# The Industry of the Future: From Industry 4.0 to Industry 5.0 – Integration of Humans and Technology: New Technologies

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# Integration of Robotic Technology and Human Creativity: from Automation to Humanization

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***Abstract:*** *It is well known that with the emergence of Industry 4.0, the focus was placed on the digitalization and automation of industrial processes through technologies such as the Internet of Things (IoT), Big Data, artificial intelligence (AI) and robotics, which led us in the direction of smart production processes with the goal of ''smart factories''. Unlike Industry 4.0, Industry 5.0 emphasizes the importance of humanization of technology, where people and robots work together in a harmonious environment. The paper examines whether advanced robotic technology can be synergistically integrated with human creativity to create more efficient, innovative and sustainable production practices. The paper explores the key elements that enable the integration of robotic technology and human creativity, including collaborative robots (cobots), artificial intelligence that supports creative processes and advanced sensor systems. Collaborative robots, designed to work safely alongside humans, take over routine and physically demanding tasks, freeing up time for workers to focus on creative and strategic activities. AI technologies analytically support human decisions, enabling faster and more informed innovation. Ethical and safety aspects of robotic technology integration are discussed, emphasizing the need for a transparent and responsible approach. The application of robotic technology in industry brings significant benefits, including increased productivity, cost reduction, improved worker safety and more sustainable development. The key to the success of Industry 5.0 is in creating a balanced synergy between technology and human creativity. By harmonizing automation with humanization, industry can achieve new levels of innovation and efficiency, adapting to the dynamic needs of the global marketplace. This approach ensures not only technological progress, but also social responsibility, thus laying the foundations for a sustainable and prosperous future for the industry.*

***Keywords:*** *Industry 4.0, Industry 5.0, automation, humanization, human creativity.*

## 1. Introduction

The fourth industrial revolution ''Industry 4.0'' brought a revolution in industrial processes, with the introduction of automation, digitization and smart

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technologies. This concept is based on the use of the Internet of Things (IoT), artificial intelligence (AI), Big Data analytics, virtual and augmented reality (AR), cloud computing, advanced sensors and advanced robotics to optimize production activities [1,2]. However, with the growing advancement of technology and increasing awareness of the importance of human resources, a new concept is emerging - Industry 5.0, which focuses on the synergy between technology and human creativity. The integration of robotic technology and human creativity represents a key step in the evolution of industrial practices. While automation and digitization have enabled a significant increase in efficiency and cost reduction, Industry 5.0 introduces an element of humanization, where humans and robots work together in a harmonious environment [3]. The goal is not only to optimize production processes, but also to create an environment where human workers can use their creative and intellectual abilities to innovate and improve product quality. Collaborative robots, known as cobots, are at the heart of this integration [4]. Designed to work alongside humans, collaborative robots take over routine and physically demanding tasks, freeing workers for more creative and strategic activities. Equipped with advanced sensor systems and artificial intelligence (AI), collaborative robots can collaborate with humans in real time, adapting to their needs and ensuring workplace safety [5]. Artificial intelligence also plays a key role in this integration. AI systems enable the analysis of large amounts of data, prediction of failures and optimization of processes, providing support to workers in making informed decisions. AI can also support creative processes, enabling faster research and development of new products and the adaptation of existing production lines to market demands. However, the integration of robotic technology and human creativity also brings certain challenges. It is necessary to ensure ethics and safety in the application of these technologies, as well as providing continuous education and training for workers to adapt to new technological requirements. It is also important to ensure transparency in the use of data and the protection of workers' privacy. In this paper, we will explore various aspects of the integration of robotic technology and human creativity, including the application of collaborative robots, AI systems, and advanced sensor technologies in industrial processes [6, 7]. We will analyze case studies from various industries that demonstrate successful examples of the implementation of these technologies. We will also consider ethical and safety aspects, as well as the challenges and opportunities that Industry 5.0 brings. The paper provides a comprehensive overview of how the synergy between technology and human creativity can improve industrial practices, increase productivity and innovation, and create a more sustainable and safer working environment [8, 9]. Industry 5.0 represents a step forward in the transformation of industrial processes, combining the benefits of automation with the unique capabilities of human creativity to achieve new levels of success.

## 2. Industrial Development from the First to the Fifth Industrial Revolution

The first industrial revolution began in Britain with the introduction of the steam engine (end of the 18th and beginning of the 19th century). This period is characterized by the transition from manual production to machine production, which led to mass production and urbanization. The second industrial revolution focused on the introduction of electricity, chemical processes and line production (late 19th and early 20th century). This phase enabled a further increase in productivity and efficiency, along with the emergence of new industries such as steel, oil and automotive. The third industrial revolution, also known as the digital revolution, brought the development of computers, electronics and information technology (mid-20th century). The automation of production processes using computers and robotics has enabled further efficiency gains and cost reductions. Industry 4.0 marks the fourth industrial revolution based on digitization and the application of smart technologies (beginning of the 21st century), as shown in Figure 1.[1,2,10] Key technologies include the Internet of Things (IoT), advanced sensors, additive technologies (3D Printing), artificial intelligence (AI), Big Data analytics, virtual and augmented reality (AR), cloud computing and advanced robotics, digital twins, etc. This phase enables real-time monitoring and optimization of production processes and predictive maintenance.

