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DEHUMANIZATION AND HUMANIZATION IN THE CONTEXT OF INDUSTRY 4.0 AND INDUSTRY 5.0

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Abstract

Germany is considered in literature to be a cradle of the 4th Industrial Revolution. Industry 4.0 has been topical and awidely accepted term worldwide. Countries at the forefront of industrial development have invested significant resources in research, development and strategic initiatives to introduce Industry 4.0 technologies. On the tenth anniversary of the launch of Industry 4.0, the European Commission developed and published the Principles for the Industry 5.0 Strategy, which will lay the foundations for further economic and industrial development. The article presents the results of research based on a critical analysis of the literature and surveys, conducted among representatives of German society.

Keywords

Industry 4.0, Industry 5.0, Covid, human resource, education

INTRODUCTION

Every earlier industrial revolution fundamentally changed the nature of production. It is important to see that the development of technology made industrial revolutions possible, but their necessity was always started by the desire to satisfy the needs of customers. World industry is currently undergoing a transformation from mass production to mass modification of goods.

The driving force behind all industrial revolutions so far has been the growth of the world's population, leading to production of increasingly more products. This is how the steam engine and production lines appeared, and this is how we arrived at the automated mass production of Industry 4.0. From this point of view, Industry 4.0 is a special industrial revolution, because it has enabled production of enough products to satisfy the needs of the entire world. The question is, how to go ahead with the development of production. [1]

While production evolved, so did customer needs. During the first industrial revolution, increased productivity gave the wealthier upper classes a greater choice of purchases. The second and third industrial revolutions made more products available to the masses who previously had no or limited access to goods. The fourth industrial revolution has already made most products available worldwide to average customers. At the same time, the demand for unique products expressing an individual's personality, interests and wishes has increased. Industry 5.0 is trying to find a solution to the challenge above. In the emerging situation, it is important to define the difference between customized and personalized products. Customized products are configured and selected by the customer himself, while personalized products are individually recommended and made exclusively for particular customers, based on their preferences and shopping habits. The operation is evident when shopping online. There are increased examples as manufacturers realize customer demand and the business potential inherent in customized products. [2]

Examining the current development, complexity, and globalized nature of industry, we can conclude that the European industry is still a key driver of the economic and social transformations currently taking place in the world. However, it is necessary to consider the rapidly growing role of the Eastern world and the increasing competition. Today, the focus of industrial development in the East is slowly shifting from cheap labour to production the systems controlled by artificial intelligence, to the industrial enterprises equipped with robotic workplaces and to the companies supplying intelligent services. [3]

Another important aspect of previous industrial revolutions was how management treated the workers, and what management methodology was dominant in the given period. Before the first industrial revolution, production was typically organized by family businesses, so the workplace atmosphere was generally pleasant and friendly. This changed significantly during the first industrial revolution, and even more so during the second industrial revolution. More workers were needed to implement mass production, and, thanks to wild capitalism, the workers' situation was not much better than that of the ancient slaves. The only goal of the management was profit maximization; the workers were resources that could be replaced at any time. Of course, there were exceptions as well, but that was the trend in large industrial cities. The third and fourth industrial revolutions brought two changes in the role of workers. Firstly, the workers needed more serious knowledge to perform their work, so their value increased and it became more difficult to replace them. The other trend was the spread of the Lean philosophy, the basis of which is the involvement of the employee in the development of processes. This also meant that the working conditions for employees could improve. On the part of the management, this requires a much more cooperative behaviour with the employees. Industry 5.0 can go further, since, in addition to striving for a balance between work and private life, the value of the worker increases by producing customized products. Here, management must move towards coaching-type management.

The aim of the publication is to show different perception of the basic concepts of Industry 4.0 and Industry 5.0 in terms of the need and use of the human factor in business processes, based on the literature analysis and the surveys carried out.

