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PRODUCTION COST SAVINGS THROUGH MANAGING PROCESS AUTOMATION IN MANUFACTURING COMPANIES. CASE STUDY: A ROMANIAN AUTOMOTIVE AIRBAG MANUFACTURER

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Abstract: *This paper argues that the Romanian automotive manufacturing industry needs a disruptive change to sustain GDP growth. The paper presents the results of study about a concrete example how a Romanian automotive airbag manufacturing facility has been adding value in the production and management process through automation and robotization. The manufacturing plant achieved 320%-480% productivity increase over the last 2 years due to higher automation and robotization of the manufacturing process. The paper focuses on identifying the main drivers for automation acceptance in a Romanian automotive plant from the first (+320% productivity increase) to the second generation (+480%) of automated head side airbag gluing line. We formulate the conclusion that with already existing technologies, 50% of the activities in automotive manufacturing factories for airbag gluing process in Romania could be automated today.*

Keywords: value-added, automation, automotive, manufacturing, Romania.

1 INTRODUCTION

This article intend to present how to manage the implementation of high automation in an automotive airbag factory and the effects of implementing an automated process on the different internal and external stakeholders based on the framework of the Technology Acceptance Model (TAM) (see Figure 1, below). To increase the added value in an airbag module, the airbag manufacturer needs to reduce the labor cost for the cushion production. In an airbag module, most of the manual work is generated by the cushion gluing, sewing and folding process. This paper is focusing on the gluing process for Head Side Airbags (HSAB) or Curtain Airbags (CAB). The studied airbag cushion manufacturer is relying since 2005 on a manual gluing process. In 2014, there was a first attempt to automatize the gluing process but there was still a lack of added value. To add more value in the gluing process, the airbag manufacturer decided in 2019 to start the development of an automated process using several robots.

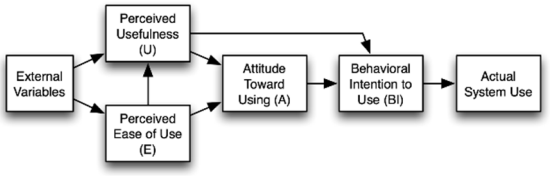

Figure 1: Technology Acceptance Model (TAM)

2 CASE STUDY: AIRBAG AUTOMOTIVE FACTORY

A global leader in mobility safety providing safety-critical components, systems, and technology to automotive and non-automotive markets is having an airbag cushion factory in Romania. This factory with 3.ooo operators is looking to increase the automation and robotization level in the airbag cushion manufacturing to solve new challenges for an automotive production in a best cost labor workforce environment. We have identified several problems that are emerging from the labor-intensive automotive manufacturing in the last 3 years, such as:

- Lack of qualified and unqualified workforce to sustain the market development and the production increase,
- Operators are no more interested in physical intensive and repetitive jobs (even if these jobs are better paid),
- Operators are less interested to come to work in overtime to increase the output of a specific line for a certain amount of time (for example 2-3 weeks),
- The big amount of manual production operation creates more quality fluctuations which must be checked 100% in a separate control operation (additional control without added value),
- The traceability in a more manual manufacturing process is complicated due to the high amount of different people executing the same operation. In case of a quality claim, the number of possible affected parts is very high due to missing an automatic traceability system and one-piece flow production.

3 DESCRIPTION OF THE ORIGINAL PROCESS AND OF SEVERAL AUTOMATION IMPROVEMENTS LOOPS

This Airbag manufacturer based in Romania invested during the last 2 years over 14 million Euros to automate and robotize the existing production processes. One of the processes is the gluing of Head Side Airbags (HSAB) or Curtain Airbags (CAB).

The Airbag Manufacturer is producing cushions for airbag modules. Airbag systems are engineered to work within milli-seconds when needed even after many years of vehicle lifetime. The production requirements and automotive quality systems standards for safety parts are designed to meet and overachieve the highest quality standards to handle the most challenging vehicle conditions.

