Special Feature

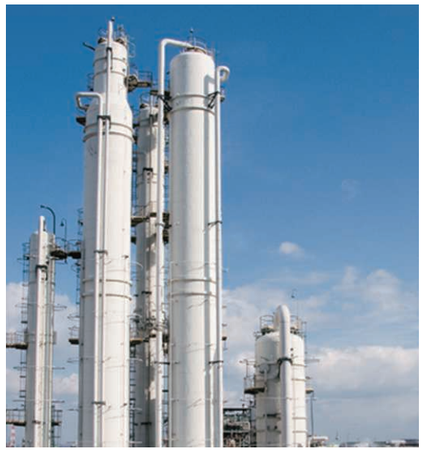
AI Solutions for Industrial Autonomy (IA2IA)

In a World First, Yokogawa's Autonomous Control AI is Officially Adopted for Use at an ENEOS Materials Chemical Plant

– One year of stable operation demonstrates this next-generation control technology can reduce environmental impact, achieve stable quality, and transform operations –

■ Summary

ENEOS Materials Corporation and Yokogawa Electric Corporation announce they have reached an agreement that Factorial Kernel Dynamic Policy Programming (FKDPP), a reinforcement learning-based AI algorithm, will be officially adopted for use at an ENEOS Materials chemical plant. This agreement follows a successful field test in which this autonomous control AI*1 demonstrated a high level of performance while controlling a distillation column at this plant for almost an entire year. This is the first example in the world of reinforcement learning AI being formally adopted for direct control of a plant*2.



Distillation columns at the chemical plant
(Credit: ENEOS Materials Corporation)

■ What Yokogawa Achieved

Over a 35 day (840 hour) consecutive period, from January 17 to February 21, 2022, this field test initially confirmed*3 that the AI solution could control distillation operations that were difficult to apply to existing control methods (PID control/APC) and had necessitated manual control of valves based on the judgement of experienced plant personnel. Following a scheduled plant shut-down for maintenance and repairs, the field test resumed and has continued to the present date. It has been conclusively shown that this solution is capable of controlling the complex conditions that are needed to maintain product quality and ensure that liquids in the distillation column remain at an appropriate level, while making maximum possible use of waste heat as a heat source. In so doing it has stabilized quality, achieved high yield, and saved energy.

■ Confirmed Benefits from the Year-Long Field Test

① **Year-round stability**
The autonomous control AI maintained stable control of the liquid levels and maximized the use of waste heat, even in winter and summer weather, with external temperature changes of around 40°C. No problems were observed, and stable operation and high product quality was achieved throughout the field test.
② **Reduced environmental impact**
By eliminating the production of off-spec products, the autonomous control AI reduced fuel, labor, and other costs, and made efficient use of raw materials. While producing good quality products that met shipment standards, the autonomous control AI reduced steam consumption and CO_2 emissions by 40%*4 in comparison to conventional manual control.
③ **Lightened workload and improved safety**
The autonomous control AI eliminated the need for operators to make manual inputs. This not only reduced the workload and helped to prevent human error, but also reduced mental stress levels and improved safety.
④ **Robustness of the AI control model**
Even after modifications were made at the plant during a routine shut-down for maintenance and repair, the same AI control model could remain in use.

Confirmed benefits from the year-long field test

- Year-round stability even with external temperature changes of around 40°C
- Optimized energy use and reduced time and cost while maintaining quality, enabling a 40% cut in CO_2 emissions
- Lightened workload and improved safety
- AI control model could be used as is even after plant shut-down for maintenance and repair

*1 Yokogawa defines autonomous control AI as AI that deduces the optimum method for control independently and has a high level of robustness enabling it to autonomously handle, to a certain extent, situations that it has not previously encountered.
*2 Based on comprehensive secondary research of publicly available resources by IoT Analytics, performed in March 2023.
*3 Press release announced on March 22, 2022: 'In a World First, Yokogawa and JSR Use AI to Autonomously Control a Chemical Plant for 35 Consecutive Days - Putting into practical use a next-generation control technology that takes into account quality, yield, energy saving, and sudden disturbances. Please refer to our company website for details.
https://www.yokogawa.com/news/press-releases/2022/2022-03-22/
*4 In comparison to the amount of steam previously used to maintain the liquid level and the corresponding amount of CO_2 emissions.