WHY EXACTLY INDUSTRY 5.0

The starting point of the Industry 5.0 revolution stems from the change in the relationship between humans and intelligent systems. [4] For the European industry to remain the engine of the development of the continent and partly of the world, it must be at the forefront of the process of digitization and sustainable development. Industry 5.0 is more than just efficiency and productivity, as it strengthens the role and contribution of industry to the development of society. It puts the well-being of working people to the centre of the production process, applies innovative technologies to create well-being in the workplace, while respecting the load ability of our planet, its available resources, and the real limits of production. Industry 5.0 places research and innovation specifically at the service of the transition to a sustainable, human-centred, and resilient European industry. Various industries play an active role in supplying solutions to societal challenges, including conserving resources, slowing and preventing climate change, and keeping desirable social stability. Industry 5.0 brings benefits to the industry and to the workers of the companies, strengthens the role of the workers, solves the development and training needs of the employees, increases the competitiveness of the industry, and supports the integration of the best talents in the ongoing processes. It is beneficial from the point of view of sustainable development, as it favours circular (renewable, recycling) production models and uses technologies that make production more efficient and are environmentally friendly at the same time. Revision of existing value chains and energy consumption practices can also increase the industry's resilience to unexpected shocks, such as the COVID-19 crisis and the current military conflict in Ukraine.

HOW TO IMPLEMENT THE ENTIRE PROCESS

At the meeting of the European Commission Committee, Directorate General for Research and Innovation dealing with the approach to the Industry 5.0 phenomenon, the participants formulated three priorities [2, 5]:

"An economy that works for people", "The European Green Deal" and "Europe ready for the digital age". Based on what is happening, most of the Industry 5.0 elements discussed in these documents are already part of the Commission's main policy initiatives, which are as follows:

- adoption of a human-centred approach in digital technologies, including artificial intelligence (proposal for the regulation of artificial intelligence)
- further education and retraining of European workers, especially digital skills (so-called Skills Agenda and Digital Education and Action Plan)
- the development of modern, resource-efficient, and sustainable industries and the transition to a circular economy (the so-called green deal, renewable energies, recycling processes)
- a globally competitive and leading global industry that accelerates investment in research and innovation (industrial strategy).

The above examples show the close connection between the industrial transformation and the social development itself.

New information materials on the Industry 5.0 policy are currently being developed. This material will contain specific policy recommendations and measures to achieve the goals of Industry 5.0, and will provide an important basis for supporting policy initiatives at European

and national level, as well as ensuring that development is in line with the political priorities of the European Union.

The introduction of environmentally friendly technologies, digitization and increasing competitiveness on the global stage transform industry support small and medium-sized enterprises, and guaranteesustainable and competitive development of Europe. This transition requires a high degree of stakeholders' acceptance, the necessary trust and public commitment to the defined principles, as this is the key to success. One of the most important principles is that industrial strategies and modernization must focus on people and their social needs. It is this innovative, flexible, socially oriented, and competitive vision of industrial development that respects the possibilities of our planet, minimizes negative impacts on the environment and opens many new socio-economic, regulatory and management challenges related to developed and applied technologies. In the international European context, a consensus appeared that says that social and environmental needs must be fully integrated into the applied technologies and that due to the complexity of the challenges, development cannot be solved by individual technologies; a systemic approach is needed instead.

Technologies supporting the Industry 5.0 concept and their creation processes:

- Development and application of human-centred solutions, human-machine interaction technologies that combine and synergistically unite the strengths of humans and machines.
- Development and industrial application of technologies inspired by living organisms, smart materials that allow the use of sensors integrated into these new materials and their improved functions, while, in addition to being environmentally friendly, they meet the requirements of recycling, thus meeting the principles of sustainable development.
- Creation and application of real-time digital twins to model complete and complex systems to realize realistic process simulation.
- Application of the highest level of cyber security in data transmission, storage and analysis systems, development, and practical application of technologies capable of handling data in accordance with the required security and at the same time ensuring system interoperability at the proper authorization levels.
- Development and application of artificial intelligence systems to analyse and search for relationships, causes and effects in complex, dynamically behaving systems, to investigate and develop procedures that lead to new, higher complexity, self-developing artificial intelligence.
- Sustainable, energy-efficient production and operation of technologies that ensure reliable autonomy.

