機械與機電系統研究所

MECHANICAL AND MECHATRONICS SYSTEMS
RESEARCH LABORATORIES, MMSL.

Intelligent Factory

AI Identification and Feedback Module for Appearance Quality of Metal Products

Traditional visual inspection are easily affected by metal surface reflections and uneven light source. It leads to misjudgment issues, especially inspects on irregularly shaped 3D metal parts. Factors like low detection rate, unstable effects, and limited applications cause difficulty to achieve the goals of intelligent inspection. Using AI for detection helps overcome problems related to metal surface reflections and uneven lighting, and interference from the shadowing.

Technical Advantages and Features

AI Image Recognition Technology

- AI deep learning module trains on complex defect features, such as random wood grains and helical gear teeth. The AI module adapts to various environments and production lines.
- The scope is to broaden to varies industries, such as food and textile inspection.

Dynamic Optimal Lighting Layout Imaging

- Combining image filtering transformations with blur analysis enables light and shadow detection, overcoming issues like reflections and uneven illumination in dynamic imaging.
- Based on light and shadow detection, dynamic adjustment reduces reflections in multi-angle imaging by light source placement and detection angles.

3D Helical Gear Inspection

- A specialized detection model for 3D helical gears achieves a defect detection rate of 98% (industry average 80%).
- Breaking through technological bottlenecks by automatically detects challenging defects such as tooth surface black spots, tip collisions, and broken teeth, identifying flaws as small as ≥ 0.1 mm.

Industrial Benefits and Business Opportunities

Industry Applications:

Metal Product Processing Industry (e.g., Plumbing Supplies, Gear Manufacturing, Powder Metallurgy).

Application Examples:

The technology, integrated into specialized gear inspection equipment, has been successfully implemented by electric vehicle gear production line. It reduces inspection time by 50%, tripling daily production capacity, and cutting annual quality control costs by about 50%.

AI Deep Learning Image Recognition

A Conventional Imaging Setup Often Leads to Reflection

Optimal Light Source Arrangement for Imaging Reflective Surfaces

3D Helical Gear Inspection Mode

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Injection Molding Full Inspection and Process Parameter Optimization Technology

Traditional injection molding industries rely on manual quality assessments, which results in unstable quality and decreased the production efficiency. The parameter adjustment is based on production experience. It leads to challenges in knowledge management and production parameters optimization. Intelligent quality control can be achieved by using AI could establish relationships between process parameters and defects in injection products, such as short shots and deformations.

Technical Advantages and Features

Big Data and AI Deep Learning Analysis and Feedback

- Big data collects from product design parameters, process parameters, and quality control inspection.
- AI deep learning models provides real-time feedback and predicts upcoming manufacturing issues.
- Saving the manual inspection labor cost in 90% potentially.

Visualization of Key Feature Information

- The visualization interface displays key features of the machinery and molds, including mold internal pressure, integral pressure, and the slope of the pressure curve.
- Real-time monitoring and control enable the setting of machinery standards to ensure the quality.

Quality Prediction through Monitoring & Simulation

- Analysis and detect the planar geometric features of the finished product by monitoring machine status.
- Workpiece quality can be predicted with 96% accuracy (industry standard often involves manual spot checks) by simulating machine status and parameters.

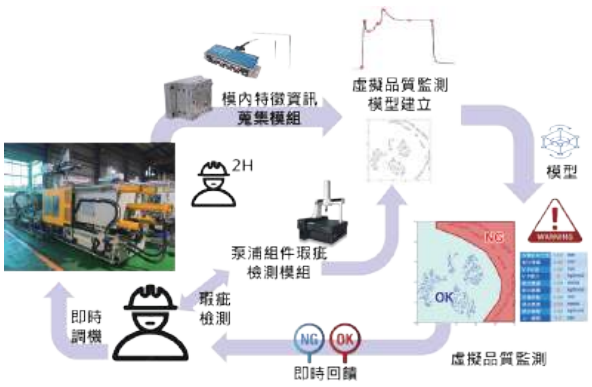
Industrial Benefits and Business Opportunities

Industry Applications:

Electronics component industry (plastic casings), transportation tools (car bumpers, interior trim panels), and other plastic products.

Application Examples:

The software module, implemented at pump manufacturer, enhances intelligent injection molding of plastic casings and sets up a quality monitoring system. This has increased the yield by 12% (from 84% to 96%) and reduced annual carbon emissions by 25.33 tons.



