Wearable Technology in Manufacturing

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ABSTRACT

Digital transformation is a key part to any manufacturer's future-proofing strategy and wearable will play a significant role in this going forward. Wearable technology, also known as wearables, integrates electronics that can be worn as an accessory or embedded on clothing into daily activities. The devices include bracelets, watches, headsets, that deliver augmented, virtual, or mixed reality experiences, and even clothing. Wearable technology is designed with the intention to make everyday tasks easier and more accessible. It is set to change the way we live and change it for the better. This paper examines the impact of wearable technology on manufacturing.

KEYWORDS: *wearables, wearable devices, wearable technology, immersive technologies, manufacturing.*

INTRODUCTION

Wearable technologies are smart devices worn by manufacturing workers that collect and transmit information and perform safety-focused functions. Industrial wearables have been picking up serious steam in the manufacturing community, and with good reason. Common wearables include smart helmets, vests and other smart clothing, and ergonomic sensors. The devices are hands-free gadgets powered by microprocessors and have the ability to send and receive data via the Internet. They help reduce injuries, enhance skills, and streamline complex assembly and maintenance processes. Companies have been testing the technology in industrial and manufacturing environments. In the manufacturing space, wearables are meant to monitor a worker's activity in real time and collect data.

Wearable technologies have created significant innovations in many fields, such as manufacturing, health, sports, education, etc. Between fitness and health tracking and even contactless payments, a ton of cool features already exist. Imagine Google Glass telling people which surfaces are too hot to touch, when machinery is malfunctioning or even when conditional hazards are present.

WHAT IS WEARABLE TECHNOLOGY?

A wearable device is any device that is worn comfortably on the body and enables user interaction. It is typically integrated into the clothing or attached to the body of a person to enhance human performance. It often includes smart devices that can be worn on the body or attached to clothes. Wearable devices have been around for centuries. The first one was introduced in the 1660s by the Qing Dynasty. Since then the popularity of wearables has shifted from royalty to the healthcare industry. Wearable computing is a natural evolution of the smartphone technology that has become so ubiquitous and indispensable in education, business, and medicine. We wear wrist watches to know the time. Perhaps the most crucial bit of wearable tech accessible today is Google Glass. There has been a proliferation of wearables from consumer gadgets to medical devices that are approved by the Food and Drug Administration (FDA).

Wearable devices or systems are usually lightweight, miniature electronic or digital devices that are worn by a user, including clothing, watches, glasses, shoes, and similar items. A wearable computer is computer-powered device that is never-sleeping ever-present network-connected electronic system that can be used at anytime and anywhere and does not in any way disturb the user's interaction with the real world. It should be worn, much as eyeglasses or clothing are worn, and interact with the user [1]. It includes all manner of technology that is on or in the body such as fitness trackers, smartwatches, smart clothing, smart rings, smart glasses, wearable mobile sensors, smart jewelry, and smart ECG (electrocardiogram) monitors.

Wearables are always ready, unrestrictive, not monopolizing of user attention, observable and controllable by the user, attentive to the environment, useful as a communication tool, and personal devices [2]. Wearables are being used across healthcare, insurance, interactive systems, safety critical settings, wearable cameras, baby and pregnancy monitors, entertainment, fitness and sports, emergency responders, and military. Typical wearable devices are shown in Figure 1 [3]. Due to it wide range of applications, international corporations such Google, Apple, and Intel are investing heavily on wearable technology research and development [4]. As with any new technology, one must exercise caution when using a wearable device.

A wearable device essentially consists of two different components: wearable and body sensors. It incorporates sensors, memory, solar cells, and batteries. It stays in contact with the body for extended periods of time. Traditional materials for wearables are mostly metals and semiconductors with relatively poor mechanical flexibility. Modern wearable technologies are characterized by body-worn devices, as smart clothing, e-textiles, and accessories. Wearable devices can be used to collect various data to support a series of innovative applications. Today, wearable devices have numerous applications due to their integration with artificial intelligence. Wearable devices can be attached to shoes, eyeglasses, earrings, clothing, gloves, and wrist watches [5].

WEARABLE TECHNOLOGY IN MANUFACTURING

The wearable technology market has been steadily increasing over the past few years with the huge popularity of fitness trackers, monitoring diet, exercise, sleep and movements. Each application of wearable technology will have its own criteria in terms of performance, environment and expected use

and in all cases, a reliable and accurate response is required from the device. Wearable technology in manufacturing uses devices worn on the body to improve safety, productivity, and training by providing workers with real-time information, physical assistance, and data collection for operational optimization. Manufacturing professionals could approach this concept in many ways. They can use wearable technology to make this age-old process more modern and efficient. Figure 2 shows the cloud word for manufacturing [6], while Figure 3 shows a typical use of wearables in manufacturing [7].