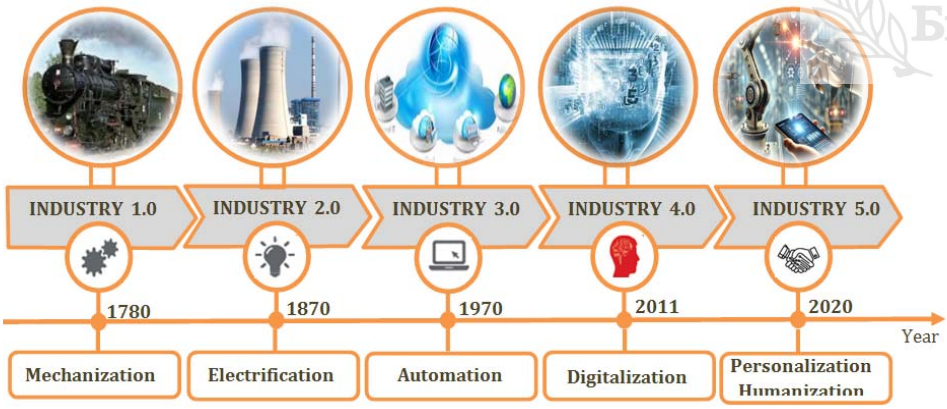


*Figure 1. Industrial development from Industry 1.0 to Industry 5.0*

Industry 5.0 builds on Industry 4.0, but emphasizes cooperation between people and smart systems (present and future) [11, 12]. Collaborative robots (Cobots) enable safe collaboration between humans and robots, by taking on repetitive and physically demanding tasks. Industry 5.0 also emphasizes the humanization of technology, sustainable development, product personalization, and ethical application of technology. From the steam engine to smart systems, industrial revolutions have enabled enormous leaps in productivity, efficiency, and innovation. Industry 5.0 represents the latest step in this evolution, combining technological advances with human creativity and ethics to create a more sustainable and prosperous future. Now, with the advent of Industry 5.0, we are witnessing a new era that emphasizes the synergy between people and smart systems [13].

## 3. Integration of Technologies and People, from Automation to Humanization

Industry 4.0 and Industry 5.0 are two concepts that represent different stages of industrial transformation, each with its own specific focus, advantages and disadvantages. To date, it is known that there are over 200 definitions of Industry 4.0 in the world, and we will single out one that says: *''Industry 4.0, also known as the fourth industrial revolution, focuses on the digitization and automation of production processes using technologies such as the Internet of Things (IoT), artificial intelligence (AI), Big Data analytics, robotics and cloud computing''* [1,2].
Industry 4.0 itself includes automation and digitalization through elements of connecting devices for data collection and exchange (IoT-internet of things), data analysis and decision-making (AI-artificial intelligence), processing of large amounts of data for process optimization (Big Data Analytics), storage and access data via the Internet (Cloud Computing) as well as automatic machines that increase precision and productivity (Robotics), as shown in Figure 2 [1, 14].


*Figure 2. Schematically presented vision of Industry 4.0 through elements of advanced technologies*

The implementation of Industry 4.0 in the company and its production processes brings a number of advantages, of which we will list a few:

- *Increased precision and accuracy of product manufacturing:* advanced sensors and AI enable precise control and reduce the risk of human error.
- *Flexibility:* Quick adaptation of production lines according to market needs and individualization of products.
- *Increased productivity:* Automation reduces production time and increases efficiency.
- *Predictive maintenance:* IoT and Big Data analytics make it possible to predict failures and plan maintenance before problems occur.
- *Reduced costs:* In the long term, automation reduces operational costs.

We are aware that every industrial revolution, in addition to its advantages, also has its disadvantages, so we will list only the most important ones:

- *Cyber security:* Connecting devices via IoT networks increases the risk of cyber-attacks.
- *High initial costs:* The very implementation of Industry 4.0 technologies requires significant initial investments.
- *Management completeness:* Advanced infrastructure and expertise are required to manage complex systems.
- *Social impact:* Automation can lead to job losses due to the replacement of people by robots.

The implementation of Industry 4.0 technologies (of which there are currently over forty-nine) is leading us towards smart production processes or ''smart factories'', which causes early job losses.This is where Industry 5.0 emerges, which builds on Industry 4.0, but emphasizes collaboration between people and smart systems (present and future) [15-18]. Let us highlight one of the definitions of Industry 5.0, which states: *''Industry 5.0 builds on Industry 4.0, emphasizing collaboration between humans and smart systems. It focuses on the humanization of technology, where humans and robots work together in a harmonious environment, using the advantages of both to achieve better results''*.The schematic representation of Industry 5.0 is shown in Figure 3.

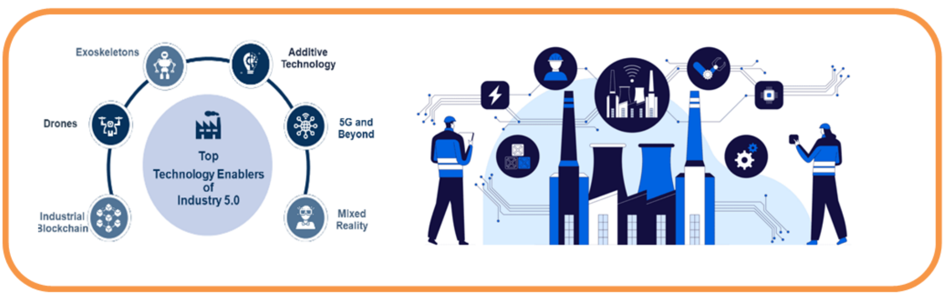


*Figure 3. Schematic representation of Industry 5.0*

Industry 5.0 is a newer concept that is being developed in response to Industry 4.0, with the aim of fully integrating people into technologically advanced production processes. While Industry 4.0 emphasizes automation and digitalization, Industry 5.0 goes a step further and focuses on collaboration between people and advanced technologies with an emphasis on sustainability, adaptability, and product personalization. One of the main goals of Industry 5.0 is to bring back human creativity and intelligence to production processes that were increasingly automated in previous industrial revolutions [18-20].

