VISION2025
NISSIN ISSIN
Represents the determination to renew the Nissin Electric Group toward 2050. "Issin" means "renewal" in Japanese.

Nissin Electric's Approach to Production Engineering

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The Nissin Electric Group has been enhancing manufacturing capabilities and improving productivity as part of its medium-to-long-term business plan VISION2025. Our main goal is to improve productivity by strengthening our manufacturing technology. Under the slogan "NISSIN ISSIN" (i.e., Nissin renewal), we have been promoting the smartification of our factories through activities that spin the dual wheels of expanding and inheriting important artisan skills and techniques, while also advancing projects that focus on NPS efficiency and the use of cutting-edge technologies. This paper presents an overview of these efforts.

Keywords: medium-to-long-term plan "VISION2025," new NPS (Nissin Electric Production System), advanced technology, artisan skills

1. Introduction

The overall strength of Nisshin Electric Co., Ltd. is based on a triumvirate of development, sales, and production capabilities. The production capability is truly a manufacturing capability, and without this focus, our development and sales capabilities could be affected.

In its medium-to-long-term plan "VISION 2025," the Nissin Electric Group has identified the following six growth strategies.[1]

(1) Strengthen corporate social responsibility
(2) Thorough labor-saving super-smart society
(3) Full development of a recycling-oriented society
(4) Increased demand due to growing environmental awareness in emerging countries
(5) Rising demand for environmentally friendly products
(6) Business opportunities from electric vehicle (EV) expansion

Nissin Electric is working to strengthen the business foundation that supports these growth strategies, and is focusing on strengthening our manufacturing capabilities and improving productivity by setting safety, environment, quality, cost, distribution, delivery, and research & development (SEQCDD) as our main issues.

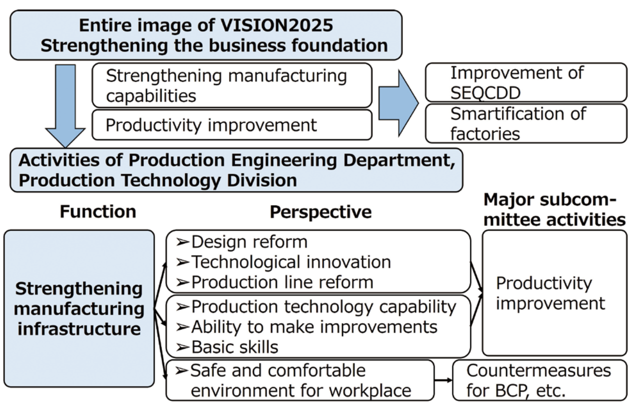


Fig. 1. Production Engineering Department VISION2025 initiatives

The Production Engineering Department, Production Technology Division plays a central role in improving the manufacturing base, promoting the activities of major subcommittees for productivity improvement from the viewpoints of design reform, technological innovation, and production line reform, etc. (Fig. 1).

Table 1 shows the system of activity themes of the Production Engineering Department. The Productivity Improvement Subcommittee, established to carry out activities within the Production Technology Division under the subcommittee themes, engages in the New Nissin Electric Production System (NPS) Efficiency Project and the Advanced Technology Utilization Project.

Table 1. Themes of activities of the Production Engineering Department

Themes	Activities	Subcommittee	Working groups (WGs), projects, etc.
1. Subcommittee theme	Company-wide cross-functional activities	Metal parts fabrication technology (collaboration with Equipment Parts Department)	• Machining (cutting or shaping of materials) • Sheet metal • Welding
	Activities within the Production Technology Division	Productivity improvement	• New NPS Efficiency project • Advanced technology utilization
2. Key management themes within the department	Major functions/tasks	• Expansion of engineers who can utilize 3D-CAD	
	Business process reengineering	• Expansion of instructors of key technologies and skills	
	Safe, comfortable workplace environment	• Maintenance and efficiency for district and infrastructure, etc.	
3. Management themes for each group	Strengthening function/activities for business process reengineering	• Establishing mechanisms and rules • Training personnel, etc.	

