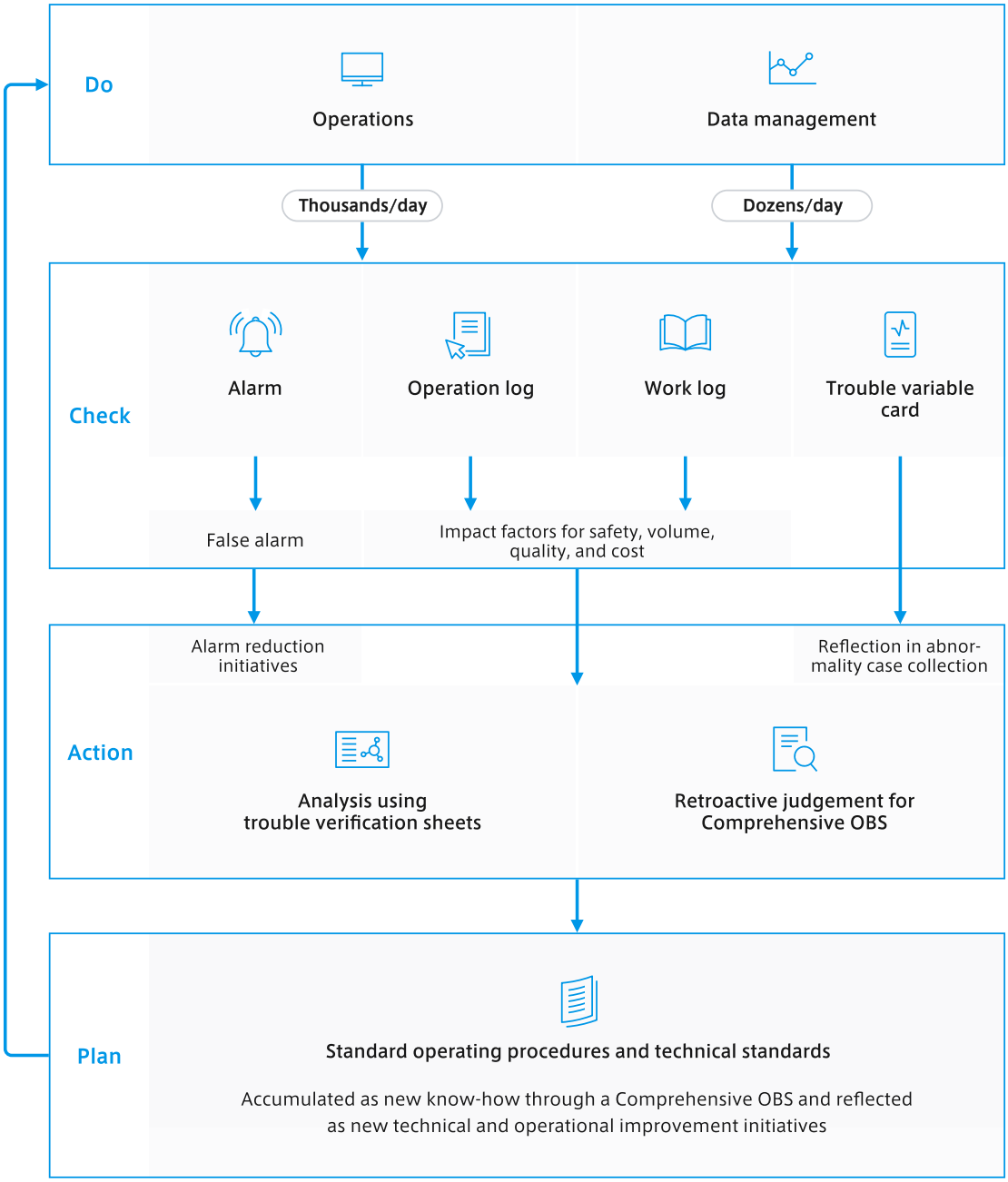
2 Proprietary AI

Two AI applications built with unprecedented logic

The Autonomous Production System utilizes Daicel's proprietary AI, developed in collaboration with the University of Tokyo. To start with, the volume and accuracy of baseline data are important when leveraging AI. A vast amount of know-how from seasoned operators, about 8.4 million bits at Aboshi Plant alone, has been made explicit through foundational Daicel Production Innovation, enabling the stabilization of production, with the high reliability of the data itself serving as one of its strengths.

