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Industry 5.0: Spectrum or Entity?

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ABSTRACT

The fast pace of innovation in technology is shrinking the world. The digital technology of Industry 4.0 has reduced the role of human beings and boosted automation. The world is on the threshold of using technology of industry 5.0 commercially with the advantage of human interaction from the technology of Industry 4.0. This research paper analyses the current state of industry 4.0 and future implications of industry 5.0 in the dynamic business environment. One emerging theme is Human- Robot coworking. There is an emphasis on sustainable and resilient production systems. The main aim of the researcher is to determine whether industry 5.0 is truly human centric and also to look at the changes the first and third world countries are likely to face during the implementation of industry 5.0. with the aim of achieving sustainable processes.

Introduction

The term Industrial Revolution refers to a series of changes that transform the industry from one state to another. The first Industrial revolution transformed the industry from hand production to machine production. The second revolution which is also known as Technological revolution introduced technology to produce goods in mass volumes and introduced disciplined working in the factories. The disruptive change in the manufacturing sector happened when Digital technology took over from analogue technology. This era is called the era of the third industrial revolution. It laid the foundation for today's business environment that has become dependent on automation. Programable logical controllers revolutionised the manufacturing industry (Huang, Wang and Zheng, 2022). The emphasis shifted to high quality mass

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production of goods. Introduction of mobile phones revolutionised communication systems and the globe started to shrink. This led to large improvement in productivity at a reduced cost (Gupta and Arora, 2022).

As the technological development continues, the Fifth Industrial revolution (also called Industry 5.0) has struck the business world. Obviously, the innovators are trying to establish new algorithms which take care of the pitfalls of the Fourth revolution (Xu, LU, and Wang, 2121). The researcher has carried out a review to assess the concept and the ideology of
Industry 5.0 including the main concerns and challenges likely to be faced by the industry while introducing human centricity along with developing a sustainable environment.

Review of Literature

The electronics and automation sector of the industry got a major boost during the 5.0 era. Augmentation of the revolution in digital space led to the introduction of (i) cyber systems that translated into operating of machines by computer-based algorithms (ii) Internet of things (interconnected networks of devices embedded with computerized sensing and monitoring capabilities), (iii) Cloud computing(Moller, Vakilzadian and Hass, 2022). The introduction of these high technology enabled systems and fast pace of automation became a part of the Fourth Industrial Revolution. As the communication and exchange of data became faster and faster, the industrial world started shrinking. Mourtzis and Angelopoulos (2022) concluded that the nations and their business started interacting and the information became available on real time basis. Humans emphasised high productive automation systems using algorithms for repetitive jobs. The interaction was one sided – humans to machines. Machines performed as the humans instructed them by drawing algorithms. This revolution also enveloped developing nations including India. Which has been adopted by Indian industries to a large extent. The adoption has given benefits to them in the form of improved productivity at a reasonable cost. The trust which the Indian industry has generated in the global customers has given multi-dimensional benefits. They have not only entered the global market but have also staked their claim that they are here to stay (Huang et al. , 2022 and Gupta and Arora, 2022)

The Fourth Industrial revolution was a one-way interaction between humans and machines. If the algorithms go wrong somewhere, the output is entirely different from the expected one. The biggest failure of Supply Chain management happened during Covid-19, when the assumptions made during forecasting went wrong. The automobile manufacturing sector is still feeling the heat of the failure (Gupta and Arora, 2022).

Huang et al. (2022) concluded that Industry 5.0 emphasizes human centric solutions to problems, including the wellbeing of the worker during the production process The industry

4.0 revolved around digitalization and automation, while industry 5.0 revolves around the three pillars of Human centricity, Resilience and Sustainability (Grabowska, Saniuk and Gaidzik, 2022). The automation of processes developed during 4.0 coupled with human machine interaction provides the base for 5.0. Introduction of 5.0 will make the working environment more inclusive and resilient (Ivanov, 2022)
Source: https://doi.org/10.1186/s13677-022-00314-5

Objective of the study

Gupta (2018) concluded that Automation and technology-dominated Industry 4.0 left minimal space for humans whereas Industry 5.0 shall be dominated by the Human-Machine relationship, conditioned by two-way communication between them. Productive performance shall be enhanced through the interaction between them. It will lay more importance on enhancing human skills and their technical capabilities. Industry 4.0 was an era of robots whereas Industry 5.0 will be an era of human – robot interaction in these dynamic, complex industrial systems. Hence, it becomes imperative to study the human factors, human centricity and technologies to achieve sustainable and resilient systems, leading to the following focused questions:

1. How will technologies of 5.0 create human Centricity?
2. Will the technologies of 5.0 be able to deliver a sustainable environment?

