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THE IMPLEMENTATION OF COBOTS IN AN AUTOMOTIVE PRODUCTION LINE

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Abstract: The automotive industry has experienced a continuous evolution in recent decades due to the rapid change in technology and the ever-changing demands of consumers. Thus, the automotive industry was forced to adopt innovative technologies and new methods in order to remain competitive and to make production processes more efficient. In the 1990s, a Kaizen-type approach was sufficient to increase performance, but in the current situation, an approach, adaptation and exploration of the potential from new perspectives is needed.
As part of the technological progress of recent years, the Cobot part is also integrated into the production lines. Collaborative robots known everywhere in the production lines of factories under the name of Cobots are descendants of robots and currently represent the most innovative solution that can bring substantial improvements in terms of efficiency, flexibility and quality of a manufacturing process.

Keywords: Lean Management, improvement, cobots

1 RESEARCH CONTEXT

In a promptly changing world, the automotive industry challenges increasingly significant trials in its quest to remain competitive and adjust to consumer demands. The production's success now axes on technology forward rapidly, with efficiency, quality, and flexibility come forward as key components.

The origins of Cobots can be tracked back to the evolution of robotics and revolutionary-edge technology. The word "Cobot" gains from "collaborative robot," and the idea of collaborative robots first surfaced in the 1990s.

Earlier the appearance of Cobots, robots were principally used in manufacturing applications that implied repetitive, risky, or substantial tasks but forced a physical separation between robots and humans. These usual robots, known as industrial robots, operated in inaccessible work areas and were detached from human operators by protection barriers.

But, with the innovation of technology and the requests of the industry, there was a raising emphasis on creating robots that might collaborate with human operators in the same space without the need for physical separation. This showed the moment when Cobots activated to gain acceptance and were specifically developed to accelerate human-robot cooperation.

The initial collaborative robots were proposed to the marketplace in the 1990s and remained considered by advanced care sensors and human existence detection facilities. These features allowed them to operate near human workers without posing a vulnerability to them. As well, collaborative robots stayed simpler to setup and align, enabling unlimited flexibility in their use thru several applications and production routes.

Over age, technological improvements continued to increase the capabilities and performance of collaborative robots. They befell more strong, specific, and flexible, opening up new chances in various businesses, containing the automotive industry.

Currently, Cobots are generally used in various grounds such as fabrication, logistics, health care, and much others. In the automotive manufacturing, Cobots are implicated in assembly activities, connecting, material processing, and numerous other operations, supporting to improved efficiency and quality in manufacture.

A Cobot is especially designed collaborative robot that succeeds along humans in a production atmosphere. Distinct of usual robots that are alone in a protection cell and do not directly interact with human operators, Cobots are produced to work in close proximity to humans, sharing the same workspace. They are equipped with advanced sensors and artificial intelligence algorithms that allow them to detect and respond to human movements and existence, confirming a secure and collaborative functioning environment.

The working of Cobots in an automotive production line gives several improvements. Firstly, Cobots can take over recurring, hazardous, or lowering tasks, releasing human operators for additional complex and valuable projects. This advantages to expanded productivity and overall process efficiency.

Secondly, Cobots are highly precise and consistent in task execution, reducing human errors and enhancing the quality of end products. They can also perform complex and delicate operations with high accuracy, ensuring consistency and reliability in production.

2 CASE STUDY - PROJECT X

After transitioning from traditional production to lean production, the next need that arose was to further optimize and streamline the production lines. To address this, a new project emerged, which will be presented in this case study.