Know-how verification from daily abnormalities

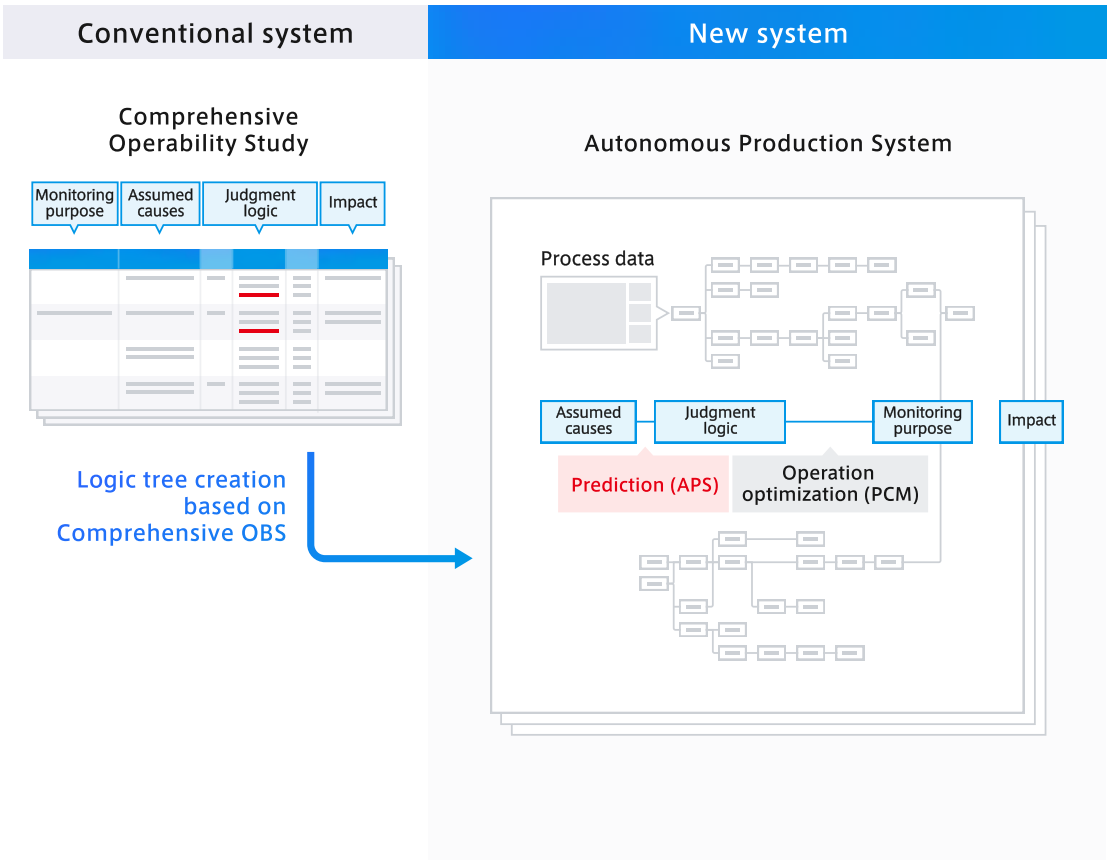


A major feature of the newly developed proprietary AI is its logic, which combines both inductive reasoning that derives answers from historical data and deductive reasoning that derives results based on rules and principles.

In the development stage, conventional AI methods such as deep learning were used to perform inductive calculations based on historical data, but the prediction accuracy for quality indicators was only around 60% and considered insufficiently accurate for a chemical plant with a diverse range of variables.

To address this, two proprietary AI applications in the Autonomous Production System, **PCM (Plant Capability Maximizer)** and **APS (Advanced Prediction System)**, were developed with logic that combines both inductive reasoning and deductive reasoning. These AI applications instantly combine complex cause-and-effect relationships between the effects of changes, such as changes in quality and cost, and their causes, production operation data accumulated over approximately 20 years, real-time data, and chemical engineering rules and principles to calculate and derive optimal solutions with high accuracy.