In the case of a systemic approach, one must consider many problems, which, however, seem to be solvable. What are these challenges?

At this moment, a significant difference between the philosophy of Industry 4.0 and Industry 5.0 becomes clear. According to the basic principles of Industry 5.0, it is necessary to develop a human-centred approach in the social dimension, to apply a sociocentric approach, to solve the challenges of time to satisfy heterogeneous needs, while society must be integrated into the process of developing, acquiring and increasing trust in new technologies and accepting their practical use.

The application of the Industry 5.0 philosophy requires the adoption and application of some principles, defined as follows:

- The high speed of transformation requires decisive and quick measures on the equal to the government and the state administration, it is a political dimension. It must integrate active approaches to government-state management, knowledge and strategies for shaping complex, interconnected systems of industrial ecosystems and labour markets.

- An interdisciplinary and transdisciplinary approach is essential in the systemic approach of various scientific fields (life sciences, engineering sciences, social sciences, other humanities) due to the complex set of requirements for integration.
- It is necessary to find solutions to support economic profitability and competitiveness and the necessary resources for this, by developing proper business models that consider ecological and social aspects.
- It is necessary to ensure the development of systems that will enable the wide implementation and dissemination of technologies through value chains and ecosystems.

In a slightly wider context, we can say that the European industry is strong and competitive, yet facing global challenges. The export balance is good, but this situation is extremely changeable, one could say volatile. The virus epidemic that has threatened and decimated supply chains, the situation that currently has the greatest impact not only on the European Union but also on the whole world (at the time of writing this article, the war in Ukraine has been going on for several months) has made the European Union, Europe and the whole world facing serious challenges. It is necessary to re-evaluate well-established and functioning partnerships and find an answer to energy dependence. The transition to green energy is not smooth either, nuclear power plants or natural gas thermal power plants cannot simply be shut down. The EU's energy dependence on Russian energy sources has revealed vulnerability of the hitherto functioning cooperation. It is also not possible to give preference to electric cars due to the unfinished, currently developing infrastructure. The functioning of supply chains must be reassessed, and sometimes painful decisions must be made to ensure continuity of energy supply. Simultaneously, the rapidly changing needs of global consumers must also be met. The answer to the problems raised can only be a new, well-thought-out, well-planned, and coordinated innovation, a development that uses the technologies of the fourth industrial revolution to the maximum extent possible. These include cyber and physical systems based on connecting the physical and virtual worlds, the Internet of Things connecting people, machines and devices, horizontal and vertical integration across the entire value chain from the customer to the supplier throughout the product life cycle, which creates new value relationships between different functional departments, networks and ecosystems. Creating added value can be more efficient, personalized, high-quality, service-oriented, traceable and flexible.

Unfortunately, it is also obvious that Industry 4.0 is still only in the development phase, its widespread distribution is significantly hindered by the lack of resources. The lag affects the small and medium-sized enterprises trying to survive on their own in the private sector and traditional industries. Many technologies are often found only in isolated solutions, the full horizontal and vertical integration in the supply chain is still far from reality in most industrial value chains.

The concept of Industry 5.0 can also be characterized as the re-introduction of the human and value-oriented Industry 4.0, but as we can see even in the earlier phase, there is a huge lag.

Industry 5.0 cannot replace or be an alternative to Industry 4.0, but rather its logical continuation and further development. The concept of Industry 5.0 is therefore not primarily based on technology, but focuses on higher values, such as people-orientation, ecological or social benefits. This change in basic assumptions is based on the principle that technologies can be transformed into creators and enablers of value, whereby technological transformation must be designed around the needs of society and not the other way around. It is especially important because of the ongoing social development. The fourth industrial revolution is changing the way value is created, the fifth industrial revolution aims to enhance social and ecological values using the technological achievements of the fourth industrial revolution. According to the primary focus, the technologies used are not intended to replace people working in the workshop, but to support the skills of employees to create a safer and more satisfying work

environment. We can say that the basic technologies of Industry 5.0 are in line with Industry 4.0, but the basis of Industry 5.0 is characterized by a stronger direction towards human-centred technologies. Industry 5.0 complements and expands the characteristic features of Industry 4.0, the essence of which is the inclusion of a wider value system, especially the expansion of human-centeredness towards a sociocentric perspective. Unfortunately, this feature increases complexity of the process, and places drastic demands on the management of the implementation process. The goal is to change the currently prevailing techno-deterministic rationality to a human-deterministic one, while the first step towards achieving this is the development of a rationality based on common values.