APPLICATIONS OF WEARABLE TECHNOLOGY IN MANUFACTURING

Wearable technology is among the most accessible of the many IoT innovations used in manufacturing. Figure 4 shows different uses of wearables [8]. There is no shortage of practical application opportunities for wearables to shine. Common applications of wearable technology include the following [9,10]:

➢ *Safety Wearables:* These wearables have become increasingly important in the last few years. These innovations are incredibly beneficial to both employers and workers when appropriately used. Wearables increase safety and awareness, aid workers in completing complex and demanding tasks, and connect users to their work and with each other. Body-worn sensors can track environmental conditions like heat and noise and identify unsafe postures to prevent injury. GPS-enabled devices can warn workers if they are near dangerous areas, such as a high-traffic zone with heavy machinery. Smart clothing can alert workers and supervisors to signs of fatigue or heat stress. Being constantly aware of all the moving parts of a facility or warehouse can be a challenge and proper safety awareness practices are essential. Companies have created a helmet with this in mind. Exosuits and exoskeletons can be worn to prevent injury and fatigue. Not only can wearable safety technology prevent accidents and injuries from occurring, but it can also collect crucial data for movement and body positions, environmental factors, biometric data, auditory data, and other forms of important worker data. The future of wearable safety technology is astonishingly bright for both manufacturers/producers of this technology as well as for the actual users of this technology.

➢ *Worker Ergonomics:* Ergonomics is an applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely. The role of

wearable technology in ergonomics is to keep the human body as safe as possible from an ergonomic standpoint during work activities. Worker ergonomics can affect worker safety, injury prevention, production, quality, and worker satisfaction with their work tasks.

➢ *Environmental Monitoring:* Wearable technologies are frequently used for environmental monitoring. Workers typically are assigned a device at the beginning of their shift and required to wear it for a certain portion of their shift to collect data about the air quality in the area they are working. The device collects this data over the workers' shifts and can detect any unsafe air conditions that workers may be exposed to.

➢ *Cloud Manufacturing:* Cloud manufacturing has emerged as a new solution to address many challenges. It is a manufacturing version of cloud computing. It is a business strategy towards services, customers, and demands. It is a service-oriented, customer-centric, and demand-driven process with well-established industrial automation. Enhanced human–machine interaction is one of the core areas for the success of the next generation of manufacturing. Applying wearable technologies can increase the value of cloud manufacturing, avoid waste and increase sustainability, and reduce risk and prevent human error on the shop floor.

➢ *Warehouse:* Warehouse functions are some of the most relevant and valuable applications of wearable devices. Today, wearable technology is used greatly in warehousing applications such as piece picking. In a warehouse, the situational and contextual data allows order fulfillment employees to find goods or ordered products faster — the devices pinpoint exactly where an item or order is located and helps facilitate the next steps. Wrist-mounted, glasses-view, or dashboard-displayed screens help forklift drivers to find and fulfill orders quickly. Productivity increases from wearable voice command tools can increase factory warehouse efficiencies. Figure 5 shows a typical warehouse [11].

BENEFITS
Wearables are already helping manufacturers empower their front-line workers, keep them safe, and increase productivity. With wearable technology, the potential is endless, from providing proximity alerts, employee tracking, hazard notifications, safety analytics, and more yet to be seen. In this new era of Industry 4.0, manufacturers are given the opportunity to empower their workers with comprehensive

software and new technological innovations. Manufacturers monitor workers' vital signs, such as blood pressure or heart rate, using wearable technologies. Other benefits include [12]:

➢ *Safety:* Safety is an obvious reason manufacturers may choose to deploy certain wearable tech. An incredible portion of industrial wearable innovations is centered around safety and worker protection. Augmented reality (AR) glasses are a wearable technology that can be used in many situations and are especially innovative regarding safety.

➢ *Automation:* Due to increased automation, simple tasks are increasingly being taken over by automated machines. As automated machines take over simpler mass-production assemblies, manual tasks for low-volume and high-mix productions are getting more and more complex. This trend is requiring human involvement in areas that deal with large production.

➢ *Efficiency:* A major benefit of using industrial wearables is that it increases process efficiency. Smart glasses provide technicians with real-time, hands-free instructions, data overlays, and access to digital manuals, reducing errors and documentation needs. AR can provide step-by-step guidance through complex assembly tasks, improving accuracy and efficiency.

