*https://doi.org/10.69624/1816-2126.2024.2.3*

# Management of technologies in ethylene production enterprises during the fourth industrial revolution

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**Abstract:** This article discusses the application of the 4th industrial revolution technology in ethylene production facilities. The manufacturing industry has recently undergone a significant transformation with the emergence of the industry 4.0 revolution. The Industry 4.0 revolution is characterized by the integration of digital technology and advanced automation to create smart, connected manufacturing enterprises. This integration enables real-time communication, remote monitoring and data collection, providing manufacturers with improvements in quality, reliability and flexibility. Industry 4.0 is about to create "smart enterprises" that are fully automated, data-driven and fully connected to supply chains. In ethylene production facilities, Industry 4.0 is revolutionizing production operations by introducing new technologies and concepts that increase efficiency, productivity and safety. This revolution is powered by the incorporation of modern technology such as artificial intelligence (AI), machine manufacturing, the Internet of Things (IoT) and robotics into industrial processes. As technological advances continue to develop, the ethylene production process will become more productive, environmentally friendly and strengthen its position in the chemical industry.

**Keywords:** Industrial 4.0 revolution, Ethylene production enterprise, New technologies, Ecological cleanliness, Artificial intelligence, INTERNET of things, Robotics.

## 1.INTRODUCTİON

Ethylene is considered the most important petrochemical ingredient in the manufacturing industry in various parts of the world today. Currently, it is produced by the thermal cracking process, which is expensive. Ethylene (C2H4) is considered the most important raw material in the petrochemical industry. It is mainly used to produce plastics, fibers and other value-added organic chemicals for consumption in various applications such as packaging and transportation. Ethylene derivatives account for almost 70% of petrochemical products, including high and low density polyethylene, ethylbenzene, styrene, polystyrene, acetaldehyde, ethylene glycol, acetic acid, vinyl acetate, and polyvinyl chloride. Global ethylene capacity has increased over the past decade due to high consumption in many applications and is expected to reach 200 million tons by 2026 [2]. The global ethylene market was valued at US$ 132 billion in 2022 and is projected to reach US$ 228.69 billion by 2032 [8]. Ethylene production increased rapidly mainly in the mid-20th century, when oil and chemical companies began to separate it from refinery off-gases and produce it from natural gas and ethane (derived from refinery effluents) [1]. Ethylene is stored in liquid form under high pressure or at low temperature. However, ethylene is often delivered directly to consumers through pipeline networks. The future of chemical production relies heavily on technological advances, and ethylene is almost always at the forefront of innovation in this area. Researchers are exploring new methods to increase the efficiency of ethylene production, reduce energy consumption and develop new applications. For example, the development of catalysts that improve selectivity and productivity during ethylene production has greatly increased productivity. In addition, advances in downstream processing techniques have enabled the production of high-quality and customized ethylene derivatives that meet various industry requirements.

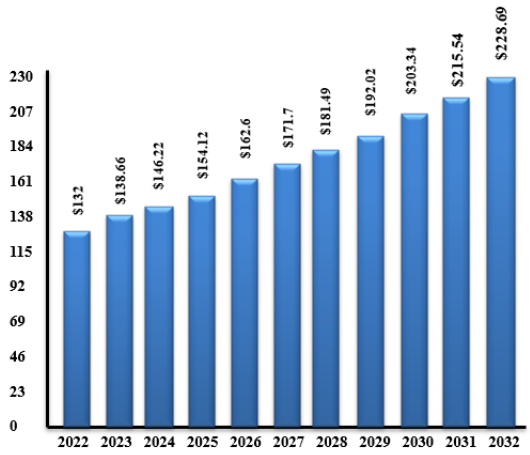


***Fig. 1. Annual growth graph of ethylene production***

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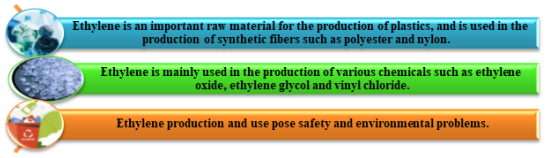


***Fig. The importance of ethylene in the petrochemical industry.***

Ethylene production and processing pose safety and environmental problems. Ethylene is a highly flammable gas and requires strict safety measures during production, transportation and handling. Ethylene leakage can cause explosions and fires, which can result in property damage and loss of life. Ethylene production also creates greenhouse gases that contribute to climate change. Industry 4.0, also known as the Fourth Industrial Revolution, a set of technologies that are transforming manufacturing by making it more automated, integrated, and rationalized.