One of the main pillars of Industry 5.0 can be individualized human-machine interaction, which means connecting people with technology, as well as connecting human innovation with the innovative capabilities of machines. [6]

The following technologies support people in performing physical and cognitive tasks:

- Multilingual speech and gesture recognition and prediction of human intentions.
- Monitoring technologies for the mental and physical stress of employees.
- Collaborative robots working with people.
- Augmented, virtual or mixed reality technologies.
- Development and expansion of human physical abilities (exoskeletons).
- Development of human cognitive abilities: connecting the abilities of artificial intelligence and the human brain (connecting creativity with analytical abilities), decision support systems.

EXAMPLE

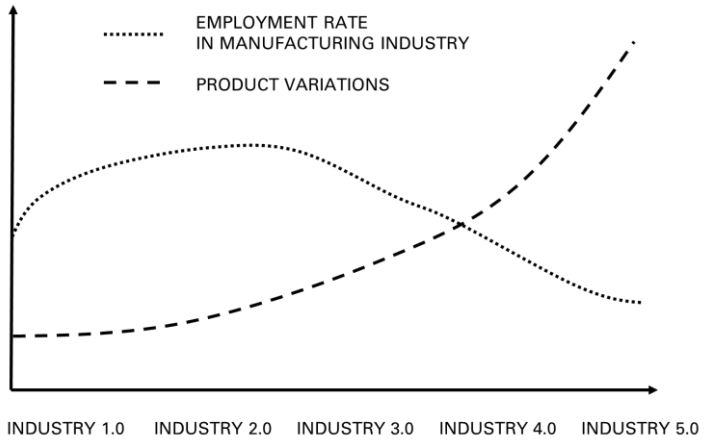


Fig. 1 *Global trends during the evolution of the industry - based on [7]*

In its research, the Reserve Bank of Australia [7] also examined the development of skills required from manufacturing workers and the number of manufacturing workers. It found that, since the middle of the third industrial revolution, the number of people working in industry has steadily declined, and so have those working in agriculture (Figure 1). This phenomenon is the result of the automation of production processes. With the increase in automation, the possibility of producing more product variations were created, which met the demands of the market (Figure 1). The research also showed that the only area where the number of employees is increasing is the service sector [7]. This also an answer to the question of what the most important task of Industry 5.0 activities is – to use customer demand for unique products, to supply services to products that can increase the value of the product, and increase the number of workers performing higher-level work.

