INTRODUCTION OF COLLABORATIVE ROBOTICS IN THE PRODUCTION OF AUTOMOTIVE PARTS: A CASE STUDY

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***Abstract*—This short contribution witnesses the commitment of the research group of Mechatronics and Industrial Robotics of the Polytechnic University of Marche in collaboration with Techpol, a leading automotive company, in spreading the integration of collaborative robotics in small and medium-sized enterprises. Collaboration between humans and robots will harness the flexibility of humans and the precision of robots, fostering a safer working environment. By reducing the human workforce and utilizing their cognitive capabilities, which are more fulfilling for them, this integration will generate added value for the enterprise.**

***Index Terms*—collaborative robotics, human-centered robotics, computer vision**

I. INTRODUCTION

This project was the result of a collaboration between Marche Polytechnic University and Techpol, a company specialized in the design and molding of plastics in the automotive sector. The work was aimed at demonstrating that collaborative robotics integrated into small and medium-sized enterprises can easily and effectively solve many business problems with relatively small investment. The primary concept behind collaborative robotics, widely acknowledged, revolves around establishing human-centered automated processes, enabling humans to interact with the robot workspace with an acceptable degree of risk, bringing a safer work environment by reducing the use of human workforce and exploiting instead their cognitive skills, enhancing the working condition together with their satisfaction.

Over time, advancements in technology have allowed robot manufacturers to develop increasingly dependable collaborative robots with enhanced safety features and improved workspace-sharing capabilities, achieving higher performance levels [1], [2]. Nevertheless, in the corporate landscape, particularly for small to medium batch production with average unit costs, human labor remains the preferred choice [3]. This project seeks to challenge this prevailing bias by showcasing the effectiveness of collaborative robotics, demonstrating how it can bring economic and technological advantages to enterprises. The primary objective of the project is to illustrate how deploying a single UR5e cobot from Universal Robots at a plastic welding station can lead to a financial benefit, but of greater significance to the redirection of human labor. By doing so, human efforts can be redirected on value-adding activities for the company, rather than expending valuable cognitive skills and flexibility on monotonous and burdensome tasks [4], [5].

Apart from the integration of cobots, this case study illustrates how the utilization of these machines facilitates technological innovation across diverse sectors, reshaping the company's perspective and propelling it towards a future empowered by novel methodologies applicable within its industry and beyond, fostering potential expansion and establishment in new domains.

II. DESCRIPTION OF THE CASE STUDY

The core focus of this article centers around exploring the use of a UR5e collaborative robot by Universal Robots, integrated into a CEMAS welding station for plastic articles. The primary objective is to automate the process of picking and placing pairs of parts inside the machine to achieve the final assembled article, thereby eliminating the need for human operators in this specific repetitive task. The assembly process involves two parts, with the lower part positioned in the lower section of the welding machine, and the upper part similarly placed, which, however, results as a non ergonomic action. Subsequently, upon machine activation, the doors are closed to ensure operator safety, and the welding procedure commences.

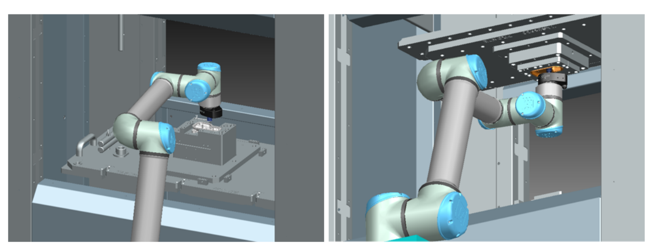

Fig. 1. Picking and positioning of parts in the lower (a) and upper (b) molds of the welding machine

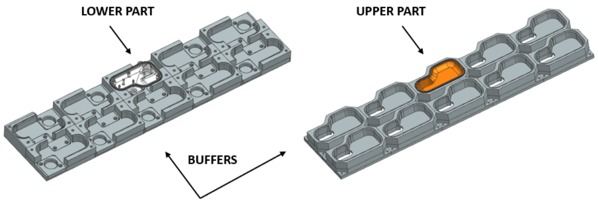

Fig. 2. Buffers for lower and upper parts

However, during this phase, the operator experiences idle time while waiting for the welding operation to conclude before retrieving the assembled parts and proceeding with subsequent tasks within the work cycle.