2.1 Project definition

The future will be characterized by increasing product diversity and simultaneously reduced product cycles. At the same time, the customer's demand for high-quality and sustainable products is increasing. For Hirschmann Automotive (HA) this tendency stands for constantly decreasing production volumes with an ever-increasing number of variants. With delivery times steadily decreasing, the complexity of this trend is increasing from a manufacturing perspective. Human-robot collaboration (HRC) is a solution approach to

counter this trend in production. The goal of HRC is to combine the strengths of man and machine in an optimal way:

Human: flexibility

Robot: accurate and repetitive

The optimal use of collaborative robots (Cobot) is based on the following statements:

- Robot must be configured by trained employees.
- The robot software must be simple and intuitive.
- The time demand for robot changeover should not exceed ¼ of a working shift.
- The robot must be integrated into the mechanical circumstances

2.2 Scope and evaluation

The main purpose of the project is to effectively evaluate, implement, and expand the utilization of Cobots within HA's operations, with the ultimate goal of achieving enhanced efficiency, improved quality, and increased productivity.

The targets are as follows, delineated according to their specific focus:

Organize workshops with possible suppliers:

The objective is to arrange workshops where potential suppliers of Cobots can showcase their offerings and engage in discussions with HA. The objective is to estimate different providers, their capacities, and the rightness of their Cobots for HA's requirements.

Display possible function playing field of Cobots at HA and know key values:

The target is to identify and submit individual areas inside HA's operations, such as value, manufacture, or logistics, anywhere Cobots can be successfully applied. This concerns showcasing the possibility gains of Cobots, involving increased efficiency, increased quality, and improved production.

Describe criteria and conditions for the handling of Cobots and initiate a company case at HA:

The goal is to determine clear reasons and conditions for the assumption of Cobots at HA. This includes agreeing the mandatory capabilities, running metrics, and mixing aspects. Also, creating a business case requires evaluating the financial sustainability and anticipated return on investing for executing Cobots.

For the extra focuses of evaluating and view for further purposes, and implementing Cobot function for the "Bolzenklemmleiste" containing CE Certification:

Assessment and outlook for additional applications:

The point is to run a comprehensive evaluation of possible future efforts for Cobots beyond the initial identified areas. This involves evaluating other processes or jobs within HA's processes that could benefit from Cobot execution and considering the potential impact on productivity, efficiency, and value.

Implementation of Cobot application for the "Bolzenklemmleiste" including CE Certification:

The objective is to successfully implement a Cobot application precisely for the "Bolzenklemmleiste" process, which entails the use of Cobots for the run wheel clamp operation. The execution process should submit with the necessary CE Certification conditions to ensure protection and directing compliance.

By adopting these intentions, HA aims to effectively estimate, implement, and multiply the deployment of Cobots within its operations, reaching superior efficiency,

advanced quality, and intensified productivity.

The following risks need to be identified:

Unusual time investment by the involved departments

There is a possibility that the execution of Cobots may need a significant volume of schedule and effort from the involved departments. Assigning appropriate reserves and effective time management will be crucial to avoid waits or overloading the departments.

Interruption due to arrangement of work dimensions in other projects:

There is a possibility that the performance of Cobots may be postponed due to the prioritization of work dimensions for other projects. It is essential to ensure appropriate resource organization and effective organization between projects to avoid waits in Cobot implementation.

Acceptance of Cobot technology:

There is a risk of resistance or lack of enthusiasm in accepting and adopting Cobot technology by team and the management crew. Providing enough training, collaborating the benefits, and demonstrating the efficiency and safety of Cobots will be necessary in gaining agreement and necessary support.

Great capital investment at the starting of technology application:

Implementing Cobots contains a substantial initial investment in obtaining the robots, configuring and installing them, as well as training the staff. A careful evaluation of costs and long-term profits is necessary to justify the investment and confirm accurate financial planning.

Absence of knowledge in CE certification and risk evaluation in Cobot system use:

The exploitation of Cobots needs compliance with specifications and regulations, involving CE certification and risk assessment. Absence of experience in this area can establish a risk, and adequate training and consultation will be mandatory to confirm compliance and safety in Cobot utilization.