Effects of customized customer demand on production

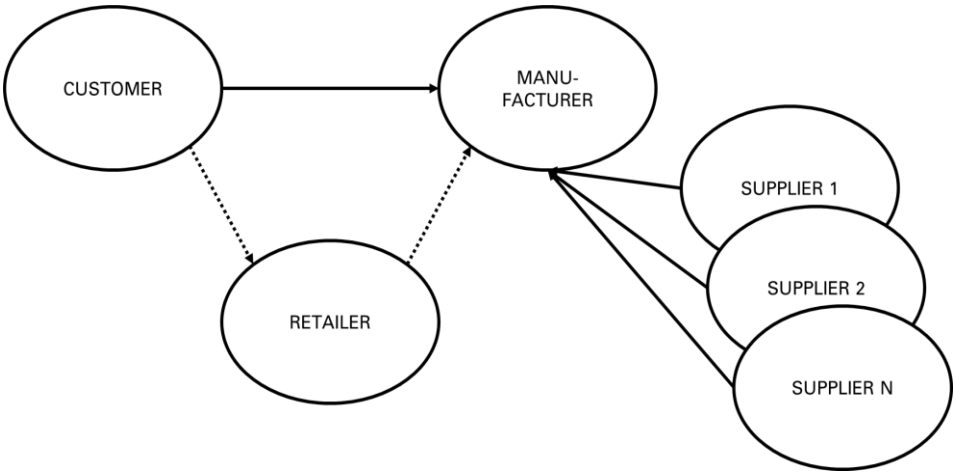


Fig. 2 *The sales business model of a customized product [own processing]*

Changes in customer needs are accompanied by changes in business models. As Figure 2 shows, the business model for customized products is quite simple. In the case of a classic store, the path from the manufacturer to the customer goes through several steps, through warehouses and distributors. In the case of custom-made products, this chain is shortened and there is generally one seller between the customer and the manufacturer. Depending on the industry, it is common for the manufacturer to ship directly to the customer. As the manufacturer is closer to the customer, the customer expects faster delivery, which automatically requires the supplier to be closer to the manufacturer. For a company to make custom products, or to make them worthwhile, the following components are needed (Figure 3):

- Customer: with unique needs and budget to pay for customization.
- Marketing and customer relationship management: the customer must be addressed on the market by a unique product. This is the role of company marketing. Based on Figure 1, the marketing activity can be conducted by the manufacturing company, but also by the retailer.
- Production: custom production requires flexibility from the production side. The proliferation of flexible manufacturing systems (FMS) has grown significantly in recent years. Nevertheless, it is still a serious question how a unique product can be part of mass production. From the manufacturing side, it is important to have unique product customization options that marketing can advertise in the market and that the customer is willing to pay for.
- Logistics and supply chain management: for production flexibility, it is important that intra- and inter-logistics processes are more flexible. The flexibility of internal logistics processes can often be increased only by warehousing. The main means of increasing the efficiency of external logistics processes is if the suppliers are closer to the manufacturing company.

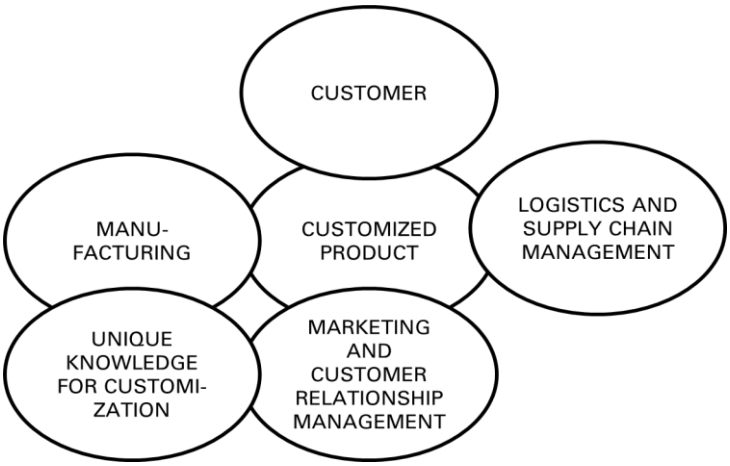


Fig. 3 *The key components in making a customized product [own processing]*

Flexible production of customized products

Product customization in manufacturing is not entirely new, although it played a completely different role in the past. The "uniqueness" of the product can be also achieved, for example, by printing the expiry date on the food on the packaging or, in the case of electronic equipment, by inserting the user manual in the package in the language of the market to which the product was delivered. Yet, these operations, which cannot even be considered customization, have caused many production problems:

- Where these operations should be performed?
- How do these operations affect the production process of the product?
- To what extent should these operations be integrated into the production line?
- How can the logistics of these activities be well organized?

If we think further about the product customization activity in the production process, we can distinguish two main versions (Figure 4).