The fundamental concept underpinning this project involves the creation of a parts buffer as visible in Fig. 2 that enables the robot to operate independently until its stock is depleted. Through the utilization of a 3D printer, negative molds of the lower and upper parts were produced, effectively serving as storage for the robot. Additionally, simplified machine poses were fabricated to facilitate laboratory testing. A designated buffer position is established within the workspace, and subsequently, the robot is programmed to execute as many pick and place operations as there are pairs present in the buffer. Consequently, the operator's primary responsibility involves reloading the buffer whenever its stock is exhausted. Notably, the loading interval requiring the operator's intervention is directly influenced by the number of pairs stored in the buffer. A larger number of pairs in the buffer corresponds to longer intervals between operator interventions.

During the laboratory experiments, the robot was equipped with a Cognex camera. Leveraging the capabilities of the In-Sight Explorer software and proper calibration, the camera facilitated the definition of pick points for the parts. Subsequently, it supplied the robot with the necessary coordinates to reach these points with the appropriate gripping hand configuration. The camera's advantage became apparent when changes in the buffer's orientation or position in the workspace were detected. For the pick and place operations, the robot utilized a Vacuum Gripper by Robotiq.

From an economic point of view, conducting an analysis comparing the initial investment in purchasing the robot and various equipment with the resulting economic return yields clear insights. Originally, when the operator was responsible for batch production, the entire cost was attributed to their time spent on the batch. However, with the integration of the robot, the operator's time allocated to the batch becomes inversely proportional to the buffer size, as it depends on the buffer loading interval.

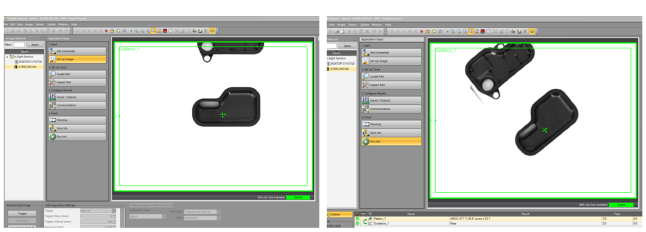

Fig. 3. Definition and identification of the part's pick-up point based on the changing position and orientation of the buffer

TABLE I
ANALYSIS OF TIMING OF THE ROBOTIZED WORKFLOW

Batch Type	**Buffers of 10 pairs**		
	Batch items	***Time Batch Op.***	***% Op. for Batch***
Non Robotized	1000	18,1 h	100,00%
Robotized	100	1,81 h	10,00%

In the case study, a time-saving of 90% as shown in Table I was achieved, leading to substantial cost savings in the overall batch production. As welding machines can be employed simultaneously on different batches, the potential for integrating additional robots arises, enabling one operator to manage multiple machines. This chain mechanism has the potential to generate significant profit for the company.

The economic benefits and efficiency gains demonstrated through this analysis showcase the viability of adopting collaborative robotics within manufacturing processes, leading to improved productivity and profitability for enterprises producing small and medium-sized batches, shifting human labor to tasks requiring mental skills. .

III. CONCLUDING REMARKS

The development and use of mobile collaborative robots in industry is indeed intended to benefit workers, not eliminate them. What is expected is a redefinition of human activities in a context of human-robot integration that will lead to higher-performance production and in some ways lighter for the worker. The collaborative dimension underlying the coming revolution will lead to a downsizing of workloads, freeing workers from the heaviest and most strenuous tasks. The operator is thus placed at the center of production according to the basic principles of Industry 5.0, securing a financial yield for businesses through the implementation of this innovative technology.

REFERENCES

[1] R. R. Galin and R. V. Meshcheryakov, "Human-robot interaction efficiency and human-robot collaboration," in *Robotics: Industry 4.0 issues & new intelligent control paradigms*. Springer, 2020, pp. 55–63.
[2] S. Proia, R. Carli, G. Cavone, and M. Dotoli, "A literature review on control techniques for collaborative robotics in industrial applications," in *2021 IEEE 17th International Conference on Automation Science and Engineering (CASE)*. IEEE, 2021, pp. 591–596.
[3] T. Kopp, M. Baumgartner, and S. Kinkel, "Success factors for introducing industrial human-robot interaction in practice: an empirically driven framework," *The International Journal of Advanced Manufacturing Technology*, vol. 112, no. 3, pp. 685–704, 2021.
[4] P. M. Bednar and C. Welch, "Socio-technical perspectives on smart working: Creating meaningful and sustainable systems," *Information Systems Frontiers*, vol. 22, pp. 281–298, 2020.
[5] G. F. Prassida and U. Asfari, "A conceptual model for the acceptance of collaborative robots in industry 5.0," *Procedia Computer Science*, vol. 197, pp. 61–67, 2022, sixth Information Systems International Conference (ISICO 2021).