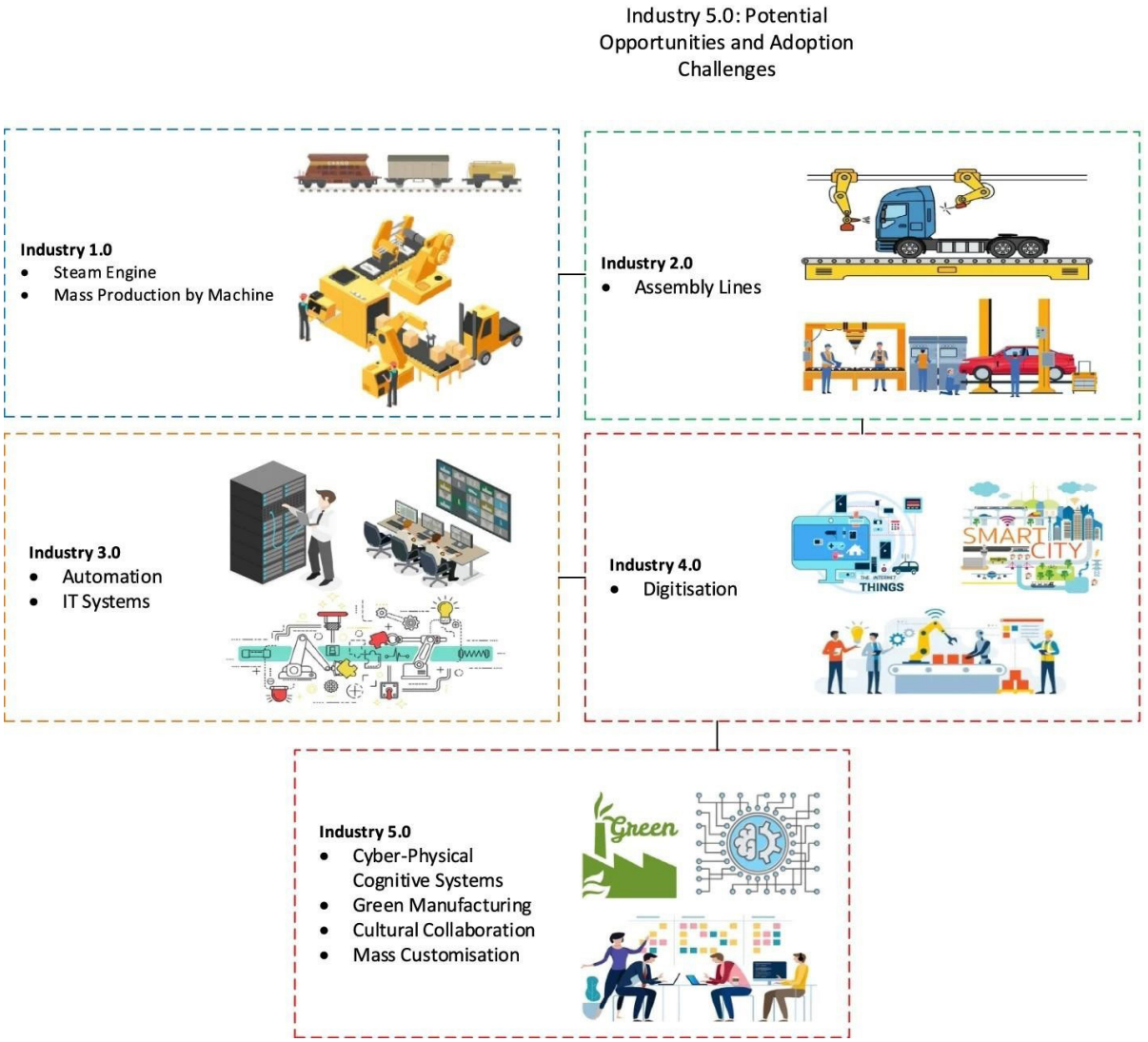

Fig. 1. Industry 5.0

Industry 5.0- Concept and Ideology

The Covid-19 issue exposed the economic and technological adversities of the business environment not only in developing countries but also in developed countries. It made the industry rethink the existing working process, methodology, resilience, sustainable environment and role of human technology interface in the dynamic customer-oriented market (Madhavan, Wangtueai and Sharafuddin, 2022). The turning point from phase 4.0 to 5.0 is the relationship between automation and human beings. Industry 4.0 concentrated on automation leading to improvement in efficiency, optimising processes and reducing the role of human beings in day to day working as smart digital factories improved the efficiency and output quality. While Industry 5.0 will introduce the socially-smart factory for seamless communication between automation and people leading to cyber-physical production systems Leng, Sha, Zheng and Zhuang, 2022). It will also focus on human-driven sustainability so as to reduce the waste and create customised products with high quality (Maddikunta, Pham, Prabadevi and Dev, 2021). This revolution will exploit the cognitive (creativity and knowledge)

capabilities of humans while interacting with intelligent systems (Nahavandi, 2019).