Furthermore, by leveraging the Comprehensive Operability Study cultivated through Daicel Production Innovation, we developed a computational algorithm that has a low computational load and enables accurate predictions even with less training data compared with conventional AI methods. The Autonomous Production System built with these two AI applications is a proprietary system unique to Daicel and has been patented.



❶ PCM (Plant Capability Maximizer)

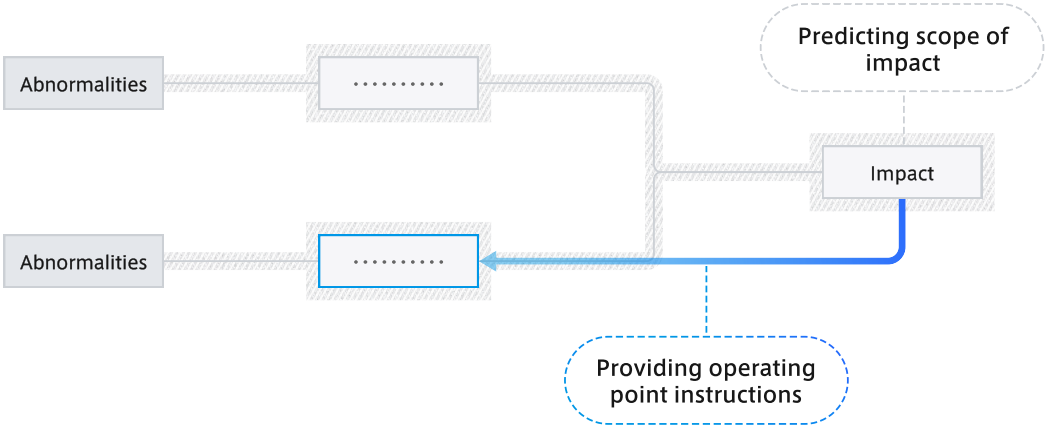
Deriving optimal solutions from trade-off relationships among multiple quality and cost indicators

The PCM predicts indicators for safety, quality, production volume, and cost in real time and derives optimal operating conditions to maximize each of these indicators. By improving production efficiency based on conditions at any given moment, it has made cost reductions possible.

Because the complex cause-and-effect relationships-linking changes in factors like quality and cost to their causes- are known in advance, the PCM can predict the future impact of changes occurring in upstream

processes (such as whether quality will deteriorate). It then issues instructions for recovery through adjusting production conditions in downstream processes, such as for the material or heat balance. This makes it possible to consider what should be done in each individual process to respond to the requirements of further downstream processes. In demonstration tests, the prediction accuracy for the set quality indicators is over 90%, significantly outperforming the approximately 60% result when calculations were performed using inductive reasoning alone.