Process Parameter Collection and Feedback System

Information Visualization of In-Mold Features and Full Inspection of Injection Molding Quality

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AI Smart Magnetic Particle Inspection Module for Magnetically Conductive Materials

Surface and subsurface cracks inspection is crucial in steel manufacturing. Fluorescent magnetic particle inspection (MT) techniques are typically the method for inspection. Uneven powder residue can lead to misinterpretations and result in error rates exceeding 20%. Additionally, exposure to black light (UV) poses risks to human eyes and skin, potentially causing conditions such as cataracts. AI is necessary to accurately identify defects, given the challenge of defining uneven residues in images.

Technical Advantages and Features

AI Defect Inspection Module

- AI deep learning-based defect detection technology distinguish true and false defects with over 90% accuracy, compared to 80% with manual detection.
- Reducing reliance on personnel and increasing equipment competitiveness.

Fluorescent Imaging and Multi-Axis Synchronized Imaging System

- Fluorescent imaging highlights the features of shallow subsurface crack defects.
- Multiple synchronized mobile imaging modules expand the imaging range from 0.2 to 12 meters at the same resolution.
- Reducing the time required for manual inspection by 55%.

Defect Distribution Visualization and Real-Time Feedback

- Defect distribution is presented through a visual interface that includes information on defect size and location.
- Based on defect distribution, the system provides immediate feedback to the grinding process.

Industrial Benefits and Business Opportunities

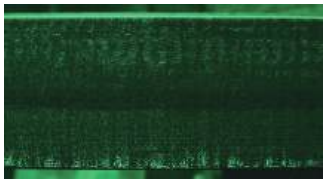
Industry Applications:

Metal Processing (Casting, Forging, Steel Bars), and Steel (Steel Billets, H-beam Steel) Industries.

Application Examples:

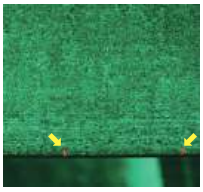
The module, implemented in steel industry, established the first domestic AI inspection process for surface defect detection and removal, reducing inspection times by 50% and boosting accuracy from 80% to 90%.

Fluorescent Magnetic Inspection Imaging Module



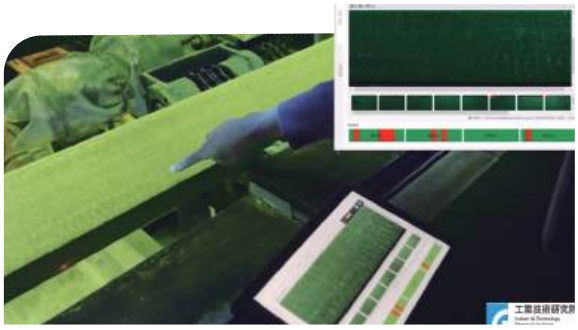
Residual Fluorescent Magnetic Particles

Original Images



AI Detection Results

Fluorescent Magnetic Particle AI Detection that Overcomes Misjudgment due to Residual Particles



Real-Time Feedback on Visualized Defect Status

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Non-Symmetrical 3D Composite Braiding System

In response to the demand for energy conservation and carbon reduction, components must maintain structural strength while reducing weight. Traditional composite braiding and stacking methods require customized molds and depend on manual lamination for forming, which is particularly challenging for tubular structures and irregular shapes, material utilization rate achieves only 60% - 70%. This technology introduces a 160-spindle radial composite braiding device that tightly fits outer fibers to core surfaces via weaving and axial expansion; dual-arm propulsion aids in swiftly producing complex three-dimensional parts, thereby improving material utilization.

Technical Advantages and Features

Radial Composite Braiding Equipment

- The first domestic radial composite braiding equipment, featuring 160 circular motion of the spools.
- Fiber utilization has increased to 80%, up from 60-70% with traditional equipment.

Dual-Arm Propulsion Control

- Combines dual-arm synchronized control for high stability.
- Suitable for manufacturing slender workpieces up to 3 meters in length.

Optional Expandable Axial Fiber

- The expandable 40-strand axis enhances the product's tensile and bending strength, broadening its application range.

Industrial Benefits and Business Opportunities

Industry Applications:

Aerospace Industry, Transportation Industry, Green Energy Industry.