The new NPS Efficiency Project, which was the company-wide activity began in FY 2019, succeeds the NPS Efficiency Project (2015-2019), which was a company-wide activity, and along with the project name change, the activities have transitioned into a working group (WG) format.

As shown in Fig. 2, the Productivity Improvement Subcommittee is organized by the Production Engineering Department in cooperation with the production engineering departments of all business divisions to promote these two projects and key management themes within the department. As a specific implementation team, an organizational structure has been set up whereby the engineering, training, and factory management departments collaborate with the relevant divisions.

This paper reports on the activities of the Productivity Improvement Subcommittee as part of headquarters activities under the subcommittee theme, the expansion of instructors of important technologies and skills as activities under the department's priority management theme, examples of the utilization of advanced technologies and the promotion of digital transformation (DX) realization activities, and the efforts of the Plant Management Department.

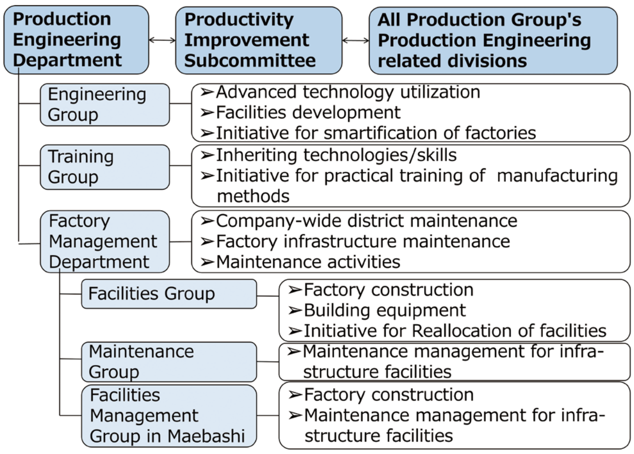


Fig. 2. Organization and mission of the Production Engineering Department

2. Productivity Improvement Challenges and Solution Initiatives

The Productivity Improvement Subcommittee is actively involved in both these projects: the new NPS efficiency improvement and the utilization of advanced technologies. The achievement of the goals of these activities is quantitatively and continuously measured and monitored using key performance indicators (KPIs).

2-1 New NPS efficiency project

The concept of this project activity is "pursuit of ease of manufacturing." The purpose of this project is to go beyond the boundaries of the manufacturing department and strengthen the ability to make improvements from sales to design, manufacturing, and construction related to manufacturing, as well as to rectify the workflow, specifications, and other information across multiple departments and divisions.

The project has five working groups that focus on the activities shown in Table 2.

Four distinctive activities are listed below.

(1) The Sales WG and Engineering WG are taking advantage of the company's low-volume, high-mix production format to optimize the accurate communication of information between the engineering and design departments to meet the one-of-a-kind specifications demanded by our customers and to improve operational efficiency.

(2) The Design WG is using the feedback function to improve the design to be easy to manufacture and assure quality.

(3) The Production Engineering and Manufacturing WG tackles actual quality and productivity issues faced by factories through industrial engineering (IE) practical training program, effectively killing two birds with one stone by developing human resources and solving problems.

(4) The Construction WG is developing a mechanism to improve and propose improvements to the safety of on-site installation work and ease of installation.

Table 2. Key activities of the new NPS efficiency project

Work flow	Working Group	Activity details
Finalizing specifications	Sales	• Improving operational efficiency through the rectification of information • Optimizing communication to produce basic design and meet specifications required by customers through enhanced efficiency
	Engineering	• Optimizing the transfer of information from the Engineering Department's basic design to the design staff in each business division
Production	Design	• Improving efficiency of detailed design in collaboration with Engineering Department • Design improvement for easy manufacturing
	Production engineering and manufacturing	• Concurrent overall optimization activities for the Design/Manufacturing divisions
		• Enhancing improvement capabilities through IE practical training • Improved productivity through collaboration among Design, Quality Assurance, and related departments
Construction	Construction	• Shortening of construction period • Improved productivity through collaboration among Design, Production, Quality Assurance, and related departments

Among these, the IE practical training program is a six-month program in which key improvement personnel recommended by each business division focus on solving manufacturing issues. Since its introduction in the second half of 2020, 176 employees have participated in the program by the second half of 2023 (target: 200 by the end of FY2025). Of these, 10 (target 20) have been certified as IE instructors. Today, these IE instructors are actually involved in IE practice and guidance, and the IE method is being used on a regular basis throughout the Group.