In Industry 4.0, robots and machines take over many tasks, while in Industry 5.0, humans and machines work together to create synergy, where technology helps to reduce monotonous tasks, while humans remain responsible for the creative and strategic component of production. Industry 5.0 emphasizes the importance of customizable and personalized solutions, which enable the production of products according to the specific needs of customers. The technology is not only a means to speed up processes, but also to create products that are better adapted to individual desires and market demands. Personalization is becoming essential as it enables rapid adaptation to market trends and end-user needs. Unlike previous industrial revolutions that focused on mass production, Industry 5.0 offers greater flexibility and sustainability. Products can be designed to be more environmentally friendly, using recycled materials or reducing their negative impact on the environment through smart technologies. As consumers become more environmentally conscious, Industry 5.0 also involves the development of sustainable business models that reduce waste and promote a circular economy. From a technical perspective, Industry 5.0 uses advanced tools such as artificial intelligence and data for predictive maintenance, production optimization, and smart product development [21-23]. For example, in the automotive industry, robots and data analysis systems can work together with humans to create vehicles that are fully customized to the needs of end users, while humans contribute creative ideas for design and innovation. An important aspect of Industry 5.0 is also the social dimension. This production model aims to improve the quality of jobs by creating work environments that better support human creativity and health. Automation can take over physically demanding or dangerous tasks, while humans can work on higher-level, intellectual tasks, reducing stress and increasing worker satisfaction. Industry 5.0 also supports the development of intelligent ecosystems in which different industries are connected through smart networks, which leads to increased efficiency and reduced resource consumption. This integrated approach enables better planning, faster response to market changes, and reduced time to develop new products [24-26].

From the very definition of Industry 5.0, we see that it emphasizes collaboration between people and smart systems, which is reflected in the key components:

- *Humanization of Technology:* Industry 5.0 emphasizes the importance of humanizing technology, ensuring that technological advances contribute to human well-being. This includes adapting technology to the needs of workers, improving working conditions, and ensuring the ethical use of technology.
- *Integration of AI and Human Intelligence:* Artificial intelligence supports people in their daily tasks, analyzing large amounts of data, and providing informed recommendations. AI systems can suggest innovative solutions and improvements, while humans make final decisions based on their intuition and experience.
- *Personalization and Adaptability:* Industry 5.0 enables greater personalization of products to specific customer needs. Flexible manufacturing systems allow for rapid adaptation of production lines to respond to changing market demands.
- *Collaborative Robots:*Cobots are designed to work alongside humans in a safe and flexible work environment. Rather than replacing human workers, cobots take on repetitive and physically demanding tasks, allowing workers to focus on creative and strategic activities. This collaboration increases worker productivity and satisfaction.
- *Safety and Ethics:* Industry 5.0 emphasizes the importance of worker safety and the ethical application of technology. Transparency in data use, privacy protection, and the promotion of ethical standards are becoming key aspects of modern industrial practices.
- *Sustainable Development:* The integration of smart systems and human creativity enables more efficient use of resources, waste reduction, and energy consumption optimization. Sustainable approaches to production are becoming a key part of Industry 5.0, reducing the ecological footprint of industrial activities.

Industry 5.0 represents a step forward in the evolution of industrial processes, combining the advantages of digitalization and automation with the unique capabilities of human creativity. Through the synergy of technology and people, Industry 5.0 aims to create more efficient, innovative and sustainable production practices, thus laying the foundation for a prosperous future. Industry 5.0, emphasizing cooperation between people and smart systems, focuses on the humanization of technology, where people and robots work together in a harmonious environment. Its advantages are many, including the following:

- *Human-robot collaboration:* Collaborative robots work together with people, taking over routine tasks and allowing workers to focus on creative activities.
- *Worker safety:* Robots take over dangerous tasks, reducing the risk of injury.

- *Increased creativity:* Collaboration with smart systems encourages innovation and adaptability.
- *Personalization:* Greater ability to adapt products to specific customer needs.
- *Sustainable development:* Industry 5.0 technologies contribute to reducing the ecological footprint and better use of resources.

There are also some weaknesses of the implementation of Industry 5.0, some of which are:

- *Education and training:* Continuous education of workers is required to work with advanced technologies.
- *Complexity of integration:* The integration of people and smart systems requires sophisticated infrastructure and mutual coordination.
- *Ethics and Privacy:* Ethics and privacy issues become more complex with greater integration of technology.
- *High initial costs:* As with Industry 4.0, implementation requires significant investment.

Industry 5.0 brings revolutionary changes in the way we produce, consume and develop technologies. With an emphasis on human-machine collaboration, personalization, sustainability and social responsibility, this model represents an evolution towards a smarter, more sustainable and more flexible industrial future [2,27].