Application Examples:

Established the first domestic "Composite Component Verification and Trial Production Laboratory," which develops lightweight composite components and leads Taiwanese manufacturers into the international composite component market.

In the aerospace industry, the development of carbon fiber engine blade weaving technology is currently in the phase of small-scale production testing.

In the defense industry, lightweight personal protective equipment is being developed to provide the national military with high-strength protective gear.

Irregular Structures and
Slender Composite Braided Products

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Prognosis Monitoring System, PMS

Traditional manufacturing often faces interruptions in operations due to equipment inspection and maintenance cycles. These gaps can result in issues or shutdowns, requiring expert intervention and impacting production capacity. Moreover, inefficient maintenance scheduling can lead to higher costs. AI-based prognosis monitoring systems, learning from expert analysis techniques, streamline complex sensor data to provide intuitive equipment status information. This system acts as a 24-hour monitoring AI engineer, accurately predicting machine conditions, diagnosing anomalies, and offering immediate feedback.

Technical Advantages and Features

Customizable Equipment Health Monitoring

- Monitor the health of equipment according to ISO vibration standards, such as air compressors and mechanical vibrations.
- Customize specific health indicators to accurately predict equipment lifespan.

Equipment Health Trend Forecasting & Optimal Maintenance Scheduling

- Capable of predicting the deterioration of health status or even the Remaining Useful Life (RUL), with an error rate of less than 10%.
- Providing recommendations for optimized maintenance scheduling, with proven cases that have increased equipment lifespan by at least 50%.

Automatic Fault Diagnosis for Rotary Machine

- Capable of automatically diagnosing 17 common faults in rotary machines, including bearing and gear damage.
- The accuracy of fault diagnosis exceeds 85%.
- Proven cases have reduced maintenance operation time by up to 30%.

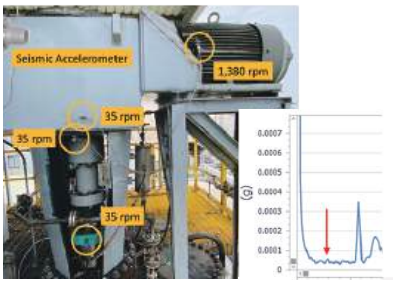
Industrial Benefits and Business Opportunities

Industry Applications:

Electronics, semiconductors, metals, petrochemicals, automation, and information services industries, among others, are all applicable as long as they can utilize vibration signal collection and AI analysis.

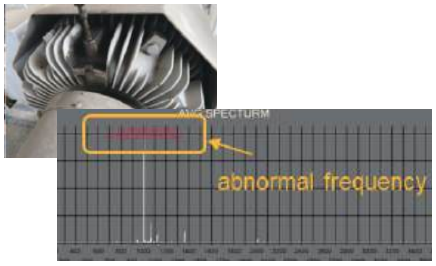
Application Examples:

This technology has been applied to over 500 pieces of machinery. Partnering with leading manufacturers, such as a domestic semiconductor vacuum equipment producer, has led to a 50% increase in equipment lifespans. Similarly, collaboration with a top domestic machining factory has improved tool lifespans by 10% through optimized drilling processes. In the green energy sector, we worked with a state-owned enterprise to diagnose gearbox anomalies in wind turbines a month in advance, effectively leveraging the benefits of predictive maintenance.



Continuous and High-Quality Signal Monitoring

Fast and Accurate Fault Diagnosis



Effective Forecasting of Trend States

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Flexi-Modeler for OPC UA

Industry 4.0 adopts OPC UA as the communication standard to help integrate Taiwan's industries with international norms. By establishing OPC UA servers, data is captured from various devices and systems and provided to clients in a unified format. However, building device information models is complex, involving software installation, data definition, and security configurations, which adds to development costs and time. This technology assists users in quickly completing OPC UA modeling and facilitates the transfer of data to cloud or on-site systems for display, analysis, or decision-making.

Technical Advantages and Features

Easily Modeling

- Support various OPC UA Companion Specifications.
- Automate hierarchies and inheritance for easy, fast programming.
- Reducing user development time by more than 80%.

HMI with Industry Knowledge

- HMI with Industry Knowledge, users can get started quickly.
- With three major industrial automation communication setting interfaces: Method, Event, and PubSub.

Cross-Platform Control Module

- Seamless International Communication (IEC 62541).
- Simplified Setup, Rapid OPC UA Server Control Module Deployment.
- Cross-platform: Windows, Linux Ubuntu and ARM.