Inability to meet all requirements

There is a possibility that certain requirements or expectations may not be fully met in the implementation of Cobots. It is important to clearly define objectives and requirements while maintaining flexibility in adapting plans and strategies to ensure the desired outcomes are achieved.

To manage these risks, a proactive and well-planned approach is essential. Thorough identification and evaluation of risks will enable the implementation of appropriate measures for their management and reduction, ensuring the success of the Cobot implementation project.

The utilization of Cobots brings forth several advantages, each with its specific focus and impact:

Fast and cost-efficient application in the relevant field: By employing Cobots, organizations can experience accelerated and cost-effective implementation in their respective fields. The versatility and adaptability of Cobots enable swift integration, reducing the time and resources required for deployment.

Execution of monotonous work steps with consistent quality: One notable benefit of using Cobots is their ability to perform monotonous and repetitive tasks with unwavering precision and consistency.

These robots can execute such work steps tirelessly, ensuring a high level of quality and reducing the risk of human errors or fatigue-related deviations.

Utilization of work capacities in prioritized areas (Avoidance of bottlenecks): Cobots offer the advantage of effectively utilizing work capacities in prioritized areas. By deploying these robots, organizations can allocate human resources strategically, focusing on critical tasks that require human expertise while delegating repetitive or less complex tasks to Cobots. This allocation helps prevent bottlenecks and optimizes overall operational efficiency.

Loading of machines 24/7 independent of work shifts: Another significant benefit of utilizing Cobots is the ability to load machines continuously, without being bound by traditional work shifts. Unlike human workers, Cobots can operate around the clock, maximizing the utilization of equipment and minimizing downtime. This flexibility enhances productivity and enables continuous production, leading to increased output and reduced production time.

2.3 Project Schedule – Milestone 1

Project schedule serves as a roadmap, guiding the project team through the planned activities and milestones, facilitating coordination, resource allocation, and timely completion of tasks to achieve project success. Also an analysis was done for the budget and working hours as we can see in the below figure. The purpose of establishing milestones in a project schedule is to provide a clear and measurable indication of progress, helping to track the project's timeline, identify any delays or issues, and ensure that the project stays on track towards its ultimate goals. Milestones (MS) also serve as points for evaluation and decision-making, allowing project stakeholders to review progress and make informed decisions about the project's direction and next steps.

Project Plan	Start date:	02.02.2021
	End date:	28.02.2023
	Completion of MS1:	28.02.2021
	Completion of MS2:	30.04.2021
	Completion of MS3:	31.07.2022
	Completion of MS4:	31.10.2022
	Completion of MS5:	28.02.2023
Budget	Total project budget:	€ 99.941,80
	Machine budget:	€ 30.000,00
Hours	Estimated hours:	615h
	Machine hours:	h