Today's automation includes Industry 4.0 technologies such as artificial intelligence, the Internet of Things (IoT) and smart systems, which enable precise management of production processes and real-time analysis. These technologies improve productivity, reduce costs, improve efficiency and increase product quality.

Digitization of production processes is the process of converting analog information into digital format. In industry, this means using sensors and IoT devices to collect data from production lines and analyze it through software platforms. Digitization enables real-time monitoring of production processes, identification of potential problems and optimization of production lines. Industrial and service robots are key elements of automation in industry. By using advanced robots, production processes become faster, more precise and more efficient. Robots can perform repetitive tasks with high accuracy, reducing the possibility of human error and improving product consistency [28-30]. Automation enables 24/7 work without the need for breaks, which significantly increases production capacity. Robots can work in dangerous or difficult conditions, reducing the risk to workers and allowing people to focus on more complex and creative tasks. Using digital tools and sensors, companies can predict breakdowns and perform timely maintenance, thereby reducing production downtime and extending service life. In the long term, automation reduces operational costs by reducing the need for manual work, optimizing the use of resources and reducing the number of failures. Automated systems can quickly adapt to changes in production requirements, enabling companies to respond to market changes and personalize products according to customer needs. These advances enable industries to be more competitive and adaptable in a dynamic global marketplace. Industry 4.0 and Industry 5.0 bring significant advantages for production processes, but also present certain challenges [33]. While Industry 4.0 focuses on digitization and automation, Industry 5.0 strives to harmonize technology and human creativity. A combination of these approaches can lead to more comprehensive progress, enabling industries to be more productive, innovative and sustainable.

## 4. Integration of Robotic Technology and Human Creativity

In order to talk about the integration of robotic technology and human creativity, we must examine the trend of implementing both industrial and service robots in the world in all segments of society. In order to do so, an analysis was made based on statistical data obtained from the International Federation of Robotics (IFR), the UN Economic Commission for Europe (UNECE) and the Organization for Economic Cooperation and Development (OECD). The annual trend of the implementation of industrial robots in the world is shown in Figure 1 [33, 34, 35-38].

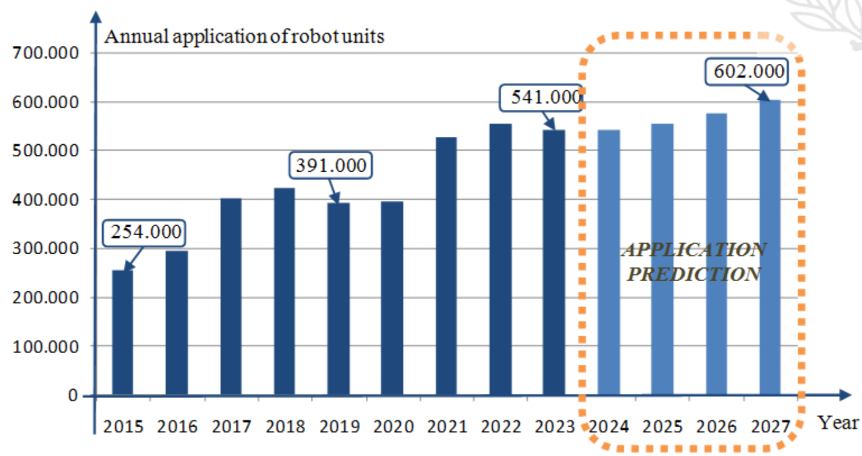


*Figure 4. Annual application of industrial robots in the period 2015-2023 and predictions of application until 2027*

The diagram shown in Figure 4 gives us an insight into the use of industrial robots in the period 2015-2023, based on which we can see an increase in use on annual basis. 254.000 robots units were used in 2015, while 541.000 robot units were used in 2023, which indicates an increase of 2.1 times in nine years. We notice that the decline in use occurred during the CORONA virus in the period 2019-2020, where the use was around 391.000 robot units. It is predicted that the use of industrial robots will continue to increase in the period 2024-2027, so that the use of about 602.000 robots is expected in 2027. This trend in the application of industrial robots can be attributed to the implementation of Industry 4.0, and robotic technology as one of its basic technologies without which it would be unthinkable to implement Industry 4.0 [33, 34, 35-38].

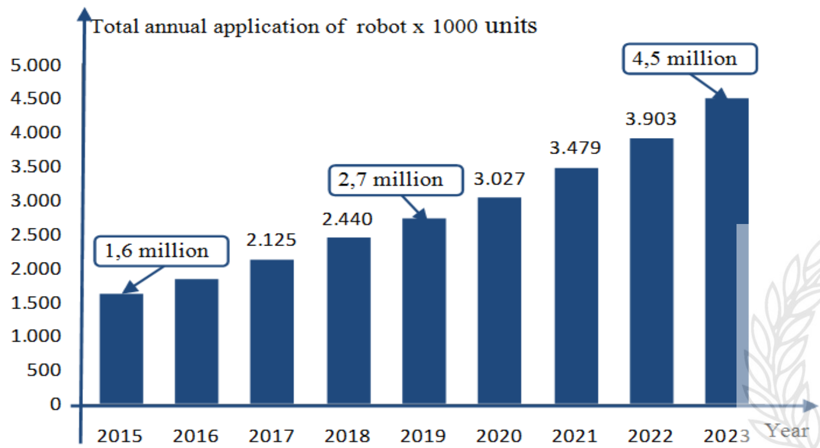


*Figure 5. Total annual application of industrial robots in the period 2015-2023*