footprint, but also contributes to the industry's overall sustainability goals. Advances in steam cracking technology, catalyst development, and carbon capture techniques are likely to increase the efficiency and environmental impact of natural gas liquids (NGL)-based ethylene production [11]. Today, ethylene plants use highly efficient methods such as steam cracking to convert natural gas liquids into ethylene. These advances not only reduce energy consumption, but also help minimize the environmental impact of ethylene production. One of the main advantages of ethylene is its significantly lower carbon footprint compared to other petrochemical products. Traditional ethylene production methods involve cracking crude oil, which releases large amounts of carbon dioxide. In contrast, ethylene from natural gas liquids greatly reduces greenhouse gas emissions. Natural gas itself is considered a cleaner fuel source, and by using it to produce ethylene, we can reduce our carbon footprint and contribute to a greener future. Additionally, advances in ethylene production technology, such as the use of renewable energy sources, can further strengthen its environmentally friendly credentials. By examining the environmental considerations of ethylene, it is possible to shed light on its potential as a more environmentally friendly alternative. Ethylene plays an important role in the production of various plastics that are scrutinized for their environmental impact. However, ethylene can also contribute to sustainable practices through recycling and waste reduction. For example, some plastic products made from ethylene, such as polyethylene, can be recycled and turned into new materials. This process helps reduce the amount of plastic waste that ends up in landfills or the oceans, thereby reducing environmental damage.

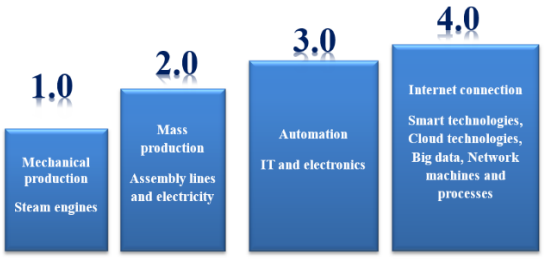


***Fig.3. Technological advances during the industrial revolution***

In ethylene production plants, Industry 4.0 technologies can be used for the following purpose:
• Process automation: Robots can perform tasks previously performed by humans, such as loading raw materials, operating equipment, and quality

control. Artificial intelligence (AI) can optimize equipment performance, predict breakdowns and enable inventory management. The Internet of Things (IoT) enables sensors to collect real-time information about equipment health and operational processes.
• Data integration: Manufacturing execution systems (MES) integrate data from various sources such as sensors, equipment and enterprise planning systems (ERP). Data platforms enable the analysis of data from various sources to obtain data on productivity, efficiency and product quality.
• Production optimization: Big data analytics are used to identify patterns and optimize workflows. Modeling and simulation allow new products and processes to be tested before they are introduced into production. Augmented Reality (AR) and virtual reality (VR) can be used for employee training and technical support.
Industry 4.0 is rapidly changing the production potential of ethylene. By implementing these technologies, ethylene producers can increase productivity, reduce costs and improve safety working conditions.
During the Industry 4.0 revolution, several emerging technologies are being used in ethylene production to increase efficiency, sustainability and overall operations.
Enterprises using Industry 4.0 technologies in ethylene production plants include BASF, Dow Chemical, and Saudi Aramco. BASF is using artificial intelligence to optimize the operation of its ethylene plants. Dow Chemical uses IoT to monitor the health of its equipment in real time. Saudi Aramco is using AR to train its employees on new equipment.
Some of the major emerging technologies used in ethylene production during the fourth industrial revolution are:

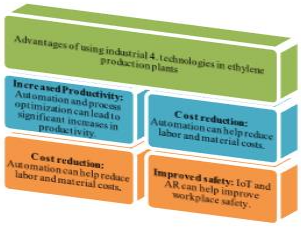


***Fig. 4. Advanced of İndustry 4.0 technologies***

• Real-time monitoring and data analytics: Industry 4.0 can perform real-time monitoring of processes and equipment through sensors combined with advanced data analytics to optimize production processes, reduce downtime and increase overall efficiency.
• Predictive Insight: Using predictive maintenance technologies allows ethylene production facilities to anticipate equipment failures before they occur, reducing downtime and maintenance costs while ensuring uninterrupted operation.
• Automation and Robotics: Automation technologies play an important role in increasing efficiency and productivity in ethylene production by simplifying processes, reducing manual intervention and improving overall operational performance.
• Internet of Things (IoT): IoT devices are increasingly integrated into ethylene production facilities to connect equipment, systems and processes, facilitate data exchange and real-time decision making.
• Artificial Intelligence (AI) and Machine Learning: Artificial intelligence and machine learning algorithms are used in ethylene production to analyze complex data sets, optimize processes, predict outcomes and improve decision making to increase efficiency and productivity.
• Cyber-Physical Systems: The integration of cyber-physical systems in ethylene production enables seamless interaction between digital technologies and physical processes, leading to improved control, monitoring and optimization of operations. • Advanced Process Control (APC): APC systems are used to optimize process parameters in real time, ensure efficient operation, reduce energy consumption and improve product quality in ethylene production.
• Supply Chain Digitization: The use of digital technologies for supply chain management enables better coordination between suppliers, manufacturers and distributors, which leads to increased logistics efficiency and lower operational costs in ethylene production.
Global ethylene production capacity is estimated to be 180 million tons in 2023. These are the leading countries in ethylene production [9].
In the future, ethylene production is expected to develop in a number of directions. It is planned to be one of the priorities of the industry due to the increase in demand, i.e., population growth, urbanization and economic development. Integration with other industries Ethylene production will be increasingly integrated with other industries such as chemical, oil and gas. In the development of new technologies, new technologies such as 3D printing and additive manufacturing will be used to create