2-2 Utilization of advanced technologies and promotion of DX realization activities

Production technology is the technique of converting "product design information" into "production instruction information" for manufacturing. The production instruction information in this context refers to information that indicates the processing steps, processing methods and techniques, manufacturing conditions, as well as the selection of equipment and jigs/tools, in order to add value to and ensure the quality of the product.

In particular, in recent years, this information has been required to support production systems that incorporate information technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and robotics, and is changing the way manufacturing is done under the so-called Fourth Industrial Revolution.

Activities are underway to make factories smarter by utilizing these advanced technologies. Making factories smarter means continuously and progressively improving quality and productivity by accumulating data from each piece of factory equipment using IoT devices, etc., analyzing them using AI, and effectively utilizing the results at the manufacturing site. In the company, advanced technologies such as 3D CAD, IoT, AI, and robots are being introduced in each department. The objectives and activities of advanced technology utilization are shown in Table 3.

Table 3. Objectives and activities of advanced technology utilization

	Objective classification	Activity details
1	Quality improvement	• Reduction in defect rate • Stabilization of quality and reduction of variation • Design quality improvement
2	Cost reduction	• Reduction of material usage • Reduced resources for production • Reduction of inventory • Management of facilities/labor-saving of status monitoring
3	Productivity improvement	• Improve utilization of equipment and personnel • Improving the efficiency of human operations • Rduction of operations and workload • Reduction of outages due to equipment failure
4	Shortened time to market and mass production	• Automation of product development and design • Faster response to specification changes • Shortened production line design and build
5	Addressing human resource shortages and training	• Utilizing diverse human resources • Passing on skills
6	Providing and enhancing new added value	• Improving responsiveness to diverse needs • Expansion of processing technologies that can be offered • Providing new products and services • Improvement of product performance and functionality
7	Others	• Strengthening risk management

Table 4. Examples of factory smartness goal-setting tables

Visualization levels	1. Facility operators	2. Production line	3. Entire factory	4. Whole Supply Chain
d. Improvements and instructions		➢Automatic ordering of parts and materials		➢Just-In-Time adoption ➢Automatic ordering of parts and materials
c. Analysis & forecasting			➢E-mail notification of abnormalities	
b. Visualization	➢Visualization of factory progress		➢List of electric power used on premises	
a. Data-process	➢Barcode reading/tablet input	➢Collection of information of manufacturing conditions		

Smartification of factories
·Management target levels 1.to 4.
·Visualization levels a. to d.
Management target levels

We use the matrix shown in Table 4 to represent the indicators of factory smartness. By expanding the level of management (horizontal axis) from equipment and workers to line processes and then to the entire factory, and by expanding the level of visualization (vertical axis) from data acquisition to visualization, further analysis, and improvement instructions, the factory will become smarter. Each business division has set a target level by the end of FY2025 and is working to achieve it.

After setting the goal of factory smartization, each business division is developing DX realization activities with examples of advanced technology introduction toward the achievement goal as the keywords of the activities (Table 5).

The Production Engineering Department utilizes IoT, AI, and robotics as tools in the process of applying the four technologies of process, production systems, management, and equipment to enhance its ability to solve technical problems in production engineering.