The trend of total annual application of industrial robots in the world for the period 2015-2023 is growing annually, from a total of 1.6 million robot units implemented in the world in 2015 to 4.5 million robot units implemented in 2023. The increase was 2.8 times in just nine years. It is predicted that the total annual application of both industrial and service robots will increase in the coming years, as companies around the world are in the process of complete automation of processes in all industrial branches. The development and implementation of advanced technologies such as: advanced materials, advanced sensors, AI-artificial intelligence, Internet of Things (IoT), Big Data analytics, and cloud computing leads to the development and implementation of the second-generation industrial robots – collaborative robots whose application increases every year, as shown in Figure 6 [36,37]. Figure 6 shows the trend of the use of collaborative industrial robots in the world and in China for the period 2017-2022. In 2017, 11.000 units of collaborative robots were used. With the numbers constantly rising every year, in 2022 this amount increased to around 55.000 units of collaborative robots used in the world.

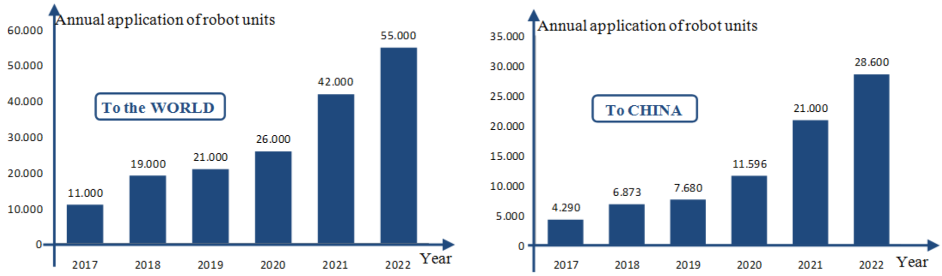


*Figure 6. Annual application of the second-generation industrial robots ''Cobot'' in the period 2017-2022 in the world and in the country of China*

In six years, the increase in the use of collaborative robots in the world was five times greater.The largest use was recorded in China, which in recent years has become the leader in the use of robots in the world. In 2017, of the total use of collaborative robots in the world, 4.290 units were used in China, which represents about 39% of the use worldwide, while in 2022, this amount increased to 28.600 units of collaborative robots, which is 52% of the total world use of collaborative robots. The comparative analysis of the implementation ofthefirst-generation industrial robots and the second-generation industrial robots – collaborative robots in the world for the period 2015-2022 is shown in Figure 7 [33,34,35-38].

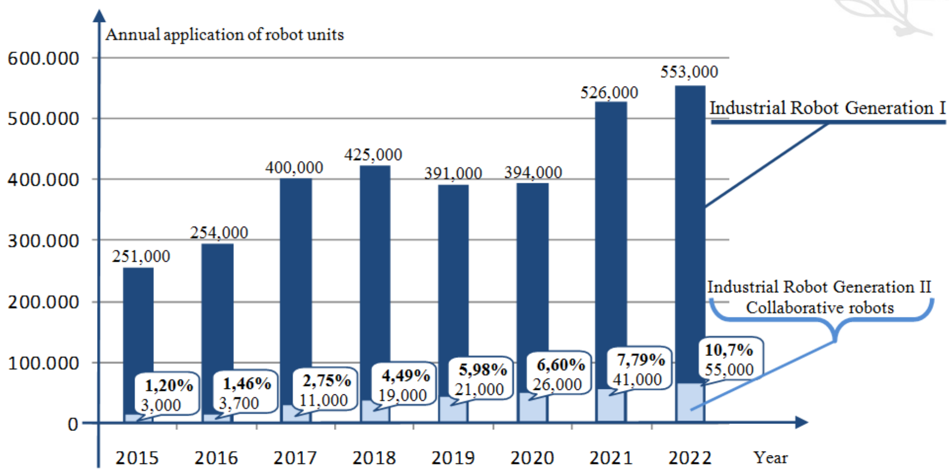


*Figure 7. Application ratio of the first-generation industrial robots andsecond-generation industrial robots ''COBOT'' in the world for the period 2015-2023*

We will present the comparative difference in the application of first-generation industrial robots and second-generation industrial robots – collaborative robots for the period 2015-2022. Out of the total percentage of industrial robot usein 2015, 1.2% goes to collaborative robots. In the following years, the percentage of the use of the second-generation of industrial – collaborative robots increased annually, so that in 2022 their use has increased to 10.7%. In just seven years, the increase in the use of collaborative robots was 8.9 times. It is expected that the use of collaborative robots in all industrial branches in the world will increase in the coming years. Collaborative robots in the robotics industry are currently the main topic of research in the world. The goal is for workers to work safely with robots, which will assist them in carrying out their daily tasks without any risk. It must be noted that collaborative robots are not intended to completely replace workers, but to work together with the worker and to remove the barriers in production processes that currently exist and confine first-generation industrial robots [39-41]. During work, a human can operate in different fields of work, and perform very complex operations and analytical tasks, while a collaborative robot is simple to operate, performs monotonous repetitive operations, can handle hazardous materials, as well as lift heavy objects. The differences between workers and robots are shown in Figure 8.