4 HEAD SIDE AIRBAGS

Head side airbags were developed to protect front and rear passengers' head and neck region, which is the most vulnerable body area in the case of side collisions. Using specific design features these airbags can also provide passenger protection during rollover events.

In addition to the standard head impact protection, this airbag module and cushion manufacturer developed an unique “airtight” technology to keep the gas as long as possible inside the airbag to expand its protection capability to protect also from secondary collisions and/or rollover events.

This specific designed and manufactured head side airbags (HSAB) or curtain airbags (CAB) offer the highest level of occupant protection and safety for different occupant sizes in tests

and real-world accident scenarios (see Figure 2, and Figure 3, below). These airtight cushions meet all market and customer-specific requirements thanks to their modularity, the large selection of materials and ongoing innovations.

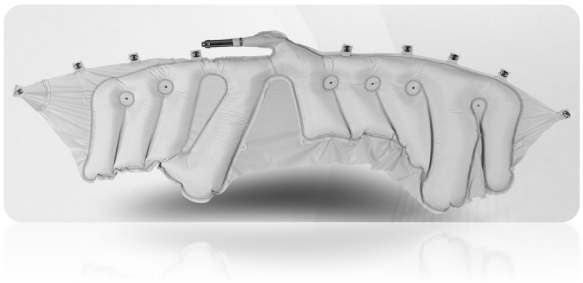

Figure 2. Head Side Airbag

The Airtight version is provided by the gluing process at the airbag cushion manufacturer.

The head side cushion gluing process consists in applying a 10 mm wide silicone rope before sewing, to reinforce the seam and to keep the air inside the cushion.

Two of the biggest challenges for the manufacturing company are to fulfill the customers increased demands and to keep a high level of competitiveness on the market by increasing the level of productivity and efficiency.

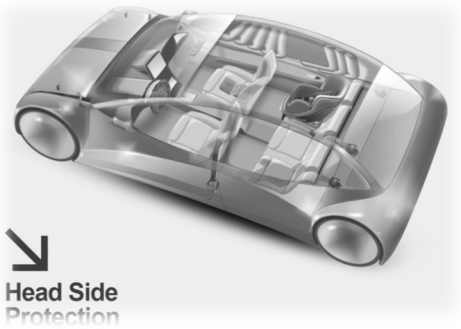

Figure 3. Head Side Protection

Implementation of automated gluing process – a lighthouse project for this airbag manufacturer.

In 2005 the gluing process started with low-automation machines, then in 2014 the airbag manufacturer began to install the first industrial robot for dispensing glue automatically. In 2019 a new project was started consisting of using a semi-automatic gluing line to improve the productivity and added value for all head side airbag with cut, seal, and sew technology. In 2022, a second-generation automated gluing line was implemented.

The first concept was developed in 2014. It includes a 6-axis industrial robot and an injection system (see Figure 4, below). It needs 2 or 3 operators depending on the cushion size, and the output is around 100 pcs/h.

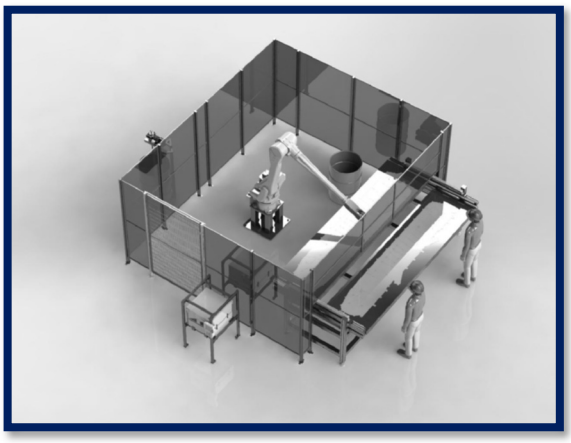

Figure 4. Simple dispensing robotic cell

This simple robotic dispensing cell is still in use for serial production. It has the advantage of more flexibility but due to the reduced output, it is now used mostly for small series and prototyping.

In 2019 a new concept: the automatic gluing line was developed and launched by the local engineering team.