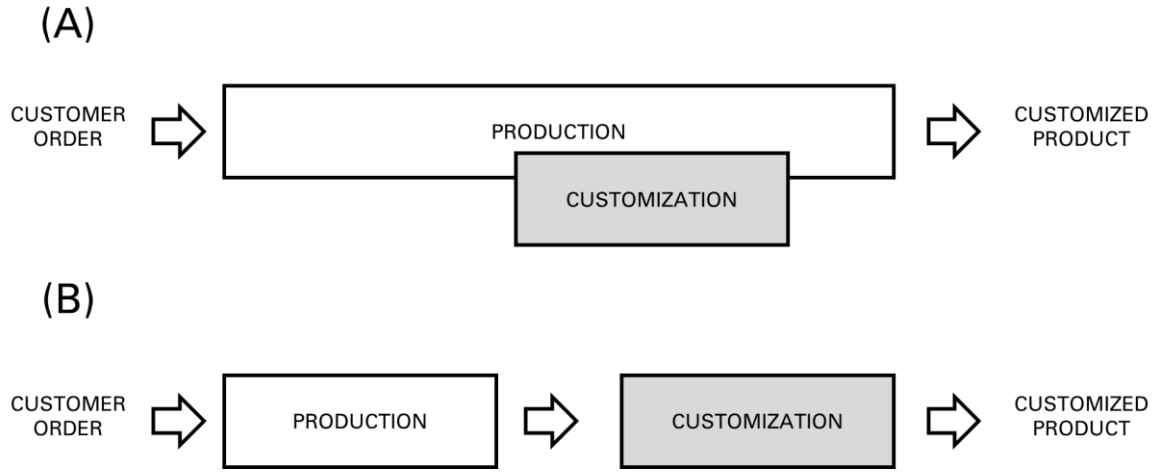


Fig. 4 *Integration of customization into serial production [own processing]*

✓ In case (A), the adaptation is part of the standard production process; the adaptation takes place in one (or more) production steps. Customization is part of the production line.

✓ In case (B), adaptation takes place independently of serial production. In this case, a basic product is usually produced, from which a customized product is produced completely separately. In some cases, other standard manufacturing steps may then take place.

Table 1 In-production and after-production customization

(A) In production customization	**(B) After production customization**
Simpler material flow	Increased complexity of material flow (external suppliers can also be involved)
Non existing or minimal WIP stock	Warehouse required between Production and Customization
Shorter lead time	Longer delivery time
Industry 4.0 focus	Industry 5.0 focus
Less manual work, more automation	Possibility to employ highly skilled workers for customization purposes

Table 1 compares the main characteristics of the two versions. It is clear that the first version tries to integrate customized products into the Industry 4.0 production methodology. This reduces the manual work and tries to process the customized product as a mass product.

In the case of version (B), the basis of the product is mass-produced. This is called the core product. Customization, on the other hand, is chosen separately from the production of the base product. This can have huge advantages in that more workers can be involved in the production of the product:

- The customization part can be creative work that the worker can do partially or completely remotely, it is not necessary to be in the factory;
- In the case of customization, handwork can make product much more valuable, thus increasing profit of the product;
- Since manual work can be planned worse in terms of production planning, self-adjustment improves production stability.

Sample from the textile industry

Let us look at a factory that produces embroidered shirts decorated with Hungarian folk motifs. The customer can choose embroideries from the catalogue or send his own sample. The pattern can be placed on the front or back or on the sleeves of the shirts.

In the first case (Figure 5), customization is integrated into the production process of the polo shirt. In this case, the question of how much the degree of adaptation changes the dynamics of the process is especially important. Just think that if, for example, we need to do a unique embroidery on the front and back and on the sleeves of a shirt, it will take much longer than if we only need to do a small pattern on the front. This results in the process dynamics being different for each product, which can cause unused capacity for the previous (trimming) and following (sewing) process steps, as these operations have to wait for the fitting operation. In this case, the embroidery is done by a mass-produced machine.