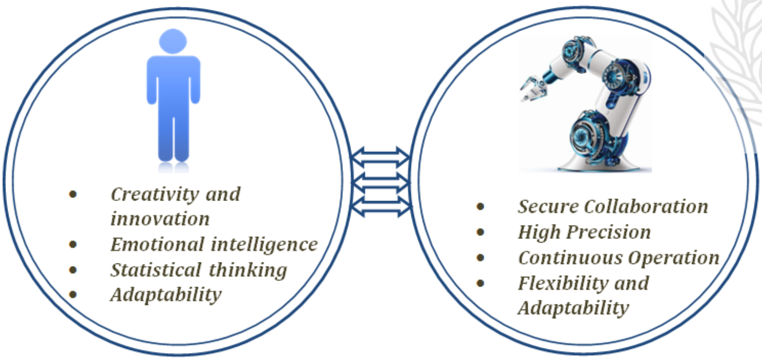


*Figure 8. Advantages of humans and second-generation industrial robots - collaborative robots ''Cobots'' [47-48]*

Humans possess creativity and innovation, emotional intelligence, strategic thinking and adaptability. The human ability to generate new ideas and innovative solutions is unparalleled. Creativity enables adaptation and improvement of existing processes and products. People can understand and respond to the emotions of others, which is essential for cooperation, teamwork and conflict resolution. Empathy and communication skills play an important role in the work environment. They can analyze complex situations, make long-term decisions and develop strategies to achieve goals. This ability allows companies to adapt to changing market conditions. People can quickly adapt to new situations and working conditions. Flexibility and the ability to learn new skills isthekey to success in a dynamic environment. In relation to humans, collaborative robots ‘’Cobots’’ have the following advantages: safe cooperation, high precision, continuous operation, flexibility and adaptability. Second-generation industrial robots ‘’Cobots’’ are designed to work alongside people, with advanced sensor systems that recognize the presence of people and prevent collisions. This ensures a safe working environment and reduces the risk of injuries. They can perform tasks with a high level of precision and repeatability [42-44]. This capability reduces the possibility of errors and improves product quality. Second-generation industrial robots can operate 24/7 without the need for breaks, thus increasing production capacity and efficiency. This capability enables continuous production and reducing downtime. Another advantage is that they can be quickly programmed to perform different tasks, thus enabling rapid adaptation of production lines to changing market demands. The synergy between humans and cobots creates an optimal working environment in which the advantages of both sides are combined. Humans bring creativity, emotional intelligence and strategic thinking, while cobots ensure safe collaboration, precision, continuous operation and flexibility. This combination allows industries to achieve greater productivity, innovation and adaptability, thus creating a more sustainable and competitive business model. The human ability to generate new ideas and innovative solutions is unmatched. Creativity enables the adaptation and improvement of existing processes and products [45,46]. The advantages of collaborative robots over workers and first-generation industrial robots include: *heavy lifting*– collaborative robots can lift loads weighing more than 20 kilograms, which reduces physical effort and the risk of injury to workers;*handling hazardous materials*– they can work with dangerous chemicals and high-temperature objects, which protects workers’health;*injury reduction*– the use of collaborative robots reduces the risk of injuries at work;*flexibility of application*– collaborative robots do not require fences, which reduces the required work surface to perform tasks;*high sensitivity*– they are equipped with advanced force, torque and visual sensors, which ensures a safe work space and protective zones (as shown in Figure 8 and Figure 9);they can recognize collisions, safely identify tools and monitor forces;*easy programming*– they are easily programmed for various tasks, which increases their flexibility; *adaptable work cycle*– the automatic work cycle of collaborative robots is flexible and easily adapted to specific tasks;*worker safety*– work safety is ensured in accordance with ISO 10218 and ISO 13849 standards, including functional safety and safe zones. Safe zones are maintained by monitoring the speed of the robot in relation to the distance from the worker.

Collaborative robots combine power, precision and sensitivity, thus enabling a safer and more efficient work environment for workers.

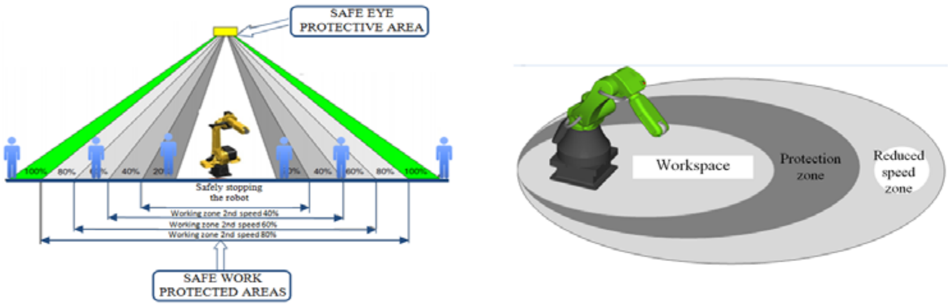


*Figure 9.Worker safety is ensured by reducing the robot's speed based on the worker's proximity, using FANUC's DSC – Double Safety System [48-52]*