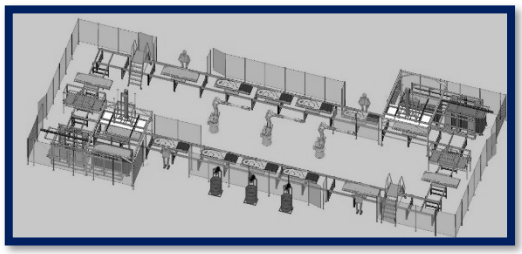

Figure 5. 1st automatic gluing line concept

The new automation concept includes 3 industrial robots and a long conveyor, with several other automation devices used to complete this process. The final concept was planned for 4 operators. (see Figure 5, above)

After the first concept was found, an improved design was developed to reduce the size of an automated line as the space in the factory is limited. The concept was modified, and the second version of the automated gluing line was more compact, with better productivity per square meter (see Figure 6, below).

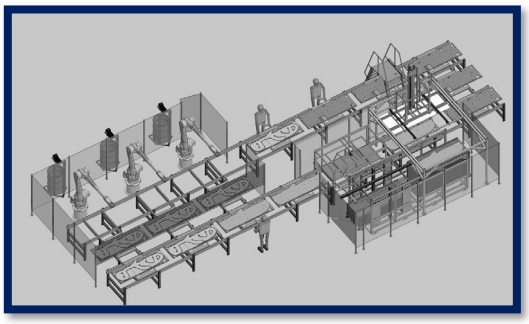

Figure 6. Final design for 1st automatic line

Then a second generation of the automated gluing line was developed in 2021 including the production ramp-up. It has the highest level of automation and productivity with the lowest amount of operator per shift. It started in 2021, has an extra robot used for palletizing, and uses only 2 workers achieving highest productivity level (see Figure 7).

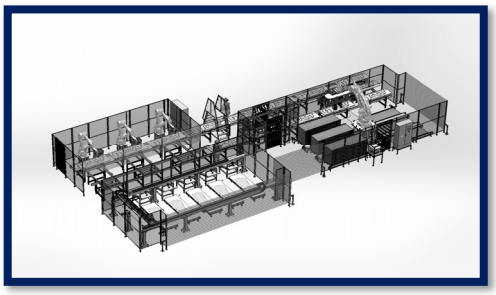

Figure 7. 2nd generation of automatic gluing line

The improvements can be shown on the following scenario: 100 000 pcs to be produced (see Table 1 and Figure 8, below). The evolution of worker productivity is positive, increasing each time compared to the previous situation. The same is with the unit production cost which was reduced 4,8 times in the case of the automatic gluing machine #2 compared with the low-level automation, confirming that the use of automation is contributing to increasing the costs savings.

Table 1. Production costs

#	Low automation	Simple robotic cell	Automatic gluing machine #1	Automatic gluing machine #2
Year of use	2005	2014	2019	2022
Output pieces/h	100	100	240	240
Workers	4	3	3	2
Productivity/ worker	25	33	80	120
Increase in productivity versus low automation (%)		+32%	+320%	+480%
Man-hour/ year	4000	3030	1250	833
Full Time Equivalent (FTE)	25	19	8	5
Unit Production Cost	31,250 €	23,674 €	9,766 €	6,510 €
Decrease of production cost (%)	-	24,24	68,75	79,14

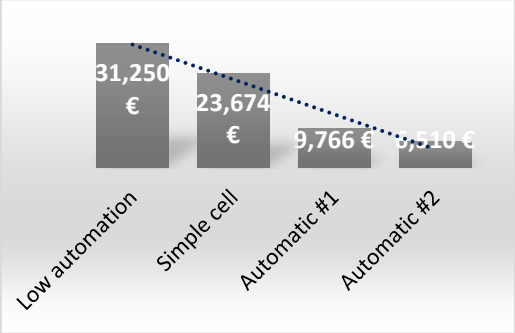

Figure 8. Production cost comparison

Full Time Equivalent (FTE) is used to calculate labor variable cost when it is not possible to split one headcount in a smaller unit. The formula for calculating FTE is the following:

FTE is an employee's scheduled hours (X) divided by the employer's hours for a full-time workweek (Y). When an employer has a 40-hour workweek, employees who are scheduled to work 40 hours per week are 1.0 FTEs. Employees scheduled to work 20 hours per week are 0.5 FTEs

$$FTE = X / Y$$

Where, X means employee's scheduled hours and Y means employer's hour for a full-time workweek.