Source: Hirschmann Automotive

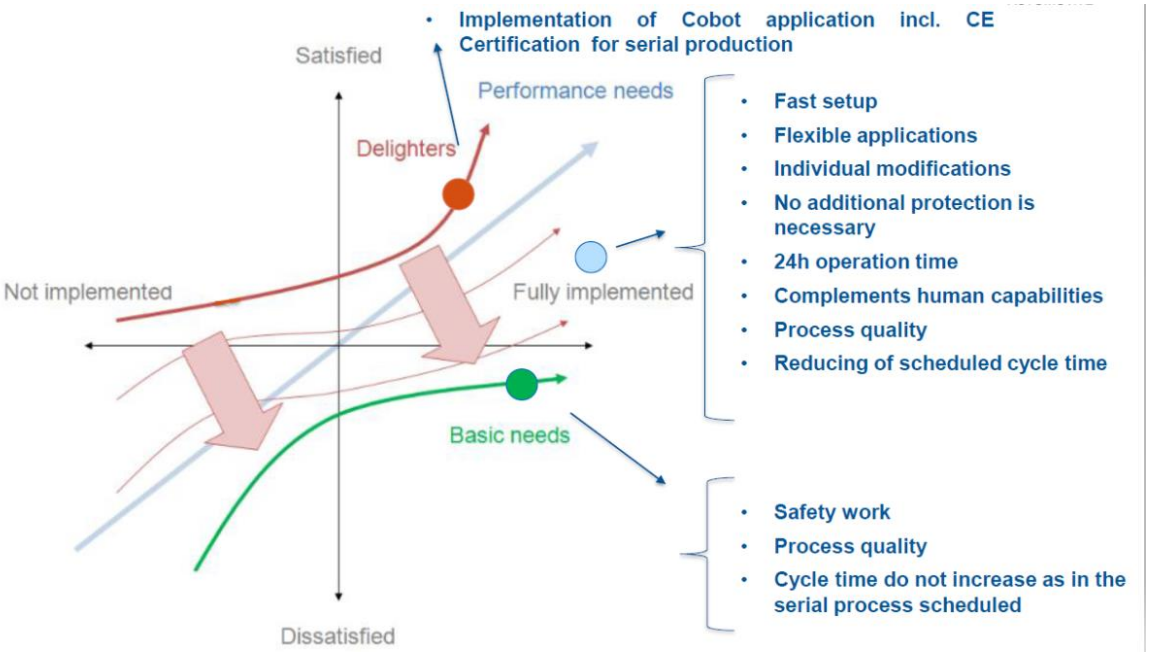
Figure 1. Project definition

2.4 Milestone 2 – IDENTIFY

To identify the needs and expectations of customers regarding Cobots, careful analysis and effective communication with relevant customers and stakeholders were conducted. The key steps taken to understand the customer`s needs and expectations regarding Cobot implementation were as follows:

- Conducting market research to understand current industry trends and needs and identifying similar companies that use Cobots to understand their reasons and benefits for implementation.
- Consulting industry experts, robotics consultants, and specialized engineers to gain valuable perspectives and insights into Cobot implementation.
- Studying and analyzing competitors to understand how and to what extent they utilize Cobots.

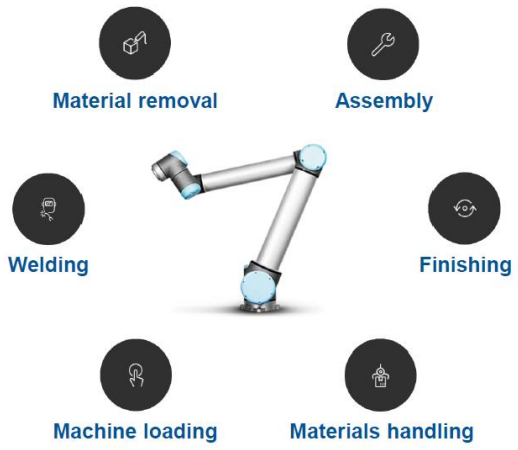
Based on this information, was created Figure 2.



Source: Hirschmann Automotive

Figure 2. Customer expectation

Following market research, participation in specialized trade shows, customer expectations, and, last but not least, identifying areas within the production process where the implementation of Cobots would be profitable, we have reached the definition of the internal need and what the Cobot application should possess.



Source: Hirschmann Automotive

Figure 3. Cobot application

2.5 *Milestone 3 - DESIGN*

In order to achieve a customized design, the method pursued towards reaching the desired goal was:

- Selection of potential partners
- Identification of potential applications together with the suppliers
- Workshops in production together with suppliers

2.6 *Milestone 4 - OPTIMIZE*

Several tests were conducted in the logistics department, quality areas within the analysis laboratories, and in production. Lines with potential were identified; however, from a cost perspective, implementing Cobots is not profitable in all cases. For example, in one of the process cases below, the potential exists but it is not a priority:

- Laser marking process
- Laser welding process
- Loading of injection molding machines

➢ Deposit of parts in blisters

During the workshop was done a feasibility analysis for 7 processes and the results help us to make a prioritization for Cobot implementation.