Industrial Benefits and Business Opportunities

Industry Applications:

Plastics and Rubber, Machine Tool Industry, and Automation.

Application Examples:

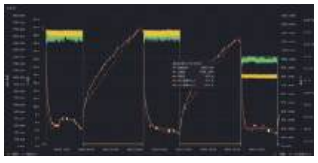
This technology has been implemented in nationally renowned injection machine controllers and intelligent pumps, aiding manufacturers in rapidly establishing information models with companion specifications and constructing OPC UA servers, which has doubled production reporting efficiency and reduced development time by 30%.

Flexi-Modeler
Easily Modeling

Import

Cross-Platform
Control Module

Apply



Pump Test Facility

Pump Test Facility

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SECS/GEM Communication Technology

Electronic device controllers handle data collection, equipment monitoring, and production control in factories. However, diverse brands and models lead to non-standardized communication technologies, complicating integration and requiring extra manpower and time. The SECS/GEM standard can be quickly implemented through simple, automated settings, solving issues with complex processes, multiple devices, and challenging information integration.

Technical Advantages and Features

International Communication Standards

- SECS/GEM is the official communication standard in semiconductor industry.
- Equipment uses the standard (SECS/GEM) to communicate and process and data.

Efficient Core Driving to Fully Interconnect the Entire Factory's Information

- Efficient driving structure technology offers application on a broad product range, equipment and factories.
- Improving factory connection, increasing automation efficiency, and reducing labor costs.

One-Stop Professional Consulting Services

- With over 20 years experience in industry counseling, thousands cases service has facilitated collaboration users and makers.
- One-stop services including factory visits, specification negotiations, and validation.

Industrial Benefits and Business Opportunities

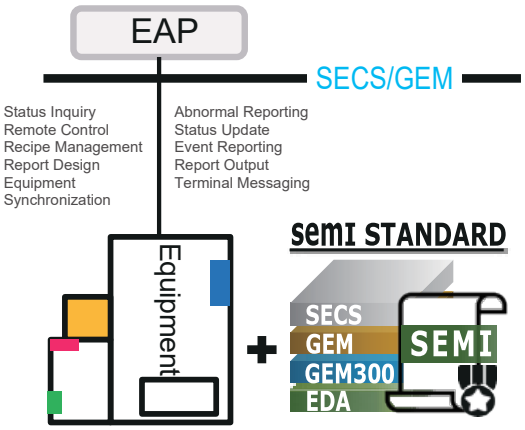
Industry Applications:

Semiconductors (including Wafer Foundries and Packaging/Testing Facilities), PCB Printed Circuit Boards, Panel Manufacturers, and Solar Energy.

Application Examples:

Assisted the largest domestic photomask manufacturing company in SECS/GEM communication standard implement while facilitating the sale of their photomask cleaning equipment to major semiconductor companies in the United States, generating additional output value exceeding 30 million NT Dollars.

Guided a top domestic die-sorting equipment manufacturer to integrate advanced semiconductor communication systems into the LED machines and the solution was successfully sold to Toshiba Corporation and OSRAM GmbH, receiving high customer praise.



Comprehensive Professional Technical Services

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AI Visual Inspection Platform

The rise of high-mix, low-volume manufacturing poses increasing demands on inspection flexibility. With three decades of experience in smart vision inspection, we integrate traditional AOI with AI technology to develop innovative and adaptable inspection systems, helping manufacturers significantly reduce inspection costs.

Technical Advantages and Features

50+ Inspection Applications

- Uses AI-based image training to detect complex, abstract defect features such as random wood-grain scratches and chipped spiral gear teeth.
- Overcomes the limitations of traditional visual inspection, including glass transparency and metal glare.

20+ Inspection Equipment

- Enables AI-edge computing without cloud connectivity, reducing latency and enhancing integration with production lines.
- Supports 5G and cloud communication to provide scalable computational power and real-time feedback.

10+ Unique AI Models

- Detects a wide range of defects across products such as circuits, wood grains surfaces, solar panels, polarizers, plumbing hardware, yarn cones, and contact lenses.
- Supports object detection in applications such as PCB circuits, transportation systems, cultural artifacts, and food products.
- Accurately identifies defect types, including dents, cracks, scratches, stains, pits, and residual glue.