Technology of Industry 5.0

According to Longo, Padovano and Umbrello (2020) Human Machine collaboration will lead to the extensive use of robots / cobots for labour intensive repetitive tasks whereas humans will oversee the personalisation of products and look for innovation in the product and manufacturing process. Socio-technical evolution is a reality for those involved in the implementation of Industry 5.0. Manufacturing and production processes are likely to undergo a change as the information technology will reach the next level coupled with intelligent strategies empowered with technically advanced machines (Prassida, and Asfari, 2022) The new business processes being introduced / undergoing change are:

1. Designing and Integration of cyber-physical production systems involving human aspect
2. Automatic identification and traceability
3. Information sharing through 6G network
4. Artificial Intelligence based system for organising and supervising new processes
5 Industrial simulations for design and calibration of new components and processes
6. Use of Augmented reality for intelligent decision making
7. Robots for real time collaboration with humans
8. Development of Digital Twins (Bistsch, 2022and Wang et al., 2022)

Mortini, et al.(2022) analysed that the collaborative robots are taking over low value-added repetitive jobs and the workers are involved in optimising processes which require a virtual model designed to reflect a physical object. The virtual model gets data on real time and uses simulation, machine leaning and reasoning to help fast and quick decision- making. DT systems allow product and production optimisation while ensuring operational safety

Human Centricity

The customer requirements are becoming more and more dynamic and complex. Industry 5.0 has evolved while technology is being augmented with human centricity. Individuals are using the power of technology to meet customer requirements. The technology has its own limitations, specifically in the field

Table 1: Industry 4.0 and Industry 5.0

Features	Industry 4.0	Industry 5.0
Focus	Automation based on digital technology for efficiency improvement	Creation of human centric manufacturing process associated with sustainable environment
Emphasis	Use of big data and its analysis to optimize business processes	Human interaction on real time basis and collaboration
Competencies	IoT, AI, Machine leaning for quick decision making	Combination of advanced technologies with human skills and creativity
Use	Robots and autonomous machines for repetitive, hazardous, or precision tasks	Development of new skills and competencies among human workers
Factories	Smart factories for self- optimization of production processes	Integrated, flexible production system for adaptation to customer requirements and market trends
Technologies	Digital technology and Automation for production process optimization	Advanced technologies such as nanotechnology and biotechnology for creating new materials, processes and products
Efficiency	Predictive maintenance, remote monitoring, and real-time data analysis for efficiency improvement and cost reduction	Prioritization of sustainability and ethical production practices to minimize waste and reduce environmental impact

Source: atoss.com

of operator safety and real time flexibility. Human creativity and flexibility are being used to overcome the limitations of the technology (Xu et al.,2022 and Wanand, Leirmo, 2023). The present technology intensive systems are replaced by socio-technological systems. However, the workers need to acquire and upgrade their knowledge and skills for optimum use of these systems. The new paradigm is creating new job opportunities, career growth and work balance. To move along with human-centred transformation, workers are acquiring knowledge and grabbing the opportunity to play an active role in successful implementation of the transformation (Brauner, Ziefle, 2022). The workers are acquiring multifaceted skills to meet this challenge.

According to Rannerthauser et al. (2022) the personalisation of customer requirement has reached the next level. Taking a real-life example, technology has provided an application with which Diabetes Type – I patients can monitor their lifestyle and modify it in line with the advice from software. This technology is based on Artificial Intelligence which can understand the reaction of the body in different situations and advise accordingly.

Sustainability

Recognising the need for preserving the environment, part of the vision of industry 5.0 is to create a sustainable environment. As technology advances, so does the need to eliminate waste. New polices are being framed, requiring minimal use of natural resources. A network of smart sensors coupled with customised software is providing real time data of energy consumption and overview of the climate. These integrated systems provide feedback and suggest alternation in processes to reduce the impact on environment. Industry 5.0 has suggested 6R methodology and L.E.D (Logistics Efficiency Design) principles to achieve the objectives (Nahavandi, 2019).

1. Recognise: The first step is the recognition of the need and the opportunities to convert waste material into something useful, also called upcycling.
2. Reconsider: The designers need to reevaluate the business processes and redesign them to realise the benefits of Upcycling.
3. Realise: Recognition of the need and reconsidering the processes, new innovations lead to environment friendly processes.
4. Reduce: Industry 5.0 emphasizes reduction in the use of natural resources as part of new processes.
5. Reuse: Reusing the waste material which was earlier being thrown away, is the essence of industry 5.0
6. Recycling: The new processes being developed ensure either reuse of waste or its cycling to the advantage of the environment and industry(Maddikunta et al., 2021).