Predicting impacts from abnormalities and deriving optimal solutions

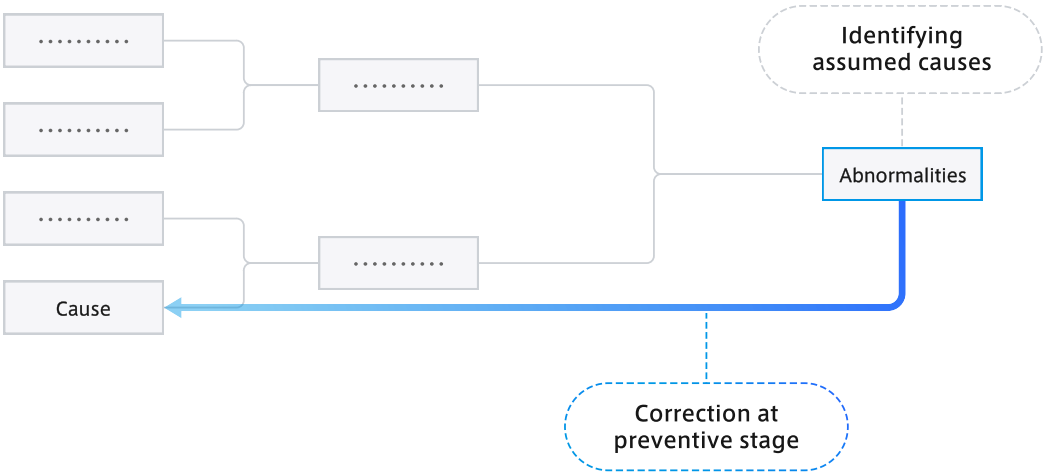


2 APS (identification of the causes of abnormalities)

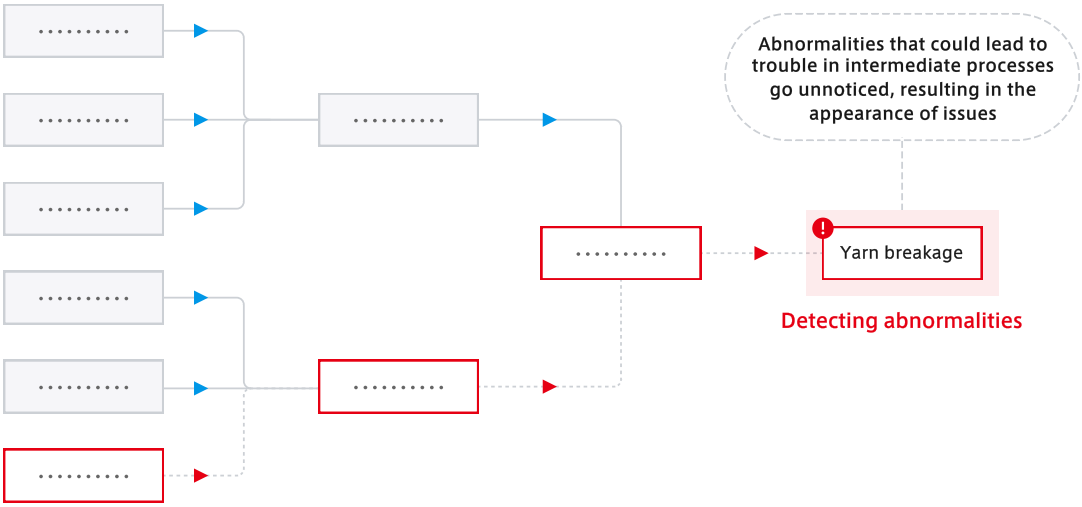
Suppressing minor fluctuations caused by process and equipment abnormalities in downstream processes

During production implemented in accordance with the operating conditions planned by the PCM, deviations from the plan may occur due to unforeseen circumstances, such as equipment failures or environmental changes. To suppress these deviations, the APS detects early signs of abnormalities and continuously adjusts operating conditions to ensure that operations proceed as planned. For abnormalities that arise, the APS uses AI supported by a knowledge base built from explicit know-how to detect early signs from manufacturing process data and estimate the underlying causes.

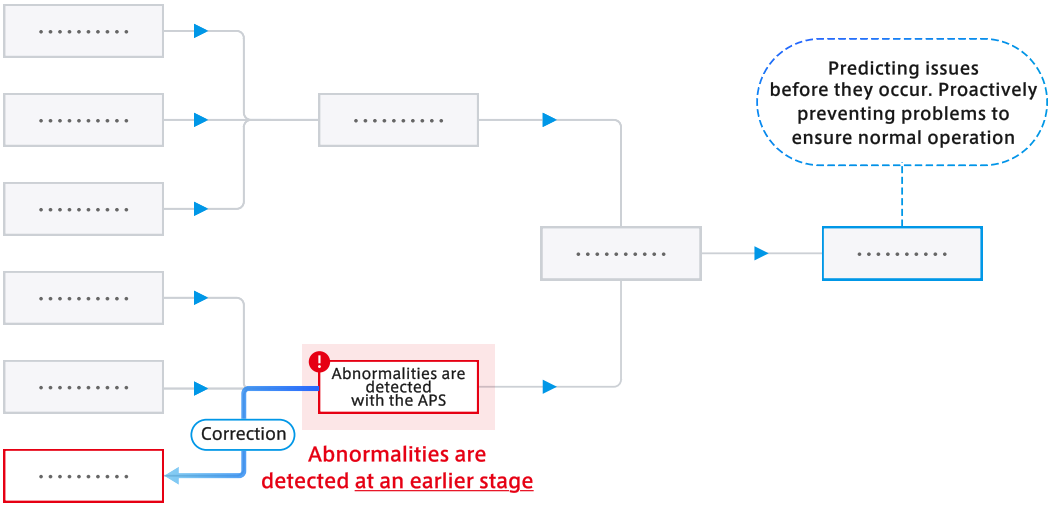
Identifying the causes of manifested issues and responding before negative impacts worsen



