Chapter 13
Unraveling Future of Smart Manufacturing and Diffusion Mechanical Fault Diagnosis Prognosis: IoT in Industry 5.0 Fostering Sustainability

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ABSTRACT

Industry 5.0 the next wave of smart manufacturing as the era of Industry 5.0 is upon us, characterized by human-centric, sustainable, and resilient production systems, and is already starting to influence the future of smart manufacturing. Central to this evolution is IoT-based mechanical fault diagnosis and prognosis. IoT systems utilize

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sensors for real-time data monitoring of machinery, or fault detection and failure prediction to adopt preventive maintenance strategies. This method reduces down-time, lowers operating costs, increases productivity and is also environmentally friendly. Issues related to data security and system interoperability offer challenges, but continued evolution in IoT frameworks offers transformative opportunities. In their own right, IoT-based fault management not only transforms manufacturing but also corresponds to global sustainability targets while establishing a stronger foundation for resilience in industries moving forward.

1. INTRODUCTION

IoT-enabled FDP achieves accuracy and adaptability in dynamic manufacturing settings by leveraging emerging technologies such as machine learning, edge computing, and digital twins. Industry 5.0 emphasizes the integration of human labour with technological processes; joint systems that maximize productivity without sacrificing employee wellbeing. The future of smart manufacturing is inherently rooted to how the evolution of Industry 5.0 incorporates advanced technologies along with a human-centric and sustainable mindset. This shift goes beyond the Industrial Automation focus of the 4th Industrial Revolution by enabling the Human-Machine collaboration, but then adds a couple of most important aspects, Resilience and Environmental Sustainability. Internet of Things (IoT) is one of the main enablers of this transition as it plays a significant role in mechanical fault diagnosis and prognosis (FDP), transforming conventional manufacturing processes and transitioning practices towards sustainability (Cordell, 2024).

IoT-based FDP leverages networks of connected sensors, devices and analytics to ensure real-time monitoring of machinery to identify faults and predict failures ahead of time. This preventive action minimizes unexpected downtime, enables smoother operations, and lowers the cost of treating damages. IoT improves resource utilization, extends equipment life, and avoids energy wastage, demonstrating an ideal partnership with efficiency objectives. Industrial machinery use embedded sensors to continuously monitor characteristics like vibration, temperature, and pressure to accurately identify faults. This data is processed using advanced data analytics and machine learning models to discover patterns, predict failures and recommend timely interventions (Gwala & Mashau, 2024).

Industry 5.0 takes IoT-enabled FDP one step further by facilitating integration with technology such as digital twins, edge computing and artificial intelligence (AI). Digital twins generate corresponding digital copies of physical systems, making it possible for manufacturers to model and assess how mechanical equipment performs under different situations. This improved accuracy in fault detection and allows

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