possible applications	Process	Integration Capability	ROI (Estimation/ good guess)
Process 1: Potential Distributor	• welding • leak measurement and • laser marking.	need of resolving some issues	+++
Process 2: Terminal Block	• welding • seal assembly	+	++
Process 3: Seal Assembly	• seal assembly	++	+ (scalable to similar processes)
Process 4: Housing Assembly	• housing assembly	Process is much harder to develop and integrate	Processes is not considered in this estimation
Process 5: Cable Assembly	• cable assembly	Process is much harder to develop and integrate	Processes is not considered in this estimation
Process 6: HV Assembly Heat Shrink Tubing	• assembly	Process is much harder to develop and integrate	Processes is not considered in this estimation
Process 7: Connector Over molding	• over molding	Process is much harder to develop and integrate	Processes is not considered in this estimation

Source: Hirschmann Automotive

Figure 4. Evaluation of variants

Comments regarding feasibility of the process:

Process 1: Potential Distributor -> Affected processes at the areas of welding, leak measurement and laser marking.

The handling of the components it is easy to implement, and the connection to the machines should also be easy to map with socket connections.

All work steps can be automated by a robot in one concept. A new layout plan is required.

Source: Hirschmann Automotive

Figure 5. Potential Distributor line

Process 2: Terminal Block - Affected processes at the areas of welding and seal assembly. (weld terminal and seal press on aluminum sleeves)

Process has to be split. In the second process step, the aluminum sleeves can be handled, and the pressing process can be automated. It must be ensured that the aluminum sleeves can be made available to the robot system in a tray with fixed positions.

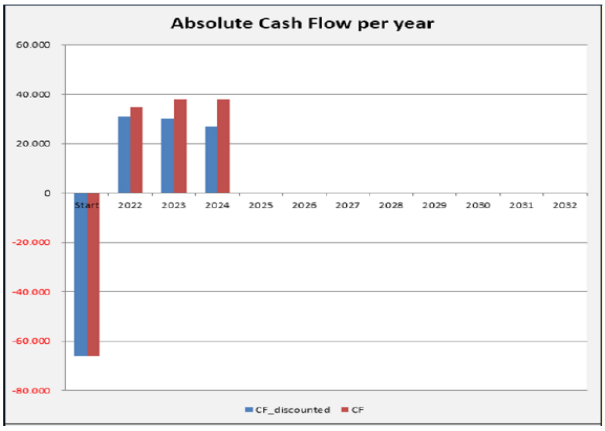
Source: Hirschmann Automotive

Figure 6. Terminal Block line

Process 3: Seal Assembly- Gasket assembly Can easily be automated. The communication to the participant of the seal supply must be guaranteed. In addition, trays are needed that can be loaded by the robot.

Economic KPIs @ i=0,12:	
NPV @ beginning of 2022	22.018 EUR
DCF Payback/Breakeven after	2,18 years
Nominal Payback/Breakeven after	1,83 years
Internal Interest Rate of Return (IRR)	30,27%
Return on Investment	167,13%

calculation basic values:	
total invest (machines, devices, tools, one time costs)	66.000 EUR
total benefits	110.307 EUR