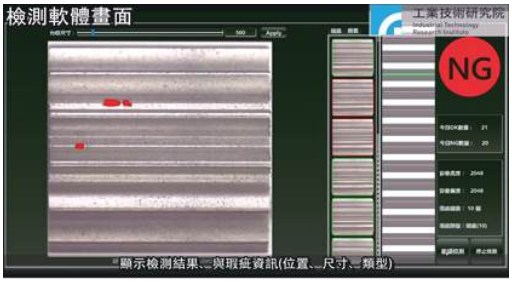
Industrial Benefits and Business Opportunities

Industry Applications:

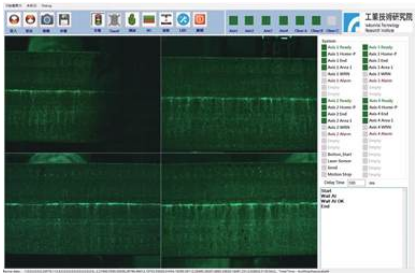
Metal Processing, Semiconductor, and Consumer Electronics Industry.

Application Examples:

Successfully integrated into a specialized gear inspection system for EV production, reducing inspection time by 50%, tripling daily output, and cutting annual quality control costs by 50%.
Partnered with Feng Hsin Steel Company to develop an AI-based magnetic inspection and grinding feedback system for steel billet surfaces, establishing Taiwan's first continuous casting defect detection and marking system for small billets. The system reduces inspection time by 50% and improves detection accuracy by 10%.



AI-Powered Gear Inspection Module



AI-Powered Magnetic Inspection and Grinding Feedback System for Steel Billet Surfaces

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AI Operator Guidance & Motion Analysis System

Despite advancements in Industry 4.0, many labor-intensive industries continue to struggle with automation due to the diversity of manual tasks. Our AI-driven system provides real-time guidance through SOPs, significantly reducing training time and preventing losses caused by human error.

Technical Advantages and Features

Easy to operate, No Training Required

- Intuitive interface design enables easy operation and reduces training time by over 50%.
- Supports a wide range of tasks, such as inspection, assembly, and manufacturing.

AI Guidance, Prevents Human Error

- AI monitors posture and hand position in real time, guiding operators through every step.
- Standardized operations improve product reliability and optimize workforce utilization.
- Minimizes human error, reduces risks, and enhances product quality.

Real-Time Operational Data Visualization

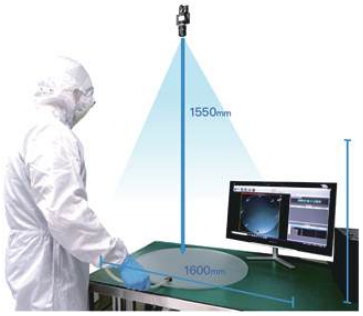
- All operational data is uploaded in real-time, ensuring complete quality traceability.
- Real-time video recording and storage for on-demand review.
- Demonstrates correct actions and alerts users to errors, reducing human error by over 90%.

Industrial Benefits and Business Opportunities

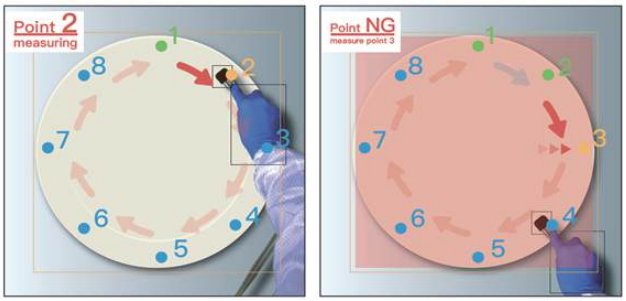
Industry Applications:
Semiconductor, Automotive, and PCB Industry.

Application Examples:

Adopted by Hung Jie Technology Company for manual particle inspection following semiconductor fixture cleaning, the system records operator actions and integrates with the MES system to ensure fixture cleanliness and traceability. It enhanced hourly output by 2.5% and facilitated successful entry into T Company's supply chain.



Operator Inspection Action Guidance Scenario (Desktop)



AR Guidance and Real-Time Alerts

Operator Handling Action Guidance Scenario (Upper Body)

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Servo Stamping Optimization Technology

Adjusting motion profiles for servo presses is time-consuming, reliant on experience, and sensitive to ambient temperature, especially when forming hybrid materials. Our technology enhances simulation accuracy, reducing the need for repeated parameter adjustments and significantly improving production efficiency.