Conventional system

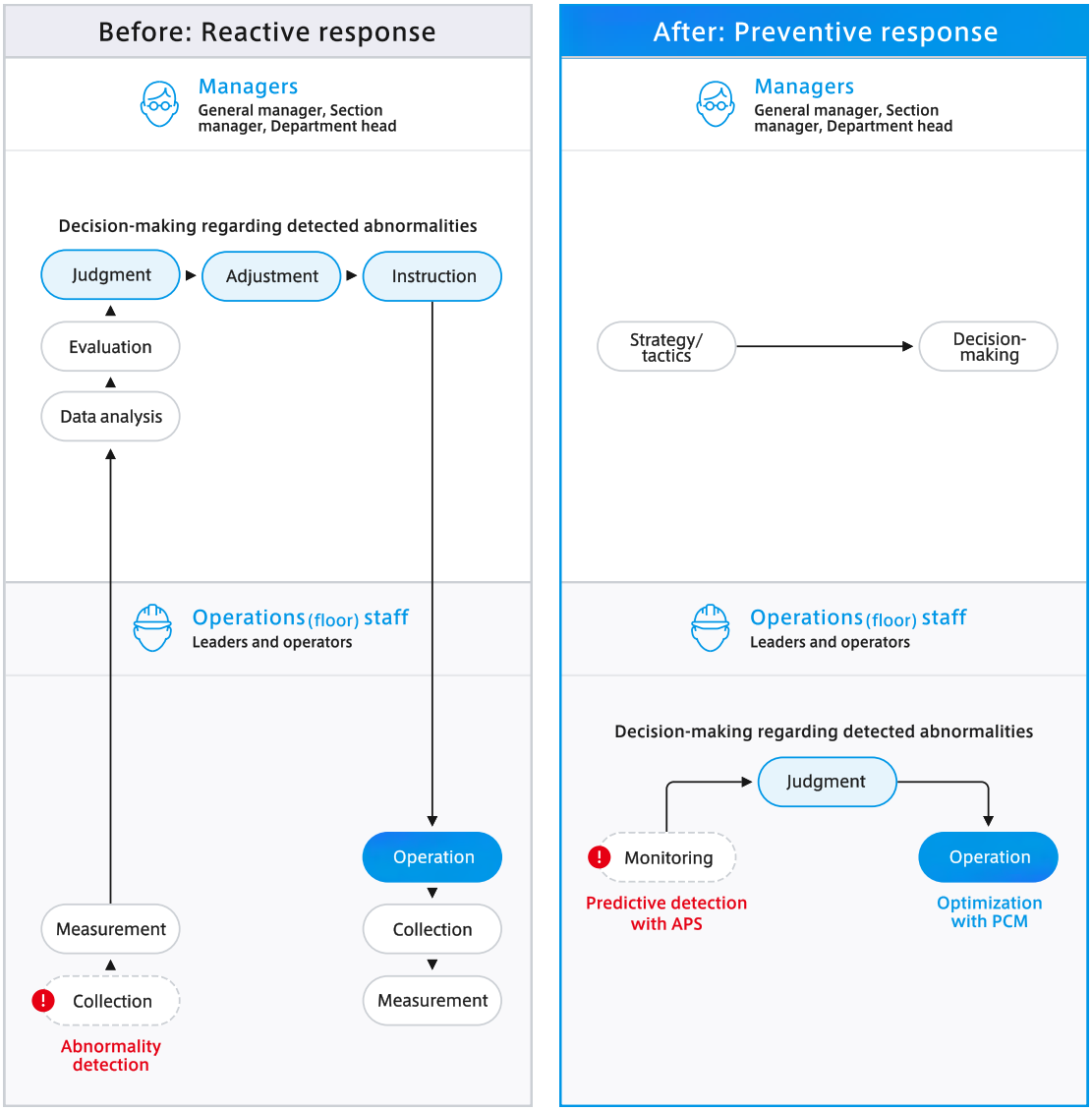


System after APS implementation



It is also necessary to detect operational variations with greater sensitivity and prevent issues early. It is now possible to address issues- that previously could only be addressed after an abnormality in the plant process had been identified - even before the abnormality becomes apparent. In demonstration tests, causes of abnormalities were predicted 100% of the time, and detections at incorrect timings were kept to just 0.03%.