➢ *Physical Support:* Companies can invest in new technology that supports and protects their workers while giving them the edge over their competitors. These devices provide physical assistance during tasks like lifting and bending, reducing strain and fatigue. Such a task in illustrated in Figure 6 [12]. Employees who frequently perform physically strenuous tasks can wear a real-life exosuit and gain additional mechanical strength for their back.

➢ *Workplace:* In recent years, certain manufacturers are requiring workers to use wearable technologies at work to increase efficiency and productivity and mitigate health and safety risks. Workers need to be able to freely move around in their workplaces but also need to know how close is too close. The six foot guideline is not always easily ascertained without tape measure. The Social Distancer solves this worry by alerting users if they are within 6 feet of another individual. Employees can then move around their workplace with confidence and adjust their positioning with the helpful alerts of this little device. Wearable technologies, such as exoskeletons, aim to reduce musculoskeletal

injuries in industrial workplaces. Exoskeletons are one form of ergonomic safety technology. They are designed to reduce muscular fatigue and injuries by providing support to specific muscle groups. Figure 7 shows a man wearing a full-body exoskeleton to aid in carrying out a task [13].

➢ *Extending Reality:* Extending reality with wearable glasses or headsets can be beneficial, if done properly. Among extended reality (XR) devices, AR currently makes the most sense for the factory floor while virtual reality (VR) is effective for training purposes.

➢ *Healthy Lifestyle*: Using wearable technology one can record heath related data and use it for medical analysis. Exercise records, calorie analytics, and reminders make wearable devices of great utility. For health patients, wearables can help them track their sugar, protein, and calorie intake levels and effectively monitor and analyze their blood pressure, temperature and other medical records easily. Wearable technology come as a boon to consumers as they pave the way to instant monitoring, analysis, communication, and monitoring of one's health.

➢ *Convenience:* Wearable technology operates remotely and can be easily carried anywhere. This makes life simpler and work easy to perform- anytime, anywhere.

CHALLENGES

In spite of the benefits of wearable technology, wearable devices create legal risks and challenges of which manufacturers should be aware as they look to implement or expand the use of these technologies. Wearable technologies have faced challenges and difficulties such as security, privacy, accuracy, latency, and connectivity. Wearable products need to make sense and be properly used. In the typical plant, access to real-time data is often a challenge. Other challenges include the following [6,11,14]:

➢ *Privacy:* Privacy is a major concern because wearables can be used to collect data on personal habits, behaviors, and the health of employees. Wearable technologies implicate various privacy, surveillance, and security related concerns as it pertains to the collection, monitoring, and storage of employee biometric information. For example, manufacturers considering the use of smart glasses should be mindful that workers may inadvertently record other employees in private areas.

➢ *Security:* As wearables gain a foothold in manufacturing, security concerns will have to be addressed. The same security concerns inherent in

other digital applications apply, including phishing, malware attacks, and network overloads. Making the data secure, and abiding by government standards, is of paramount concern if wearables are to become widespread. The judicious deployment of devices is a way to improve security.

➢ *Cost:* The basic challenge is the affordability of the wearable tech. Wearables suppliers also need to address cost. The investment is greater than people realize, both in terms of the time and money spent to get this off the ground. The resources needed to test, iterate, improve, manage change, and deploy at scale are substantial. Even if you digitize your workflow processes, it is still a huge investment in time, money, and change management.

➢ *Battery Life:* This is also a concern as some of these devices, particularly smart glasses, do not currently have enough battery life to last a full manufacturing shift. Wearable tech uses modern devices like sensors, Bluetooth, GPS, storage chips which consume a lot of power. Power backup thus becomes a challenge in manufacturing where people work for long hours without access to recharge points.

➢ *Training:* As the shortage of skilled workers continues to plague manufacturing, often less experienced, junior-level candidates are brought on board, requiring extensive in-plant training. Augmented reality (AR) can be used for training, giving users the chance to visualize machine issues and "practice" engaging with the high-tech tools. This gives new recruits valuable experience.

➢ *Tech Synergy:* There is a growing synergy among wearables and the broader smart factory ecosystem. Wearable technologies do not exist as individual, static devices. As part of the IIoT, each connected device is a dynamic piece of a larger dynamic system. Typically, wearable companies operate in a silo and they are challenged to drive mass adoption. They pressure you to be device specific, locking you into their ecosystem. The challenge for manufacturing firms is that many still rely on legacy systems.