new ethylene products. In the field of digitization, Industry 4.0 will play an increasingly important role in ethylene production**Table 1. Leading countries in the use of ethylene**

| Country | Production volume |
|---|---|
| **China** | **30%** |
| **USA** | **20%** |
| **EUROPE** | **18%** |
| **NEAR EAST** | **12%** |
| **RUSSİA** | **5%** |

Artificial intelligence, big data and the Internet of Things will be used to optimize production and increase efficiency. As ethylene production facilities increasingly rely on digital technologies, they are more vulnerable to cyberattacks. Industry 4.0 requires manufacturers to invest in comprehensive cybersecurity measures to protect against data breaches, ransomware attacks, and other cybersecurity threats. Industry 4.0 technologies enable real-time monitoring and predictive maintenance, strengthen safety protocols and reduce the risk of accidents.

## CONCLUSİON

Industry 4.0 is still in its early stages and will take some time to be fully implemented in ethylene production. For the successful implementation of Industry 4.0, attention must be paid to a number of issues such as cyber security, system compatibility and employee qualifications. Despite these challenges, Industry 4.0 has great potential to transform ethylene production. Ethylene producers who can adapt to changing market conditions and implement new technologies will have a competitive advantage. The development of new and more efficient catalysts is expected to play an important role in the future of ethylene production. Although ethylene is commonly associated with the production of plastics, it also has the ability to make biodegradable alternatives. For example, it is possible to use ethylene to produce biod. One of the most interesting developments is the use of renewable feedstocks, such as bio-based feedstocks, as opposed to traditional fossil fuels. Overall, the impact of the fourth industrial revolution on ethylene production includes the goal of improved efficiency, enhanced sustainability, reduced waste, resource optimization, safer production, cyber security, workforce training, data management, technology integration and supply chain management.

## REFERENCES

1. D. Lozowski, Technology Profile: Production of Ethylene from Ethane, By Intratec Solutions, pp.1-3, 2022.
2. A.S. Bin N., A.A. Al-Rabiah, Development and Intensification of the Ethylene Process Utilizing a Catalytic Membrane Reactor, American Chemical Society, journal of ACS Omega, pp.28445-28454, 2022.
3. Y.Liao, E.Loures, F.Deşam, G.Louro Brezinski, A.Venâncio, The impact of the fourth industrial revolution: a cross-country/region comparison, Parana Papa Katolik University, Kuritiba, PR, Brazilia, pp.4-16, 2018.
4. M.Soori, R.Dastres, B.Arezoo, F. Karimi Ghaleh Jough, Intelligent Robotic Systems in Industry 4.0, A Review, researchgate, journal of Advanced Manufacturing Science and Technology, p.1, 2024.
5. M.Ghanta, D.Fahey, B.Subramaniam, Environmental impacts of ethylene production from diverse feedstocks and energy sources, SpringerLink, pp. 167–179, 2014.
6. Buenemann, A., Industry 4.0 in Ethylene Production I, 2021 AIChE Virtual Spring Meeting and 17th Global Congress on Process Safety.
7. E.Lek, How Digitalization of Process Design and Operations boosts Profitability in Ethylene production, September 1, Schneider Electric., 2017.
8. "Etilen bazarının həcmi" Precedence Research, Etilen Bazarı - Qlobal Sənaye Təhlili, Ölçü, Pay, Artım, Trendlər, Regional Görünüş və Proqnoz 2023-2032.
9. "Market Opportunity Assessment in Ethylene Market" Straits Research 2024.
10. F.Aguirre, How Industry 4.0 is Revolutionizing Manufacturing Operations?, company of Smart Factory 2024.
11. H.Zreik, Future of Ethylene Production and Use", company of Faster Capital 2024.
12. K.Moran, Benefits of Industry 4.0, SL Controls An Nit Group Company 2024.