Technical Advantages and Features

Servo Press Motion Profile Optimization

- Leveraging AI-based decision trees, the system automates analysis and decision-making, improving the thinning rate by 16%.
- Combines finite element analysis with forming simulation, achieving 88% prediction accuracy (>70% industry standard).

Light Metal Warm Forming

- Verified in warm forming of automotive B-pillars, reaching tensile strength >660 MPa (industry standard: 570 MPa).
- Achieves excellent flatness <0.1 mm (industry average: 0.2 mm), meeting ISO dimensional tolerance standards.

Hybrid Materials Forming

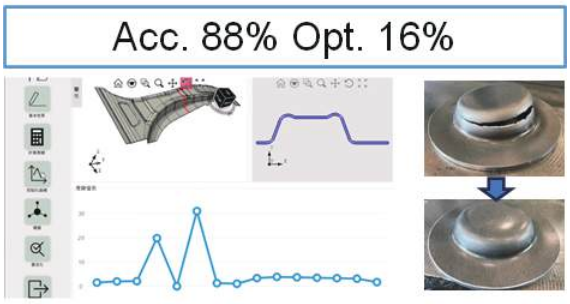
- Supports one-step forming of hybrid materials, reducing part weight by over 10%.
- Special surface treatment technology enhances the bonding strength between composites and other hybrid materials by over 30%, reducing the risk of delamination under stress.

Industrial Benefits and Business Opportunities

Industry Applications:
Metal Forming Industry (e.g., transportation, aerospace, defense)

Application Examples:
The software supports composite and light metal forming, providing parameter recommendations that significantly reduce try-out and tuning time. Adopted by Taiwan's leading servo press manufacturer, SEYI Machinery Company, it helps advance the nation's metal forming industry on the global stage.

Hybrid Materials Forming



Servo Press Motion Profile Optimization

Light Metal Warm Forming

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Intelligent Production Line Automation

Labor shortages, limited capacity, and a declining workforce remain common challenges in traditional manual operations. To address these issues, we have developed intelligent automation equipment and production lines that reduce labor and energy costs, eliminate repetitive tasks, and enhance overall industry competitiveness.

Technical Advantages and Features

High-Speed Collation

- Automated flipping, guiding, and discharge mechanisms achieve a collation rate of 350 parts per minute.
- Visual inspection, combined with high-pressure air jets, enables real-time inline screening and collation.
- AI-based object detection enables high-speed orientation and re-inspection at ≥ 6 parts per second.

Precision Assembly

- Supports integration of multi-stage processes in consumer electronics assembly.
- Integrates visual inspection with error compensation for precise automated assembly.
- Multi-vision system guidance supports various product types.

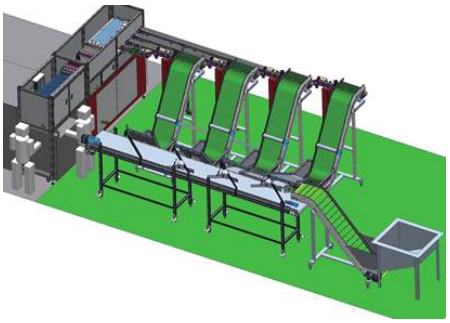
Automated Component Placement & Insertion

- Automated loading and unloading modules reduce manual handling.
- Vision-guided precise positioning improves operational efficiency by 40%.
- Ensures precise insertion, reducing costs and minimizing workplace injuries.

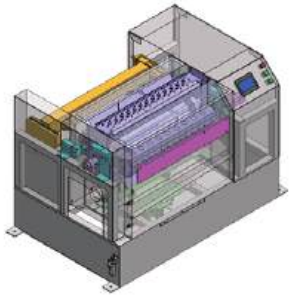
Industrial Benefits and Business Opportunities

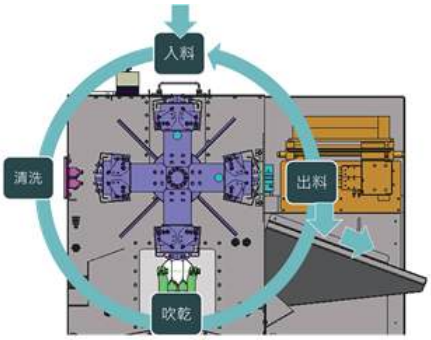
Industry Applications:
Metal Forming and Consumer Electronics Industry.