The objective is to achieve zero waste, whether by recycling or reuse. As the human centric technology is innovating, human beings are working on the processes which reduce usage and subsequently reuse or recycle, ensuring zero dumping in the environment (Maddikunta et al., 2021).

L.E.D. (Logistics Efficiency Design) is for improvement in the global supply chain process. The process of Supply Chain has been one of the major waste producers that has affected the environment to a large extent. L.E.D. is poised to bring down the after effects of the waste dumping through innovative processes. Many organisations have modified their processes for green manufacturing and production.

Discussion

Industry 5.0 is focussed on Human- Machine collaboration, Ergonomics of the operator and human skills. The production sector of the industry is shifting towards collaborative robots, Artificial intelligence and computing technology. Collaborative robots are a combination of digital technology and human centric production, that considers human and robotic characteristics equally to provide best of the results in digital production environment. Industry 5.0 is optimally using the resources, both human and machine. Since repetitive tasks are being taken over by the robots and cobots, the operator does not face the stressful environment that can undermine health. Augmented reality is integrating humans into production and design processes in real time and helps them to remain dynamic (Carayannis, Deziand Gregori, 2021). The impact of Human-Robot collaboration has

yet not been researched and computed so as to draw any conclusion which can be considered as definitive. The reason is, one, technology has not penetrated into all industries so far, two, the tools being used for evaluation have not evolved enough to study this aspect and three, the computational tools that allow complex and dynamic analysis have not been established to a fair degree of accuracy so far.

The objective of social and environmental sustainability can only be achieved once technical education has been reengineered and redesigned so that the future workforce is able to understand new technologies to make quick and appropriate decisions in real time. Thus, future technical education should focus on human-technology interaction for better understanding of cyber-physical systems. The learning strategies should focus on production error detection and additive manufacturing systems (Carayannis, et al., 2021). Production error detection system is being used to a limited extent. If a component is produced beyond the specification, the present system automatically rejects it and does not pass it for the production of final product. Whereas Industry 5.0 technology will allow the machine to interact with the operator, rectify the cause of non-conformance and produce the component as require. Additive manufacturing is the name for 3D printing, a computer controlled process that creates three dimensional objects by depositing materials, usually in layers. This technology is being used in medical science in a limited way for manufacturing 'knee' for the patient during replacement of knee surgery. The technology of 5.0 shall take physical dimensions of the knee of the patient, interact with the surgeon and manufacture knee which is customised for the patient in accordance with the advice of the surgeon. The engineers of the future must be empowered to use and improve highly complex human centric production systems which require complex and multifaceted decision making.

Limitations of Industry 5.0

Adaption of any new technology requires its understanding and acceptance. Current challenge is acceptance and implementation within the industrial law and regulation. Industry 4.0 was technically advanced but the role of workers had been reduced to minimal, however 5.0 requires a skilled and resilient workforce. Cognitive computing requires converting thoughts of humans into computerised models. Self-learning algorithms, recognition of natural language, understanding natural user interface like gestures are the challenges being faced by industry 5.0.

Conclusion

The technology of Industry 5.0 is a step ahead to that of 4.0. Whereas Industry 4.0 was dominated by automation, 5.0 gives space to humans to be at the centre of the production process. Thus, there is a paradigm and orientation shift from technologically advanced production systems to human centric production systems that are moving towards customisation. The paradigm shift is also from technology- commanded humans to a more collaborative approach, wherein humans can use the technology to advantage. In case the automation process comes to a halt because one parameter of production is not in conformance with the set parameter, the production of the component stops till the error is rectified by the operator. In 5.0, if such a situation happens, the system being human centric will offer alternate solutions to the operator. The operator can take a decision based on the alternatives provided without a long pause in the production. The automation processes of 4.0 allows a repetitive task with no human intervention to customise the product, whereas 5.0 allows human intervention and can produce a product according to the customer specifications. Replacement of knee as required by the customer and the surgeon is an example of 5.0 technology.

Scanning the business environment and the fast pace of innovations , it can be concluded that the advancement of digital technology of 4.0 will be used in 5.0 along with creation of values for humans. This new technology in smart manufacturing systems will require the workforce to be resilient and digital savvy within the domain of industrial regulation and sustainable environment.

The complete adoption of Industry 5.0 is likely to take more time as some of the developing countries are still struggling with the problems of the digital turn. The large industries of these countries have adopted 4.0 whereas small industries have yet to harvest the benefits of Few factors which have caused delay in the adoption of 4.0 technology are, high cost of infrastructure as compared to the manual system, non-availability of technical skills and reluctance to adopt new technology. The availability of infrastructure, skilled manpower in developed countries will help them to adopt new innovations quickly whereas developing countries are likely to delay its adoption.

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