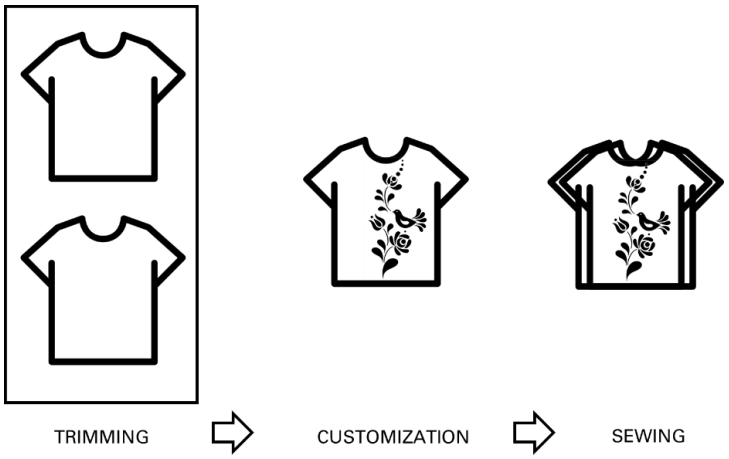


Fig. 5 *In-production customization sample [own processing]*

In the second case (Figure 6), the shirt is cut out during series production and the front and back sides are sewn together in the next stage. Customization is no longer part of the production line process. Since the sewn shirt cannot be embroidered well by machine, it is done by hand, which makes the product unique and more valuable for the manufacturer and the customer. In this case, the customization step does not even have to be done at the factory, it can be done at the employee's home with relatively flexible working hours. The production date of each product can be flexibly planned and, if necessary, the number of workers involved in this production step can be increased according to the customer's requirements (number of pieces).

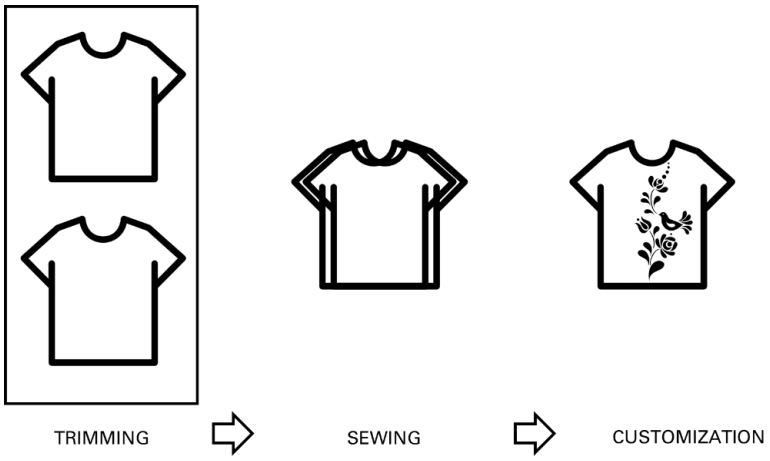


Fig. 6 *After-production customization sample [own processing]*

The two aspirations of Industry 5.0, mass customization and the involvement of more workers in production, are compatible and in many cases can lead to a better and more valuable product and to higher customer satisfaction.

CONCLUSION

In general, the challenges and opportunities discussed above form a complex system that affects technological and organizational aspects, political and social factors, as well as the three pillars of sustainability (economic, ecological, social aspects). Challenges and opportunities are a complex system and must be seen as closely related. Technology adoption and trust in technology are key factors. Initiatives must therefore gain the support of the people while

preserving the right of society to take part in the development and application of technologies. Innovative technologies must be understandable, transparent and human-centred.

Considerations carried out in the article, supported by literature analysis and survey research, show the need for the humanization of the industry in future while human beings playing a key role [8]. The question for the future remains whether we will consider individual industrial revolutions as a separate, disconnected concepts, or whether we will consider them as a continuous stream of inevitable changes in industry, affecting all areas of industrial production and aims for a high degree of automation, high-tech data collection and storage, working with big data, cybersecurity, and others. If research were to address either concept separately, their boundaries would need to be identified; in the case of flow perception, the only thing needed is to identify the point at which the environmental pillar can be added and the previously already "optimised" human factor can be reintegrated. Further research needs to be oriented towards the area of industrial maturity and the readiness of companies to adopt and apply any philosophy to their processes and everyday life, in line with the tendencies of digitization of business processes. [9]

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