Application Examples:
Successfully adopted by Taiwan's leading high-pressure cylinder manufacturer, this technology features an automated high-speed collation and feeding system that reduces operational errors, addresses labor shortages, and improves efficiency by 20%.



High-Speed Collation Equipment





Minimized Rotary Station

Material Flipping and Guiding Design

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Semiconductor Exhaust Treatment Equipment Early Warning

Semiconductor manufacturing generates large amounts of toxic byproducts (particles) that must be removed through exhaust treatment systems. However, viscous particulates can wear down or clog vacuum pumps, reducing vacuum levels and increasing the risk of wafer contamination. This early warning platform monitors and manages the exhaust system, effectively reducing equipment failures and safety risks.

Technical Advantages and Features

Cross-Brand Communication Compatibility

- Compatible with communication protocols of major global equipment brands.
- Consolidates operational parameters and status data into a unified platform for comprehensive equipment monitoring.

Early Abnormality Alert System

- Sends real-time alerts when exhaust equipment readings exceed thresholds.
- Uses vibration analysis for vacuum pump health diagnostics with ≥ 85% accuracy.

Predictive Maintenance & Health Monitoring

- Predicts equipment health degradation trends and remaining lifespan with <10% error (industry average about 20%).
- Provides optimized maintenance scheduling recommendations, extending equipment lifespan by ≥ 50%.

Industrial Benefits and Business Opportunities

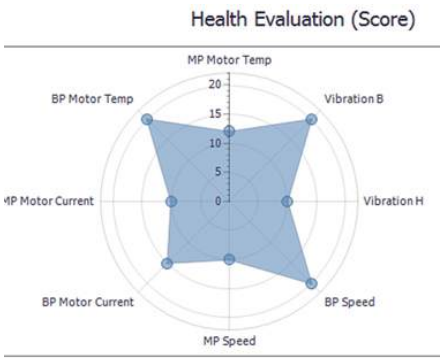
Industry Applications:

Various semiconductor exhaust gas treatment systems and processes (e.g., turbo pumps, dry pumps, scrubbers, etc.)

Application Examples:

1.Deployed by system integrators for leading semiconductor manufacturers, this technology extends equipment service life by 50% and reduces pipeline cleaning frequency by 58% annually.

2.Supported a major domestic semiconductor equipment maintenance provider in establishing standardized FQC (Final Quality Control) procedures for post-maintenance inspection, meeting international quality standards and increasing maintenance efficiency by 50%. This technology has been implemented in both Taiwan and Japan.



Exhaust Equipment Monitoring & Analytics Interface

Semiconductor Exhaust Treatment Equipment

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Tool Wear Prediction and Alert Technology

Tool wear during metal machining is difficult for operators to detect or predict in real time, significantly affecting productivity and quality. This technology enables accurate tool life analysis, reducing unnecessary downtime from routine inspections and improving overall production efficiency.

Technical Advantages and Features

Real-Time Reliable Wear Alerts

- Provides real-time anomaly alerts with over 85% accuracy (industry average: ~80%).
- Optimizes tool change scheduling to maximize tool life.

Rapid Model Deployment

- Utilizes an unsupervised AI model and requires only three full tool life cycles for training.
- Modeling requires only tool change timestamps and operates without disrupting production.

Broad Adaptability

- Vibration signal analysis supports wide applicability in automated drilling, turning, and milling processes.
- Quickly adaptable to various tool types (e.g., end mills, turning tools, twist drills) and materials (e.g., stainless steel, ceramics), reducing deployment time by up to 50%.

Industrial Benefits and Business Opportunities

Industry Applications:
Various Metal Machining Processes such as turning, milling, and drilling.

Application Examples:

1.This technology has been applied to machining centers, milling machines, and lathes. Adopted by leading domestic manufacturers for drilling heat exchanger tubes, it extends tool life by 10% and reduces rework by 50%.

2.It also enables small and medium-sized manufacturers to predict tool failure over one minute in advance, helping them meet strict quality and throughput requirements for substrate processing. The technology has been successfully adopted by a top-tier domestic semiconductor packaging and testing company.

Vibration Sensor Installation Example

Tool Wear Monitoring Interface

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