Table 5. Factory smartening activity keywords

No	Item	Keywords for Activities in Each Department	Direction
1	Similar Image Search	• Image Search System • Flow Analysis System • SCAN Function Expansion • Paperless System for Drawings	• Design Drawing Search • Manufacturing Production Efficiency • Standardization
2	Collaboration & Operation Monitoring	• Equipment, Operation IoT • Progress Management for Design, Receiving and Shipping of Parts • Unified Prevention Control	• IoT Advancement • Monitoring • Prevention Control
3	Manufacturing Navigation	• 3D Manufacturing Navigation Expansion • VR for Manufacturing • Video Manuals for Skill Transfer	• Application 3D-CAD • IoT Advancement • Traceability
4	Productivity Improvement Support	• Electronic Forms • Web Camera for Factory Visualization, Motion Analysis • Motion Capture for Engineering Design	• Work Results Acquisition • Motion Analysis, IE Support • Paperless
5	Factory Simulator	• Pruduction Schedule Utilizaion and Expansion • Online Scheduling • IoT for Performance Data Collection	• Automation of Engineering • IoT Advancement • Throughput Integration
6	Alert Support CAD	• 3D-CAD Automated Design System • Automated Check	• 3D CAD Utilization • Automatic Check Function • Design Automation
7	Procurement-related Supply Chain Management (Shipping)	• BOM Integration with 3D-CAD Data • Automated Parts Input	• Inventory Management • Automated Shipping • Automated Shelving

3. Key Management Themes within the Department

3-1 Higher quality molded products

As a concrete example of the use of advanced technology, we will introduce a case of automation of the inspection process for the purpose of improving the quality of mold (resin molded insulator) products manufactured by the Equipment Components Department, the Production Technology Division. In this case, data related to mold casting and curing furnaces as pre-process conditions in manufacturing are acquired by IoT, and the causal relationship between the data and inspection results is verified for improvement.

The part to be inspected is the assembly groove of the o-ring that seals the gas on the flange surface of the molded product. If bubbles or other defects called voids exist in this groove during the pouring process, the surface becomes defective and is detected as a gas leak defect during the post-assembly inspection. The defect judgment criteria for void defect dimensions in this groove is an approximate diameter of 0.07 mm or more, which increases the risk of gas leakage, and conventionally, skilled inspectors have visually inspected all the products.

In order to automate this inspection, it was necessary to formalize the tacit knowledge of the inspectors' judgment know-how. As a result of observation and quantification of the defective portions in the 506 cases judged to be abnormal, the size and frequency of occurrence of the defective portions were obtained as shown in Fig. 3. From the visual inspection observations, it was found that the defect areas were spherically concave, and skilled inspectors observed the shadows of the concavities.

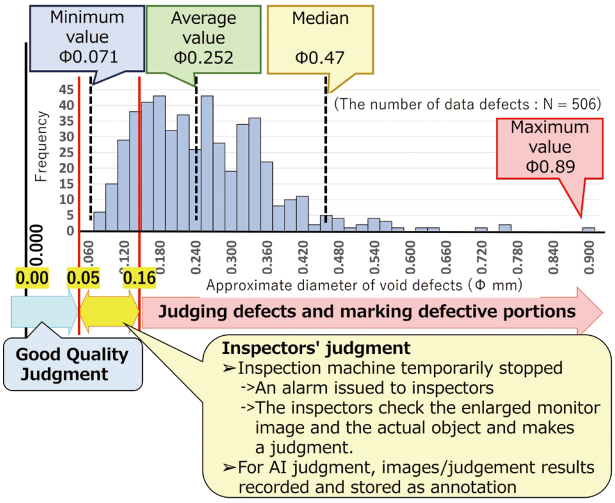


Fig. 3. Method of image processing inspection judgment of defective areas

However, there were many technical challenges in replacing this visual inspection of defects with image processing inspection. For example, the shape of the o-ring groove is curved, and it was necessary to teach the robot to perform complex movements to illuminate the groove. In addition, it was needed to use a high-magnification lens to capture images in order to find small defects.

The most difficult problems were that, as magnification was increased, minute vibrations of the robot were magnified and the depth of focus became shallow, resulting in blurred images, and the narrower field of view resulted in more frequent image capture and longer inspection time, making it impossible to achieve the rationalization effect. Therefore, we sought inspection conditions that satisfied all of the following criteria: optimal magnification, robot operation, and profitability criteria.

