Industry 4.0: Automation, Robotics & AI – Online Research and Findings about usage of Automation, Robotics & AI in various welding related industries Globally which could contribute towards Sustainable Environment.

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A B S T R A C T

Even though the Welding Industries globally developed to use Automation, Robotics & AI, the contributions towards the Sustainable Environmental concepts are not widely adopted yet. Hence, to make online research and obtain the findings by the usage of Automation, Robotics & AI towards Sustainable Environment will play the key role. Alongside, what are the challenges involved during the usage of Automation, Robotics & AI would be analyzed to enhance and widespread usage of these advancements in Welding Industries towards Sustainable Environment. Investments Versus Profitability will be analyzed to improve the usage of Automation, Robotics & AI towards Sustainable Environment in Welding industries.

Keywords: Industry 4.0, Automation, Robotics, AI, Sustainable Environment

1. Introduction

There are lot of innovations happening around Welding and its allied processes. In which, major contributions towards sustainable environment are the vital as well as challenging job. In this technical paper author is attempting to conduct detailed online research to find out the contributions of Industry 4.0: Automation, Robotics and Artificial Intelligence in the Welding and its related industries around the world along with the contributions of Creating Sustainable Environment. The Global Welding Market is Expected to reach USD 708.03 billion by 2035, with automation playing a significant role in this growth.

1.1. History & Evolution of Welding and related Industries

Welding has a rich history dating back thousands of years. In 3000 BCE Egyptians and Mesopotamians used forge welding to joint metals. In 1000 BCE, in Iron age saw widespread use of welding in tool making. In 1800s, modern welding techniques emerged, including arc welding and oxy-fuel welding. In 1881, Auguste de Meritens invented carbon arc welding. In 1900s, Shielded Arc Welding (SMAW) and Gas Metal Arc Welding (GMAW) developed. In World War II, Welding played a crucial role in ship building and aircraft manufacturing, driving innovation and adoption. In 1950s, Gas Tungsten Arc Welding (GTAW) and Plasma Arc Welding (PAW) were introduced. In 1960s, Laser Beam Welding (LBW) and Electron Beam Welding (EBM) emerged. Plus, advances in shielding gases, Flux Cored Arc Welding (FCAW) expanded the capabilities. Today, Welding continues to Evolve with advancement in technology and Automation. Friction Stir Welding (FCAW), Submerged Arc Welding (SAW) have pushed the boundaries of precision and Efficiency.

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Welding is used widely in various industries like, Automotive, Aerospace, Ship Building, Oil & Gas, Infrastructure development, medical department, Energy, Defense, Agricultural, Railways, Nuclear, Mining, Food processing industries etc.,

Because of the versatility, Welding is used in various sectors. Providing, Strong, durable joint and structure. Welding has come a long way to transforming industries and shaping modern infrastructure.

Bifurcation of Evolution in industries:

- Industry 1.0: Mechanization
- Industry 2.0: Mass Production
- Industry 3.0: Digitalization
- Industry 4.0: Cyber-Physical Systems
- And so, on

1.2. Objectives of this Technical Paper

To conduct detailed analysis about the usage of Automation, Robotics & AI in welding industries to make awareness and contribute towards Sustainable Environment.

Table 1 – Top Companies using Automation, Robotics & AI in welding.

Company Name	Country	Industry Type
Fanuc Corporation	Japan	Robotics
KUKA	Germany	Robotics
Yaskawa Electric	Japan	Robotics
Kawasaki Robotics	Japan	Robotics
Wipro PARI	India	Automation
Dristi Robotics	India	Robotics & Automation
Agastya Technologies, Tata	India	AI, Robotics

1.3. Sustainability in Welding

Reducing Environmental Impacts, conserving resources, and promoting eco-friendly practices.

Key aspects involves, Energy Efficiency, Material Conservation, Process optimization, Automation, Optimizing Welding parameters, using eco-friendly shielding gases, Implementing process Ventilation systems, Training and Education of Workforce on Sustainable practices, Introduction of Hybrid welding method, Cold Metal Transfer, Ultrasonic Welding, Good Maintenance and Energy Efficient Welding Equipment usage, Reduce-Reuse-Recycle of Raw materials and welding consumables, Finding and Usage of Newer and eco-friendly Materials and Welding Consumables, Finding and Using Renewable Energy assisted Welding Equipment, Usage of Weld Repair and Refurbishments, Welding Digitalization along with AI and ML, Usage of Virtual Reality and Augmented Reality in Weld Training, Continuous Research & Development etc.,

The above said practices are the major contributors towards building the Sustainability in the welding industry. Which is directly impacting the Environmental protection.

1.4. Role of Automation, Robotics and AI usage in Welding Industry towards contributing Sustainable Environment

Automation, Robotics and AI are bringing Welding industry contributing to a more sustainable environment. Which includes reducing energy consumption through optimized welding process and automated systems.
Precise control and real time monitoring can help to minimize wastage and emissions.

Robots and automated systems protect work force from hazardous environment and reduce accidents, which helps to improve safety and healthy workplace management.

AI powered inspection and real time monitoring ensured the high-quality welds and reduced rework, waste and ensured improved quality.

Cost of production and time can be reduced by using automated welding systems and robotics.

1.5 Key Findings

All stakeholders are knowingly or unknowingly tried to contribute or at least willing to contribute towards sustainable development. However, there are many challenges which affect the ratio of contributions from small scale to medium scale to large scale industries.
Also, there are some lacks awareness that is the major roadblock towards the contribution of sustainable environment.
Many large-scale industries are involved in majority towards reducing or balancing the carbon footprint. However, which is not considered 100% as the correct solution. Because those industries are trying to balance the carbon footprint but not to eliminate the complete negative environmental effects.

1.6 Solutions suggested in welding innovations, Research & Developments towards contributing to the Sustainable Environment

Relooking at Ancient Practices:

In ancient times, bronze was first welded using a process called forge welding. Iron was first welded using a process called pattern welding. Black smith used forge welding to create intricate metal work and tools. It is to be noted that, in ancient times, very limited environmental negative impacts were created. There are various reasons behind it. But in the ancient era people were more attached to the environment and protected the environment along with their daily life.
Few examples are fuels are collected from natural resources only. By means of Wood, Charcoal and Coal, which have the lower environmental impact compared to modern energy sources.
Ancient welders crafted the products to last, reducing the need for frequent replacement and waste generation. Products were designed to repairability and recyclability, extending their life span and reducing waste.
By Incorporating the traditional welding techniques into the modern practice to reduce the environmental impact.
Ancient practices laid the foundation for modern welding techniques and continue to influence the industry today.

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2. Illustrations

A blueprint for our common future

In 2015, UN Member States translated their vision of sustainable development into a blueprint for achieving it: the 2030 Agenda for Sustainable Development. Its 17 Sustainable Development Goals —with ambitious targets to achieve by 2030— cover the three dimensions of sustainable development: the economy, social development and the environment.

Fig. 1

3. Acknowledgements

Environmental sustainability is the responsibility to conserve natural resources and protect global ecosystems to support health and wellbeing, now and in the future. Because so many decisions that impact the environment are not felt immediately, a key element of environmental sustainability is its forward-looking nature. In fact, the

U.S Environmental Protection Agency defines it as "meeting today's needs without compromising the ability of future generations to meet their needs."

Here the author acknowledges that all the resources which are helping towards creating awareness of Environmental sustainability.

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