The collaborative robot equipped with sensors is intended for direct interaction with human workers within a shared and predefined workspace. To ensure safety during such interaction, the company FANUC developed a Dual Check Safety (DSC) system, illustrated in Figure 9 [47–52]. This system utilizes laser sensors to provide an additional safety layer and regulate robot behavior accordingly.When the worker is outside the designated zones, the robot operates at its maximum programmed speed. Upon entering the speed reduction zone, the sensor sends data to the PLC, which then issues a command to decrease the robot's velocity. As the worker approaches further into the safety zone, the speed continues to drop, eventually triggering the "Contact Stop" mechanism.If the worker steps into the collaborative working area, the robot transitions into collaborative mode with limited speed, and the "Contact Stop" status remains active. In the event of physical contact—whether with the robot, the end-effector, or the workpiece—the system halts all operations immediately.Once the worker moves away, the robot resumes operation, adjusting its speed based on the current zone the worker occupies. These collaborative robots are covered with a soft, sensitive layer that ensures the machine stops whenever the applied contact force exceeds 150 N. This threshold can be modified via software settings to suit different application requirements. A visual example of this type of interaction is presented in Figure 10.


*Figure 10. The sensitivity of the collaborative robot for the safe work of workers [47-52]*

To prevent operational interruptions, the system allows the robot to automatically resume movement after a stop, adjusting its speed based on the worker's position within the workspace. Additionally, safety measures are in place to prevent hand injuries by ensuring that the space between the robot's axes does not pose a risk of pinching [49].

The implementation of collaborative robots offers a wide range of significant benefits, making them an increasingly attractive solution in modern manufacturing environments:

- *Safe human-robot interaction:* These robots are specifically designed to operate safely alongside humans within a shared workspace, ensuring a high level of occupational safety.
- *User-friendly operation:* Their intuitive programming and adaptability to various tasks make collaborative robots easy to set up and reconfigure as needed.
- *Enhanced productivity:* Task sharing between human workers and robots enables more efficient workflows, leading to a notable boost in overall productivity.
- *Scalable automation:* In situations where full automation is impractical or too costly, collaborative robots provide a flexible solution by allowing for partial automation within the production process.
- *Ergonomic improvements:* They can be deployed to assist in physically demanding or ergonomically unfavorable tasks, contributing to a safer and more comfortable working environment.
- *Integration with Industry 4.0:* Collaborative robots are a core component of Industry 4.0 initiatives, helping bridge the gap between physical manufacturing and digital technologies.

- *Adaptability to production changes:* Due to their ability to quickly adapt to new product designs and shorter product lifecycles, these robots are ideal for manufacturers who require versatile and responsive automation solutions. This flexibility has led to widespread adoption, especially among small and medium-sized enterprises.

These benefits show how collaborative robots can revolutionize industrial processes, and improve efficiency, safety and adaptability. The basis of the implementation of ‘’Industry 4.0’’ is robotic technology, that is, the implementation of collaborative robots in production processes. In order for the company to be competitive on the global market, it is inevitable that it must move towards the implementation of ‘’Industry 4.0’’, which will result in an increase in the use of collaborative robots. When applying collaborative robots, companies have the following motives: reduction of operating costs, reduction of capital costs, improvement of product quality and consistency, improvement of work quality for workers, respecting health and safety rules, increase of production rate, increase of flexibility in product production, saving of space, etc. It is to be expected that in the future the trend of use of collaborative robots will be growing. Collaborative robots, representing a key component of Industry 5.0, which focuses on the synergy between people and smart systems, brings a new approach, putting human creativity at the center of technological progress. The integration of technology and people has evolved through several phases, from basic automation to today’s humanization of technology. Each step of this evolution has brought significant changes in the way we work, increasing productivity and efficiency while improving working conditions. With the advent of Industry 4.0, technologies such as IoT, Artificial intelligence (AI) and Big Data analytics have transformed manufacturing processes. These technologies enable real-time monitoring, analysis, and optimization of operations, thereby increasing efficiency and reducing downtime. Automated systems can operate 24/7, increasing production capacity. Industry 5.0 introduces the concept of humanizing technology, where the emphasis is on collaboration between people and smart systems. Collaborative robots (cobots) enable safe collaboration with humans, taking over repetitive and dangerous tasks, while workers can focus on creative and strategic activities. This synergy increases productivity and worker satisfaction. The evolution from automation to humanization of technology shows how technological progress can be successfully integrated with human creativity and ethics. The synergy between people and technology not only improves efficiency and productivity, but also creates a more sustainable and safer work environment, laying the foundation for future industry development.

## 5. Integration of the Balance Between Technology and Human Creativity

Integrative cooperation of humans and robots in industrial processes can significantly increase innovation and efficiency. The key way in which this can be achieved is through implementation in production processes: collaborative robots, advanced artificial intelligence, the Internet of Things (IoT), learning and discovery, adaptability and personalization, security and ethics. Collaborative robots are designed to work alongside humans in a safe and flexible environment. They take over repetitive and physically demanding tasks, allowing workers to focus on creative and strategic activities. This collaboration increases productivity and reduces the possibility of errors. AI systems can analyze large amounts of data in real time, providing valuable insights that support informed decision making. AI can recognize patterns and trends that human workers might not notice, enabling faster and more accurate innovation. IoT connects devices and systems within production lines, enabling real-time data collection and analysis. This connection enables better process monitoring and optimization, reducing downtime and improving overall efficiency. Continuous education and training of workers to work with advanced technologies is the key to successful integration. Workers must understand how to use technology to support their daily tasks and how to collaborate with robots in a safe and efficient manner. Flexible production systems enable rapid adaptation to changing market demands and product personalization. The combination of human creativity and robotic precision enables the creation of innovative products tailored to specific customer needs. Safety measures such as advanced sensors and automatic stops ensure a safe working environment. In addition, the ethical application of technology and transparency in the use of data is the key to building trust between workers and consumers. The synergistic integration of humans and robots allows industries to leverage the best of both worlds: robotic precision and efficiency, and human creativity and adaptability [49-52]. This collaboration not only improves productivity, but also fosters innovation, creating more sustainable and dynamic industrial processes.

