

ADVANCING FUTURE MANUFACTURING VIA HUMAN-CENTRIC INDUSTRY 5.0 AND SUSTAINABILITY

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ABSTRACT

Industry 5.0 (I5.0) generally represents a paradigm shift in industrial transformation, prioritizing human involvement in technological and organizational innovation. It presents a vision where people and modern technology collaboratively create sustainable and resilient production environments. This review synthesizes new insights on I5.0, including human-centric artificial intelligence (AI) and human-centricity in industrial environments. It reshapes productivity as efficiency, production, resilience, sustainability and human empowerment, which works on the changing role of the operator. This chapter discusses a more multidisciplinary approach that integrates technological advances with perspectives from psychology, organizational behaviour, and social science. Applications in manufacturing, healthcare, logistics, and education demonstrate that human-centered design increases resilience to disruption, fosters diversity, and supports the Sustainable development goals. Achieving the comprehensive vision of Industry 5.0 requires addressing key challenges, including policy issues, digital skills shortages, interoperability, and cultural opposition. Future trajectories highlight the significance of human digital twins, semantic knowledge graphs, immersive VR/AR training environments, and policy-based AI governance in building a truly human-centric industrial ecosystem. This chapter presents Industry 5.0 as a transformative socio-technical movement that integrates technological and social elements to align human well-being, technological advancement, and environmental stewardship.

Keywords: *Human-Centric Industry 5.0; Industry 4.0; Collaboration; Future Manufacturing; Sustainable Innovation.*

1. INTRODUCTION

Industry 4.0 (I4.0) is the fourth industrial revolution, defined by the combination of cyber-physical systems, big data, robots, and the Internet of Things (IoT). This revolution has created considerable potential for productivity, efficiency, and connectivity, but it has also created some shortcomings that challenge its long-term sustainability and inclusiveness [1]. When workers' responsibilities shift from manual labour to supervising increasingly complex automated systems, they often report increased stress levels [2]. The assurance of competence sometimes takes the form of fear of job security, but the human aspects of motivation, autonomy, and trust are rarely examined. In response to these limitations, Industry 5.0 (I5.0) has been highlighted as a progressive paradigm that significantly contributes to prioritizing the human element within industrial activities, as presented in Fig.1 (a) [3]. This vision of I5.0 claims that technological advancements always help advance social responsibility and environmental awareness, as presented in Fig.1 (b). It helps humans act as important co-creators by collaborating with artificial intelligence, collaborative robotics, and immersive digital systems [4].

Industry 5.0 envisions a healthy industrial sector for the future, where creativity, flexibility, and ethical reasoning are integrated with the efficiency and speed of machines [5]. The European Commission has set out three fundamental principles: resilience, sustainability and people-