Autonomous Production System and Work Style Reform



Implementation of the Autonomous Production System shifts the manufacturing floor's approach from reactive responses to preventive responses.

Before implementation of the Autonomous Production System, managers were driven by reactive responses and unable to devote sufficient time to their actual roles. However, since implementation, they have less follow-up work and have more time to dedicate to decision-making for strategy and tactics.

This is by no means a matter of superiors shifting heavy responsibilities onto their subordinates.

If the same deviation occurred before and after implementation, the decision-maker shifts from the manager to the operations team leader.
As the impact of an abnormality worsens with time, the decision-making responsibility is also a heavier burden; however, the Autonomous Production System makes it possible to detect and respond appropriately to abnormalities at an earlier stage than ever before. Because judgments can be made when the impact is still minor, the operations team can handle both the decision-making and necessary actions. The result of this is a form of delegation of authority.

Furthermore, since abnormalities can be detected before they manifest, the need for human monitoring and prediction of operating conditions decreases, and the workload of onsite workers is dramatically reduced.
In addition, by presenting the factors behind abnormalities along with recommended countermeasures, operators can take early action at a stage prior to the decision-making previously handled by managers. This leads to a reduction in the time from judgment to response.

For section and department managers, it creates spare capacity, enabling them to shift their focus toward more creative work.
The workload for operators is also reduced, and through a cycle of taking action while the impacts of trouble are small, they are able to gain experience in recovery within acceptable ranges, developing next-generation talent and improving motivation at manufacturing sites.

This kind of transformation at manufacturing sites is effective not only internally but also for external stakeholders.
It supports stable production with faster responses to customers, reduced inventories, and a balanced focus on SQDC (safety, quality, delivery, and cost).

Word List

Daicel Production Innovation

This is Daicel's proprietary production innovation method, which achieves significant improvements in production efficiency and quality by organizing, standardizing, and systematizing the know-how cultivated on the chemical plant production floor to optimize the entire supply chain.

Know-how

This is a collective term for the knowledge, skills, and ingenuity gained through practical experience and on-site operations. These elements are essential for performing tasks safely and efficiently, and by organizing them into words or data, they become easier to share and pass on to others.

Deductive reasoning

This is a reasoning method or approach that infers and explains specific instances based on general theories.

Chemical plants

These are plants and facilities designed to mass produce chemical products and materials by processing raw materials through various processes, including chemical reactions. Such facilities require safe and stable operations as well as optimized energy efficiency.

Operators

These are on-site operators responsible for the operation, monitoring, and management of plants and facilities. They include field operators, who walk the floor conducting inspections on-site, and board operators, who monitor operating conditions, make judgments, and control operations from a control room.

Inductive reasoning

This is a reasoning method or approach that derives generally accepted principles, rules, and other such inferences from individual, specific examples.

Deep learning

This is one of the machine learning methods used in the field of AI and is a technique that automatically extracts and learns complex features and patterns from large volumes of data. It is applied to areas such as image recognition, speech processing, and predictive analysis.

APS

Advanced Prediction System. This is one of the proprietary AIs used in the Autonomous Production System. During production implemented in accordance with the operating conditions planned by the PCM, deviations from the plan can occur due to equipment failures or various environmental changes. To suppress these deviations, the APS detects early signs of abnormalities and adjusts the operating conditions to ensure operation as planned.

Algorithm

These are rules or calculation methods used to solve problems or automate work procedures.

Heat balance

This is the balance between the heat input and the heat lost during the production process. It serves as the foundation for energy management and energy saving.

PCM

Plant Capability Maximizer. This is one of the proprietary AIs used in the Autonomous Production System. It predicts indicators for safety, quality, production volume, and costs in real time, deriving optimal operating conditions to maximize each of these indicators.

Optimal solution

This is the most desirable answer or method chosen from a wide range of options. This concept is essential for achieving efficient operations in production planning and problem-solving.

Material balance

This is a concept used to check whether the amount of raw materials used is in balance with the amount of products manufactured. It is useful for understanding productivity and losses.

Explicit knowledge

This is knowledge expressed in words, diagrams, or data so that it can be understood by anyone. It facilitates the sharing and passing on of tacit knowledge.