FUTURE OF WEARABLE TECHNOLOGY IN MANUFACTURING

Although wearable devices are still relatively new, their adoption is increasing at a phenomenal rate and the market excitement is on the rise. Innovations are being seen in the devices used, such as glasses with drop-down mini display panels and hardhats equipped

with screens. As industrial wearable technology continues to improve with each passing day, we can also expect prices to continue to drop as well. Understanding the driving factors and industry trends will help manufacturing professionals weigh the pros and cons of investing in mobile and wearable technology [15]. Powerful wearable devices will be equipped with comprehensive apps in the near future. With wearable technology hitting the healthcare, sharing of health related data with friends, family, and doctors would become a common trend.

Wearables are increasingly becoming part of manufacturing's digital transformation efforts with the promise of improved worker safety and productivity, as well as more efficient business operations. The manufacturing industry is excited about leveraging wearable tech in the shop floor. Factories are getting smarter and growing more dependent on technology to facilitate operations. Embracing and integrating wearable technology prepares manufacturers for the future [7]. Connected workers are the future of mixed-model assembly and industrial wearables play a significant role in this venture.

CONCLUSION

Wearable technology is a promising and revolutionary technology that is changing some aspects of our standard of living, including health monitoring, sport and fitness, performance tracking, education, and entertainment. Wearables have definitely caught the eye of many manufacturers. We are still in the early phases of these innovations and by no means will all industrial wearables be beneficial to every manufacturing company. Wearable technology offers unique benefits like enhanced work productivity, ease of use, and seamless integration.

Wearable technology is still maturing. There is an opportunity for manufacturers to achieve both tangible and intangible benefits from leveraging wearable technology. Manufacturers are increasingly embedding sensors in machinery and capturing performance and maintenance-related data points through IoT technology. Looking at wearables as a network-connected device offers manufacturers a simple opportunity to expand their industrial IoT. With their unique value proposition, wearables are set to pave way into people's lives without having to compete with other devices. More information about wearable technology in manufacturing can be found in the books in [16,17] and in a related journal: *IEEE Transactions on Learning Technologies* .

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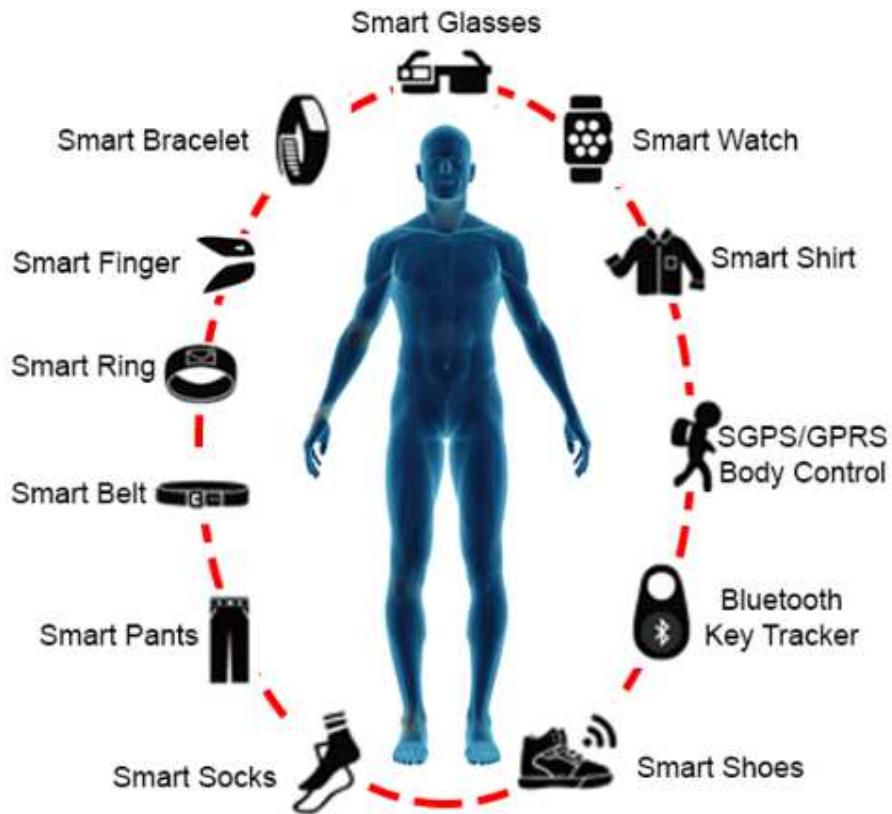
Figure 1 Different types of wearable devices on human body [3].

Figure 2 The cloud word for manufacturing [6].

Figure 3 A typical use of wearables in manufacturing [7].

Figure 4 Different uses of wearables [8].

Figure 5 A typical warehouse [11].

Figure 6 Wearables provide physical assistance during tasks like lifting and bending [12].

Figure 7 A man wearing a full-body exoskeleton to aid in carrying out a task [13].