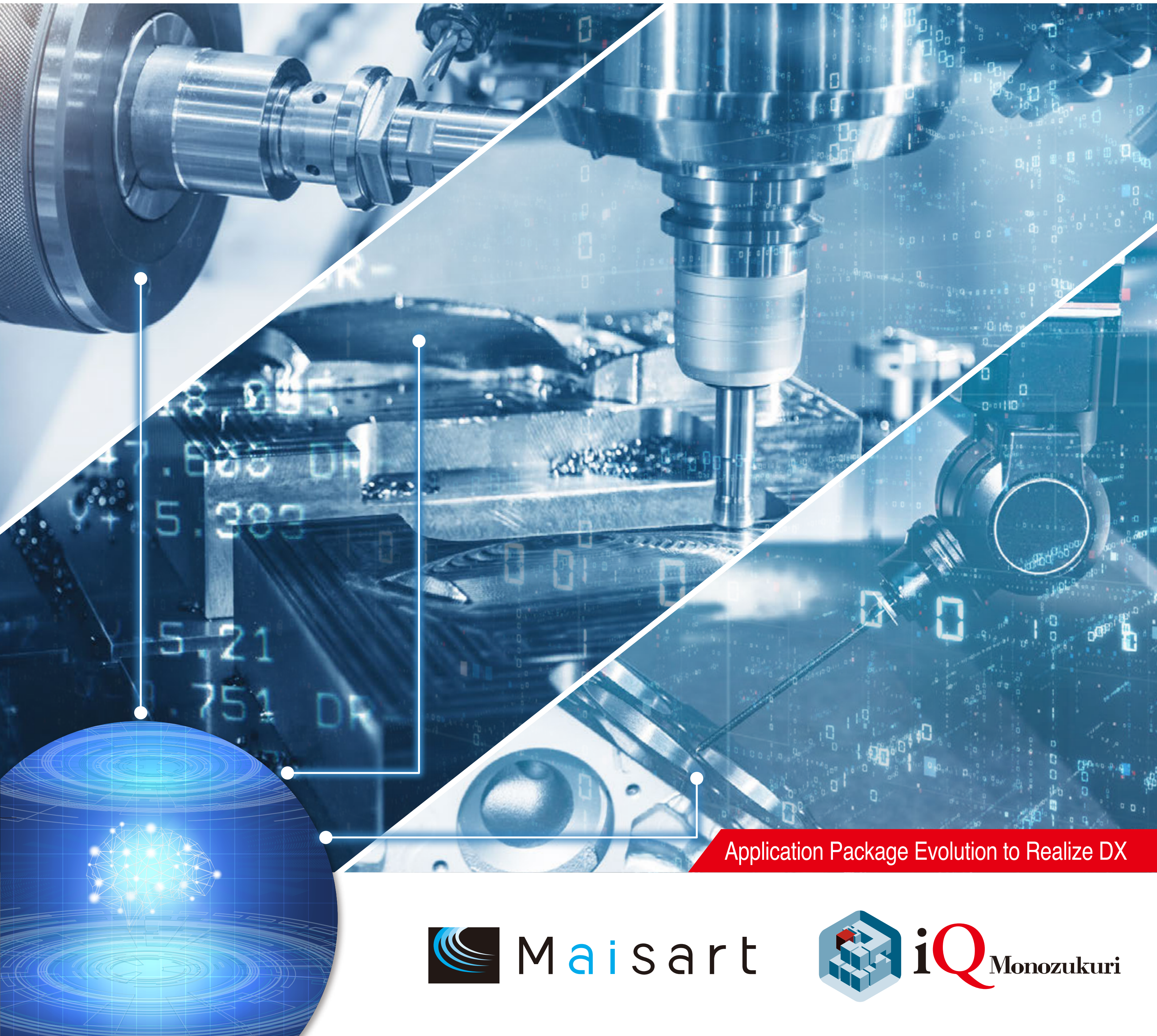
FACTORY AUTOMATION

FA Application Package iQ Monozukuri Tool Wear Diagnosis for Machine Tools

iQ Monozukuri



Application Package Evolution to Realize DX

GLOBAL IMPACT OF MITSUBISHI ELECTRIC

Through Mitsubishi Electric's vision, "Changes for the Better" are possible for a brighter future.