The unit production cost is calculated with the following method:

FTE x operator cost per year / 12 months

The assumption for total cost for 1 operator for 1 year is 15.000 Euros.

As an example, the unit production cost for low automation is:

25 FTE x 15000 euro / 12 months = 31250 euro

As future actions, the plan is to retrofit the first automatic machinery with an automatic rolling device to achieve a higher productivity as a result of lessons learned and proof of concept of the second automated gluing line with a higher level of automation.

The automation of the gluing cell had different advantages over the last 2 years and even more in the future. The most obvious ones are:

- The remaining 2 operators are having less repetitive jobs which allow them to be more involved and focused on quality, for example.
- The remaining 2 operators are having fewer physical jobs which allow them to keep the pace during the entire shift.
- The training for new operator is easier as the required abilities are less depending on individual skills (the operators has less manual influence on the quality of the finish product).
- By having less manual influence on the finish product, you also improve the overall quality of the glued parts.
- By doing so, the airbag manufacturer can reduce gluing tolerance necessary before, when the process was more manual.
- By reducing the tolerance, you consume less expensive glue.
- By consuming less glue, you reduce the weight of the airbag module, the packability of the cushion inside the airbag module is also improved.
- By reducing the tolerance, you can design a more complex and competitive cushion.
- As the labor market is empty, you can use the 2 operators released from a gluing station (improvement from 4 to 2 operators) to work on a new gluing station. Like this you have less need for new operators from the labor market.
- By increasing the added value, you can also pay better the remaining operators and avoid operator fluctuation which is stabilizing the production output over a longer period.

To verify how the implementation of automation and robotization was perceived by stakeholders, we undertook two different surveys. The first one in Romanian language was distributed to all operators, team leader and indirect labor, working in shopfloor using the technology. The total number of respondents was 30. The second survey was aimed to understand the technology acceptance for the people in charge of the automation and robotization project, the management in charge of financing and for reporting the benefits of the newly involved automation project. For example, the case of the quality and maintenance department which profits indirectly from automation implementation. The number of respondents was 16.

The results of both surveys indicated that automation and robotization is largely accepted by shopfloor employees (by 75 % of them) and by staff (84.6 % of them) as long as it was properly implemented based on a change management model such as the McKinsey 7-S model that we used for our case study. Most of shopfloor people (80%) and managers (100%) recognized the need for a highly automized gluing concept between 2014 and 2019. The worker productivity and number of headcounts involved for the 1 cell gluing robot was limited. There was a need for a new process with more robotization and less physical predictable work. After implementing the first semi-automated gluing line, everyone involved acknowledged the improvements in terms of physical predictable work, productivity, and costs. Very soon there was a management decision to invests as soon as possible in a second automated gluing line with even higher productivity coming from the lessons learned from 2020 during the implementation of the first semi-automated gluing line.

To achieve the highest cost savings from process automation it was useful from the beginning to use a change management model like one of the popular ones for example: McKinsey 7-S, Kurt Lewin, AKDAR, Kotter's 8-Step or General Electric Change Acceleration Process. Both surveys aim also to identify which were the drivers of people accepting the implementation of the new technology. The results of both surveys indicated that the technology acceptance level is high if the change management was professionally performed without skipping any step of the change management process.

In conclusion, the results of the research presented in this paper indicated that with already existing technologies, 50% of the activities in automotive manufacturing factories for airbag gluing process in Romania could be automated today. Finally, we recommend to plant managers to automate the labor-intensive production activities.

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