Balancing technology and human creativity is the key to creating more efficient and sustainable industrial processes. Here are some steps to achieve this:

- *Collaborative work:* Collaborative robots work alongside humans, taking on repetitive and physically demanding tasks. This frees workers to focus on creative and strategic activities.
- *Support for creative processes:* AI can analyze large amounts of data, provide insights, and suggest new ideas. AI supports creative processes, enabling people to make better-informed decisions and develop innovative solutions faster.

- *Flexible production systems:* Introducing flexible production lines that can quickly adapt to changing market demands allows for greater product personalization. The combination of technology and human creativity allows for the creation of products tailored to specific customer needs.
- *Investing in workers:* Ensuring continuous education and training for workers to adapt to new technologies is a key to successful integration. Workers who understand technology can better use it to support their creative tasks.
- *Resource optimization:* By using smart systems to optimize resource and energy consumption, industrial processes become more sustainable. Technology can help reduce waste and make better use of materials, while human creativity can lead to innovations that further reduce the environmental footprint.
- *Ethics in technology:* Ensuring that technology is used ethically and that data is protected is essential for building trust among workers and consumers. Transparency in the use of technology and protecting privacy are key elements of a safe work environment.
- *Encouraging collaboration:* Creating a culture that encourages collaboration between people and technology. Workers need to feel that technology is not a threat, but a tool that helps them do their job. Open communication and involving workers in the decision-making process increases their engagement and innovation.

Achieving a balance between technology and human creativity is essential for creating more efficient and sustainable industrial processes. Synergistic integration allows industries to leverage the best of both worlds - technological efficiency and human innovation - thereby creating more competitive and sustainable business practices.

The vision of the future integration of technology and people in industrial processes aims to create a harmonious, productive and sustainable work environment. Here are some key elements of this vision:

- *Collaborative work:* Smart systems and collaborative robots (cobots) will enable people to work with technology in a safe and efficient way. Robots will take over repetitive and dangerous tasks, while people will focus on creative and strategic activities. This symbiosis will increase productivity and worker satisfaction.
- *Adaptability and personalization:* The future of technology and people integration will enable greater personalization of products and adaptability of production processes. Technologies such as 3D printing, flexible production lines and AI systems will enable rapid adaptation to changing market demands and specific customer needs.

- *Sustainable development:* The integration of smart systems will enable more efficient use of resources, waste reduction and energy consumption optimization. Smart sensors and IoT technologies will enable real-time monitoring of the ecological footprint and process adaptation to achieve sustainable goals.
- *Continuous education:* Investing in education and training of workers will be a key factor for successful integration. Workers will need to continuously learn to adapt to new technologies and make the most of their capabilities. Education will also ensure that workers are safe and effective in their tasks.
- *Safety and ethics:* Worker safety will be a priority. The integration of smart systems will ensure that the work environment is safe and healthy. Ethics in the use of technology, data privacy protection and transparency will be key aspects that will build trust among workers and consumers.
- *Innovation and creativity:* Technology will support worker creativity, enabling faster and more efficient generation of new ideas and solutions. AI systems will analyze large amounts of data, providing valuable insights and encouraging innovations that will improve products and services.
- *Global collaboration:* Technology will enable better global collaboration among industrial partners. Through digital platforms, companies will be able to share information, collaborate on projects and work together on innovations regardless of geographical boundaries.

The vision of the future integration of technology and people is based on harmonious cooperation that improves the efficiency, innovation and sustainability of industrial processes. The synergy between technology and human creativity will create more competitive and sustainable business practices, ensuring a prosperous future for the industry.

## 6. Conclusion

The integration of robotic technology and human creativity is bringing about significant changes in industrial processes, moving from basic automation to the humanization of technology. Throughout the history of industrial development, from the first to the fifth industrial revolution, we have witnessed continuous progress that has enabled greater productivity, efficiency and safety in the workplace. Automation began with mechanical machines and first-generation industrial robots, enabling mass production and cost reduction. With the development of Industry 4.0, digitalization and smart systems such as IoT, AI and Big Data analytics have transformed production processes, enabling real-time monitoring and optimization. Industry 5.0 brings a new dimension, emphasizing collaboration between humans and smart systems. Collaborative robots (cobots) enable safe and efficient collaboration, taking over repetitive and dangerous tasks, while humans can use their creativity for more complex and strategic activities. This synergy increases productivity, innovation and worker satisfaction. The combination of robotic technology and human creativity creates flexible and adaptable production processes that respond to specific market needs. Integrating the balance between technology and human creativity ensures that industrial processes are sustainable, ethical and focused on long-term development. This paper highlights the importance of the evolution from automation to humanization of technology, highlighting how the harmonization of these aspects can advance industrial practices and create a more prosperous future. The synergy between people and technology not only improves efficiency and productivity, but also contributes to the creation of a more sustainable and safer work environment.

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