Changes for the Better

"Changes for the Better" represents the Mitsubishi Electric Group's attitude to "always strive to achieve something better", as we continue to change and grow. Each one of us shares a strong will and passion to continuously aim for change, reinforcing our commitment to creating "an even better tomorrow".

Our advances in AI and IoT are adding new value to society in diverse areas from automation to information systems. The creation of game-changing solutions is helping to transform the world, which is why we are honored to be recognized in the 2019 "Forbes Digital 100" as one of world's most influential digital corporations.

Mitsubishi Electric is involved in many areas including the following

Energy and Electric Systems
A wide range of power and electrical products from generators to large-scale displays.

Electronic Devices
A wide portfolio of cutting-edge semiconductor devices for systems and products.

Home Appliance
Dependable consumer products like air conditioners and home entertainment systems.

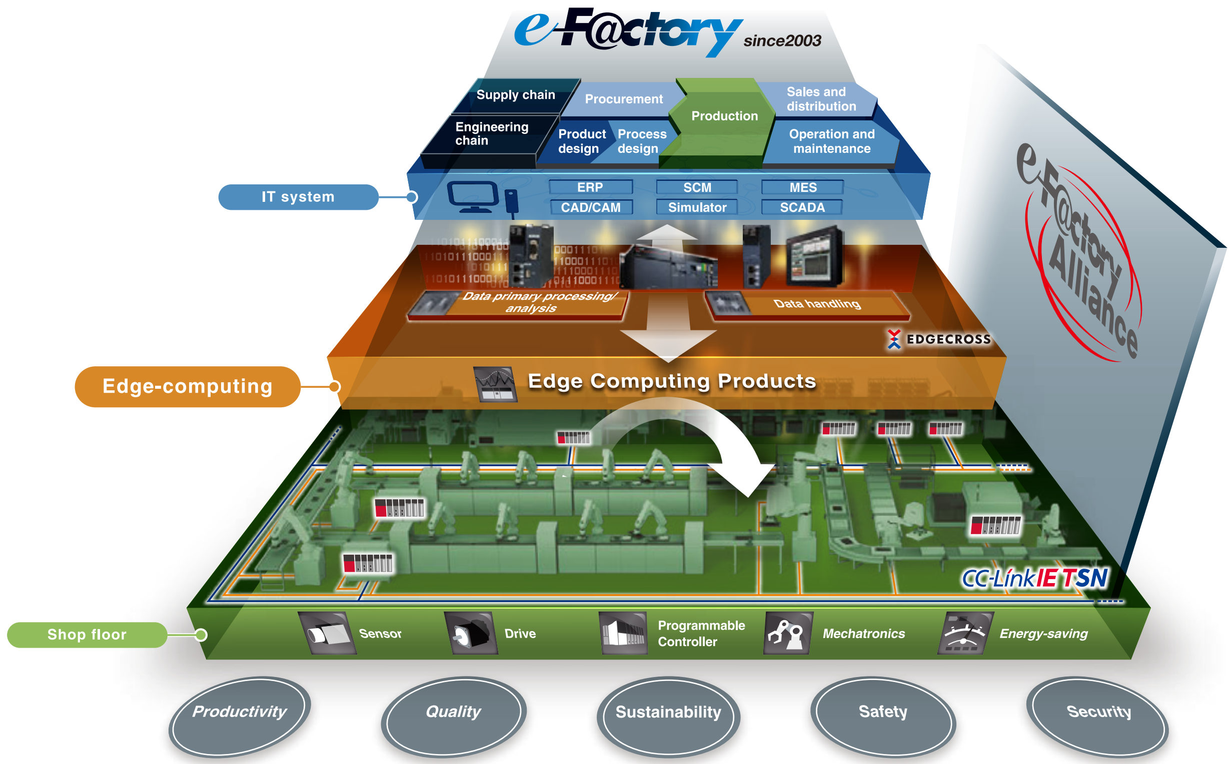
Information and Communication Systems
Commercial and consumer-centric equipment, products and systems.

Industrial Automation Systems
Maximizing productivity and efficiency with cutting-edge automation technology.

Established February 2nd 1921 Mitsubishi Electric celebrates 100 years of serving society through practical, innovative technology solving the issues of the day.