Source: Hirschmann Automotive

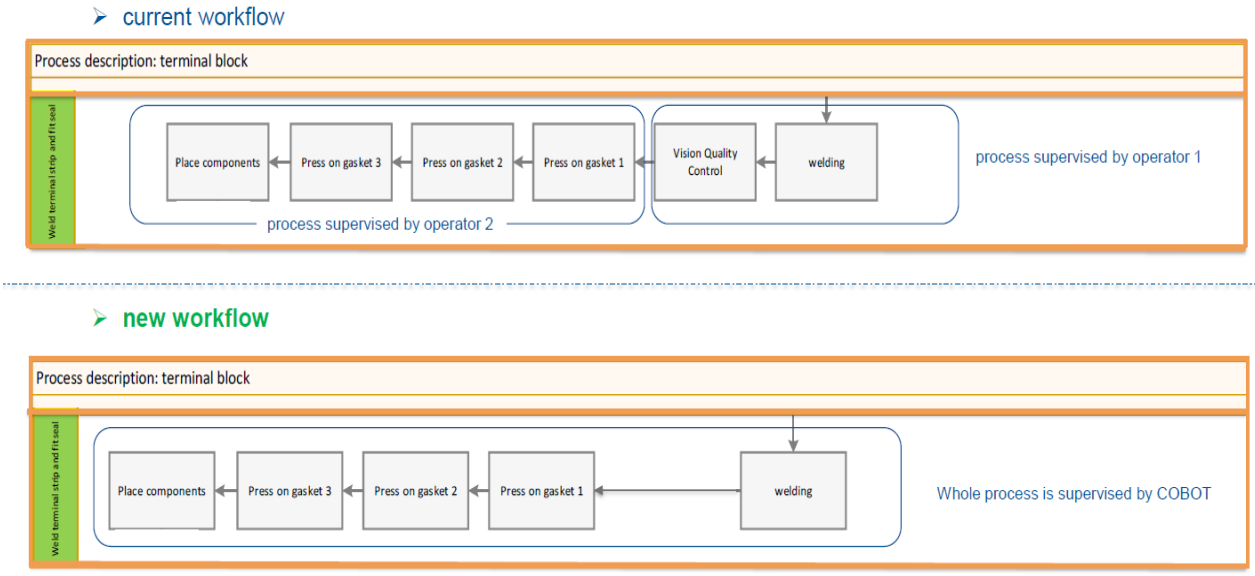
Figure 7. Financial assessment

2.6.1 Cobot – Application/ Return of investment (ROI) for line 9E -> Process number 2 -Terminal block.

To take the decision and create an overview, several options were considered within the group's factories, where we analyzed the cost implications of transferring this line and the impact of implementing Cobots without knowledge and experience. A comparison was made between the afore mentioned cost factors in euros and the investment payback period. The final conclusion was that the line will remain in Romania and the investment will be recovered in 3 years.

2.7 Milestone 5- VALIDATE

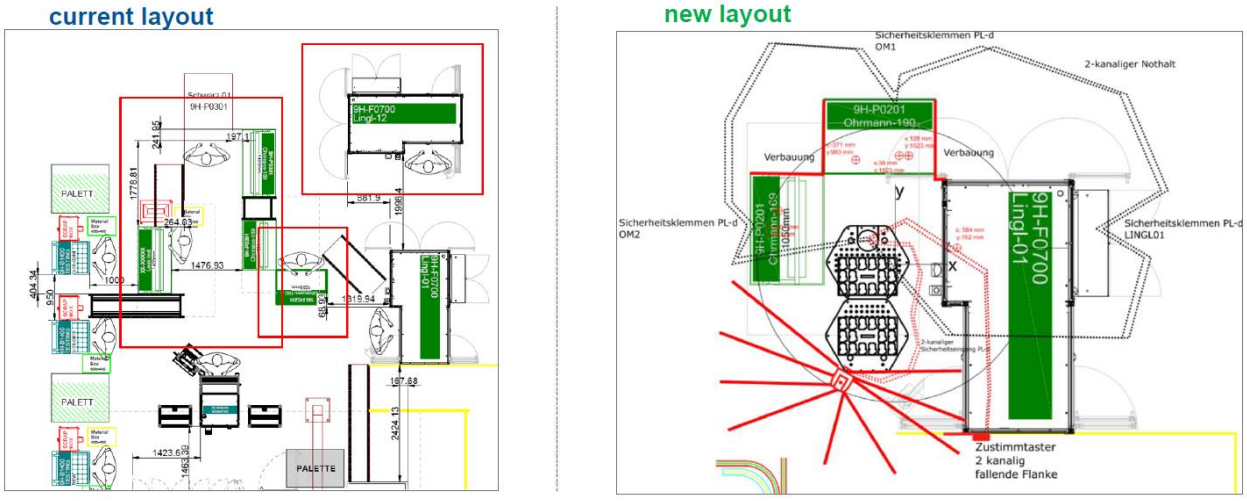
The entire process was carefully analyzed, leading to modifications in multiple areas. The first area that underwent changes was the production flow, where the visual product inspection step was eliminated, eliminating the need for an operator to oversee the line.