Factorial Kernel Dynamic Policy Programming (FKDPP), a Reinforcement Learning-Based AI Algorithm

The AI used in this control experiment, the Factorial Kernel Dynamic Policy Programming (FKDPP) protocol, was jointly developed by Yokogawa and the Nara Institute of Science and Technology (NAIST) in 2018. It can be used in areas that could not be automated, for example, where there are conflicting targets, such as the need for both high quality and energy savings.

An autonomous control AI algorithm FKDPP
(Factorial Kernel Dynamic Policy Programming)

Received the Prime Minister's Award at This Year's Japan Industrial Technology Awards

The FKDPP algorithm has received the highest award, the Prime Minister's Prize, in this year's Japan Industrial Technology Awards. The Japan Industrial Technology Awards (Nihon Sangyo Gijyutsu Taisho) were established in 1972. The purpose of these annual awards is to bring recognition to companies and other organizations that have contributed to industry and society over the year through the development and practical application of advanced technologies.

The Japan Industrial Technology Awards Ceremony
(Credit: Nikkan Kogyo Shimbun)
From left: Mr.Yanagi Vice-Minister of the Ministry of Education,Culture,Sports,Science and Technology; Mr.Nara President of Yokogawa Electric Corporation; Mr.Kanokogi President of Yokogawa Digital Corporation; Mr.Ota Vice President of Nara Institute of Science and Technology

The Future Direction of AI and Manufacturing

Hiroaki Kanokogi
President, Yokogawa Digital Corporation

Research into the use of AI in manufacturing began at Yokogawa around 2013. At the time, AI was still a term that was used more in science fiction, not the buzzword one often hears on TV today. (Back then, "AI" was generally understood in the IA field to stand for "analogue input".) However, since the AlphaGo Go-playing program defeated a professional Go player in 2015, AI technology has been in the spotlight and attracted a lot of public attention AI has continued to develop, and in their respective board game and document generation domains, technologies such as AlphaGo and ChatGPT have achieved tangible results that everyone can see.

AI research is also being undertaken for various applications in the manufacturing industry. However, people have been particularly cautious about the full-scale use of AI with plant operations. This requires high levels of reliability and safety, so the introduction of this unprecedented new technology has faced high hurdles. Moreover, the plant control technologies have been developed over many years and are themselves highly refined. Many people have therefore expressed doubts that AI cloud produce better results.

As explained on the left side of this page, a test of the FKDPP reinforcement learning AI algorithm that began in March 2022 succeeded in autonomously controlling the operation of valves at a chemical plant . After one year of stable operation, this technology was officially adopted for use at this Yokogawa customer's plant. At last, AI had succeeded in achieving "tangible results that everyone could see" in the operation of a plant . As one of the originators of FKDPP, I feel very fortunate about this. This achievement can be attributed to the passionate aspirations of the researchers from the Nara Institute of Science and Technology, plant-related staffs from ENEOS Materials Corporation, and Yokogawa's people to achieve something new, and their strong collaboration. I would like to take this opportunity to express my gratitude to all those involved.

Yokogawa Digital Corporation was founded in July 2022. As a consulting firm that has its origins in the manufacturing industry, we will work together closely with our customers to resolve issues at their plants. The manufacturing industry faces a wide range of issues from addressing a decrease of operators and difficulties in passing on technical knowledge due to a falling birth rate and an aging population to sustainability management and strengthen the resilience of global supply chains. These issues are difficult to solve simply by introducing AI technology. By transforming mindsets and developing specific measures to resolve management issues, Yokogawa Digital Corporation will provide realistic and practical proposals for the transformation of businesses transformation. As a powerful tool in this, we will provide autonomous control AI solutions that match up well with whatever issues our customers' face in running their businesses.

Yokogawa Digital Corporation Established to Support DX in Manufacturing

In July 2022, Yokogawa Digital Corporation was established to support DX in manufacturing, and started operations in October of the same year. As a consulting firm born in the manufacturing industry, we provide support to strengthen the competitiveness of the manufacturing industry, from productions to management.

While dealing with the COVID-19 pandemic, supply chain issues, and the need to contribute toward the SDGs and implement ESG management, companies must also optimize their business operations, from management and the supply chain through production, to increase competitiveness and achieve a sustainable society. Yokogawa Digital will add DX/IT know-how to Yokogawa's strong OT expertise, including DX strategy planning, AI utilization, carbon neutral services, security services, OT strategy planning, software services, and training services, aiming to become a consulting firm that integrates IT and OT and provide value for the overall optimization of our clients' businesses.