/21	Wed 5/12/21	23	Specialist Calitate
	Finalizare buy-off	1 day	Thu 5/13/21	Thu 5/13/21	24	Manager Proiect

Fig. 5. Gantt chart implementation

4. Conclusions

The main personal contribution to this study is in fact the opportunity to take part in the actual implementation of the project, from simulation phase, untill installation, commisioning and SOP. All the output data has been obtained in real simulation, all gains after conversion are measured in real time cycles.
What makes this paper unique against other articles is the fact that the whole project did not stop in a sketch status, or a basic study, I had the oportunity to take part in the entire execution, all the figures presented within this paper are the result of all the field activities conducted on site.

The entire project implementation period was 130 days, starting at 18.11.2020 and was finished on 13.05.2021.

The study presents the robotization and automation [6] of a manual manufacturing line consisting of manual cutting presses (guillotines), manual stamping presses, manual assembly processes, which includes a total headcount of 8 operators into a robot equiped, automated assembly cell which is entirely operated by a single operator.

Table 4. Manual vs automatic line comparison

	Manual line	Automatic line	Gap
Headcount (op)	8	1	-7
Cycle time (s)	186	44	-142
OEE (%) [5]	60	87	+27
Scrap (%)	4	1.15	-2.85
Work stations	3	1	-2

Overall gain after conversion from manual to automatic is included on the Table 4.

The automatic assembly cell [7] includes cutting, stamping, sealing and hemming, operations. All these operations are 95% performed with the help of robots (manipulations, sealing, hemming).

After conversion, on the entire manufacturing flow, the intervention of a single operator is needed in order to supply the components on the incoming conveyor and to unload the final product from the outgoing conveyor.

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