Furthermore, a highly rigid structure was designed to minimize the effects of vibration and other factors, and the magnification of the optical system was selected to achieve both inspection performance and inspection time. However, the judgment performance of the image processing inspection for defects in the range of 0.05 to 0.16 mm was not as good as that of the master craftsman, and it was difficult to make a good or bad judgment. Therefore, when this ambiguous defect dimension is measured, the inspection is stopped and an alarm is issued to the inspectors, who make a judgment on the monitor screen. In addition, the images and judgment results from this image processing inspection are recorded and stored as annotation data, which is used as learning data for AI judgment.

Figure 4 shows a conceptual diagram of the automatic inspection robot, an image capture screen, and an example of image processing judgment results. The system captures the shadow of a dent that exists on the o-ring contact surface (curved surface) of a molded product, extracts the edge, approximates the circle, calculates the diameter of the defective area, and compares it with the threshold value for judgment. A photograph of the exterior of the automatic inspection robot is shown in Photo 1.

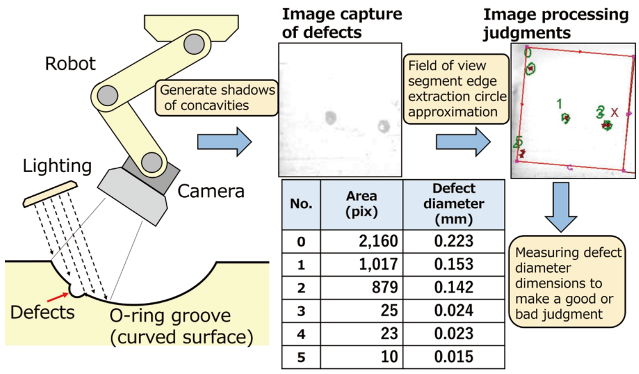


Fig. 4. Conceptual diagram of imaging method and examples of image processing judgments

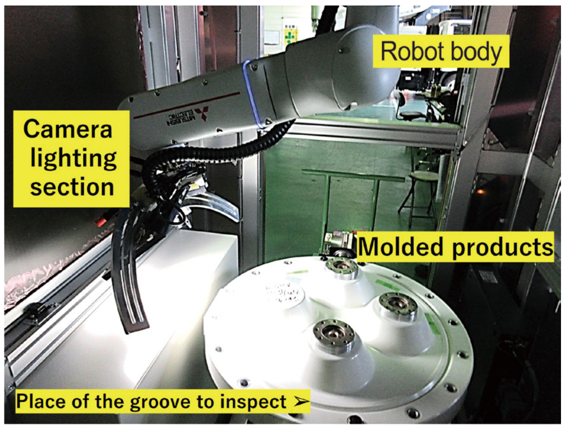


Photo 1. Exterior of the automatic inspection robot for molded parts

Molded products become defective because of air bubbles that remain when the resin is injected into the mold. In order to control these bubbles, the molding equipment injects the resin under negative pressure conditions. However, if the negative pressure conditions are abnormal, bubbles may remain on the inner surface of the mold, causing defects.

The degree of vacuum in the casting process, resin temperature at the time of casting, and oven temperature in the curing process are collected and inspected by IoT devices.

We have implemented the capability to compare data from upstream processes when defects or malfunctions occur during the inspection process. As a result, we are able to reduce defects caused by process conditions and improve overall quality. Process conditions collected by IoT devices can be monitored at all times on the desk (Photo 2), leading to a decrease in quality defects by approximately 20%. In addition, preventive maintenance activities have been strengthened by installing M2M vibration sensors in the motors of mold material mixing equipment to stabilize production.