Source: Hirschmann Automotive

Figure 8. Current & new workflow

As a result of the well-thought-out modifications, the need to optimize the layout arose, thus minimizing the footprint of the production line and allowing the possibility of repurposing the remaining space for other purposes.



Source: Hirschmann Automotive

Figure 9. Current & new layout

2.8 Summary

As a summary for the below criteria the key benefits are:

criteria	key benefits	
	serial production	COBOT application
flexibility	0	+ +
number of operator	2	0
cycle time	42s	38s
process quality	+	+
execution of monotonous work steps with consistent quality	-	++
gained knowledge (automation of processes with the help of cobots)	-	+++

Source: Hirschmann Automotive

Figure 10. Summary

2.9 Results

The goal of the project presented in this case study has been achieved, and the initial implementation of a Cobot on a production line at the Mures factory has been accomplished.

The following targets were achieved:

- Organize workshops with possible suppliers ✓
- Show possible application fields of Cobots (e.g., in quality, production, or logistics) and understand key
- Benefits ✓
- Define criteria and requirements for the use of Cobots and create a business case at HA. ✓
- List of different robot suppliers (specifications etc.)

3 CONCLUSION

The implementation of Cobots in an automotive production line has proven to be a transformative solution, addressing the evolving challenges faced by the industry. By adopting these collaborative robots, manufacturers have been able to optimize their production processes, enhance efficiency, improve quality, and adapt to changing consumer demands. Prior to Cobots, industrial robots were primarily used in applications involving repetitive, hazardous, or heavy tasks that required physical separation from human operators. Nevertheless, with the increases in technology and industry requirements, the focus moved towards creating robots that can collaborate with human operators in the equal workspace, reducing the need for physical separation. This event marked the emergence of Cobots, particularly designed to collaborate with humans and share the same workspace. The initiation of Cobots into the automotive industry has brought about notable benefits. Primarily, Cobots can take over cyclic, hazardous, or substantial tasks, freeing up human operators for additional complex and value-added tasks. This improves productivity and agrees for more efficient operation of human resources. Furthermore, Cobots show precision and stability in task execution, leading to a reduction in human errors and increased product quality. They can execute complex and fragile operations with extraordinary accuracy, guaranteeing uniformity and reliability in manufacture.

Above time, technological developments have advance improved the capabilities and performance of collaborative robots. They must enhance more deep, precise, and adaptable, opening up new occasions across several industries, including the automotive sector. Currently, Cobots are usually used in assembly, welding, material processing, and other operations within the automotive fabrication line, contributing to increased efficiency and quality. The performance of Cobots needs sensitive consideration of buyer needs, shop trends, and cost-effectiveness. Across market research, customer response, and analysis of production processes, the probable benefits and viability of Cobot implementation can be reviewed. This includes calculating the return on investment, discovering suitable tasks for Cobots, and improving the production arrangement for their integration.

As resumee, the implementation of Cobots in an automotive manufacture line has proven to be a game-changer, transforming the industry's attitude to fabrication processes. By leveraging the qualifications of collaborative robots, producers can achieve better efficiency, improved quality, and better flexibility in assignation consumer demands. As technology continues to proceed, the future holds even more possibilities for Cobots, assisting further innovation and progress in the automotive manufacturing.

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