In the future, the company aims to optimize manufacturing conditions through AI to create a model workplace that will be a pioneer for the entire company.

a) Overview screen of injection molding equipment

b) Monitor of temperature measurement for curing furnaces

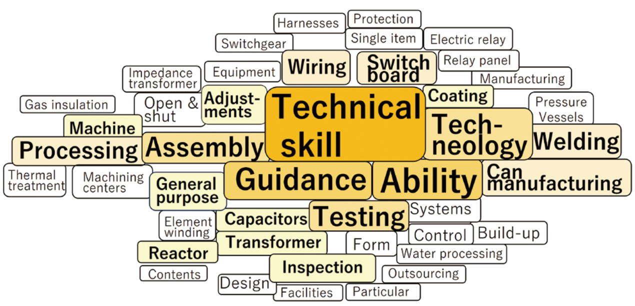
Photo 2. IoT data display screen of casting equipment and curing furnaces

3-2 Expand leadership in key technologies and skills

The company has established a system whereby engineers and technicians study the art of master craftsmanship through the pursuit of "monozukuri" (manufacturing) and pass on these important skills and techniques in the manufacturing process. We then call those who are skilled in technology technical experts (TEs) and those who are excellent in skills Meisters, and we provide incentives for them.

Currently, 44 TEs and 19 Meisters are appointed; VISION2025 aims for each division to have 5 TEs and 3 Meisters in order to promote the expansion of leadership by training the next generation of TEs and Meisters, and to further ensure the proper allocation of these leaders.

The results of data mining by AI on the linguistic information of all the texts in which TE/Meister certification tasks are described show that "technical skill" is the most frequently extracted term in the middle of "welding," "wiring," "assembly," and "testing," etc., and is the key to these tasks (Fig. 5).



Data Mining (Knowledge Discovery in Big-data)

Fig. 5. Data mining of TE/Meister certification operations

3-3 District maintenance promotion and conservation reform by plant management department

Within the Production Engineering Department, the Plant Management Department is organized, consisting of the Facilities Group and Maintenance Group in Umezu, Kyoto and the Facilities Management Group in Maebashi.

The Plant Management Department is in charge of infrastructure maintenance in the Umezu, Kujo, and Kuze districts of Kyoto, as well as at the Maebashi Works, and eventually at affiliated companies and dormitories. Since many of the factory buildings in the Kyoto area and Maebashi Works are aging, the renewal of these buildings is being promoted as an activity of the company-wide district maintenance plan.

Taking the opportunity of the factory construction, the company is responsible for the realization of a smart factory by utilizing Systematic Layout Planning (SLP)[2] technology and integrating the factory layout that pursues efficient flow of goods and the DX concept.

The maintenance group in Umezu is systemizing the inspection of infrastructure facilities scattered across an approximately 80,000 m^2 site based on the concept of "Renew Factory Maintenance."

The company is working to remotely check real-time status and manage equipment based on data from facilities by introducing IoT equipment. The company is also considering the introduction of an inventory management system for spare parts.

4. Conclusion

Our Production Engineering Department is working to improve our production engineering capabilities, recognizing the following three roles.

(1) To further improve SEQCDD, to develop unique value-added capabilities, rather than homogeneous competition with competitors.

(2) Continuously reform manufacturing methods and manufacturing systems in order to maintain SEQCDD's ability to innovate manufacturing methods and production.

(3) To promote the practical implementation of comprehensive strategies in order to achieve improved productivity. This applies to people, production methods, and the establishment of production systems, including scale, locations, and outsourcing.

In order to fulfill these roles, the Production Engineering Department is working to solve productivity improvement issues by passing on the artisan skills and making factories smarter through the use of IoT, AI, and robots.

In particular, automation using robots, etc., cannot be adopted because the apparent automation that simply replaces manual work with equipment repeats not only good actions but also bad actions. It is important to retain the artisan skills, which are the key to quality assurance, and to automate the tasks that do not add value.

It is important for our production engineers to identify the basic manufacturing knowledge and artisan skills that they should possess, relearn any skills that seem to be disappearing, and, as the concept of "learn from the past to create the future" suggests, strengthen our manufacturing capabilities by grasping the "past or old" in terms of the essence of manufacturing and knowing the "new" in information technology.

• "NISSIN ISSIN" (i.e., Nissin renewal) is a trademark or registered trademark of Nissin Electric Co., Ltd.

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