Anniversary

FUTURE MANUFACTURING



The Future of Manufacturing as envisioned by Mitsubishi Electric, e-F@ctory: “Manufacturing” that evolves in response to environmental changes in an IoT enabled world.

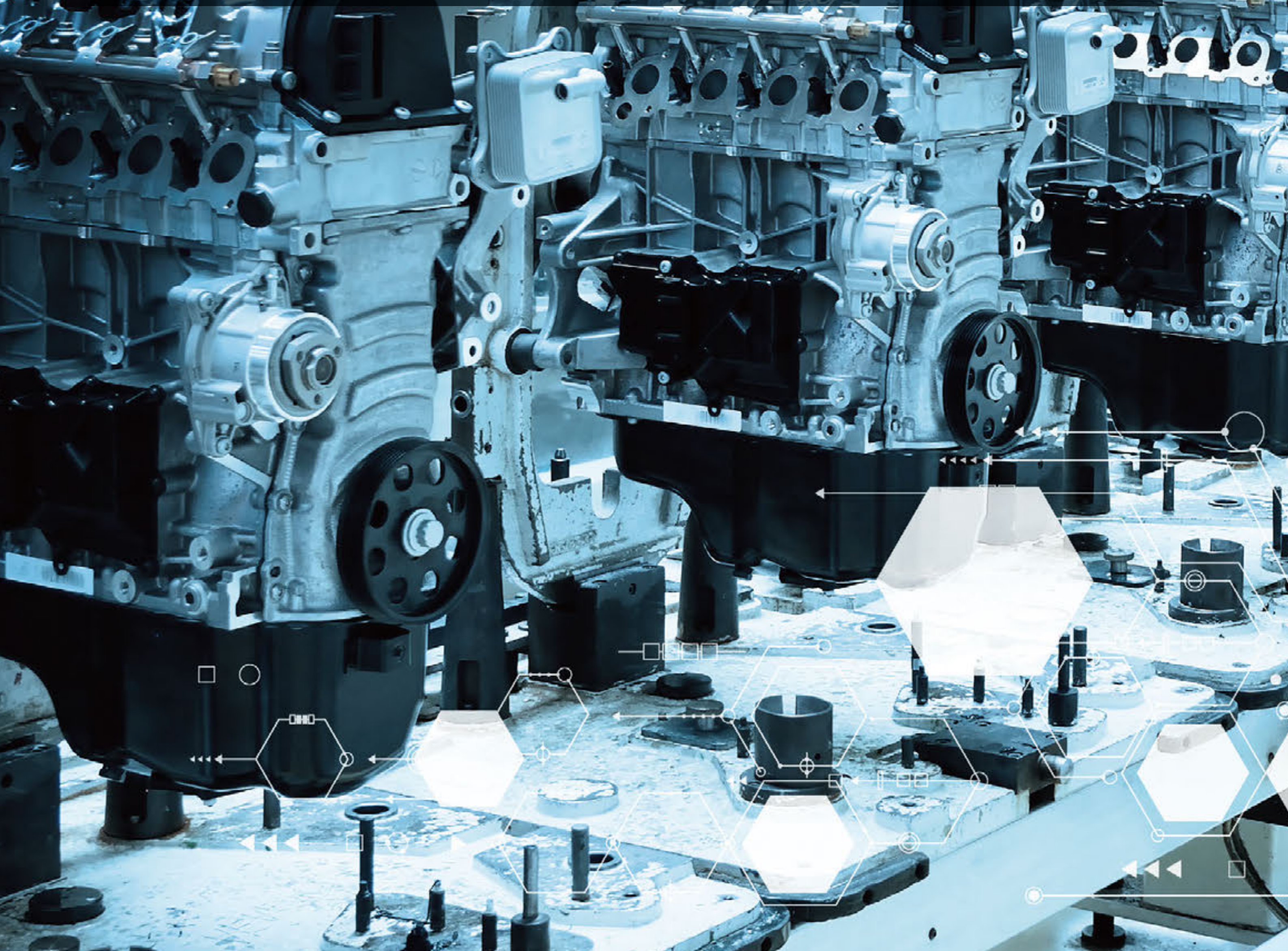
Mitsubishi Electric’s AI technologies
What is Maisart?

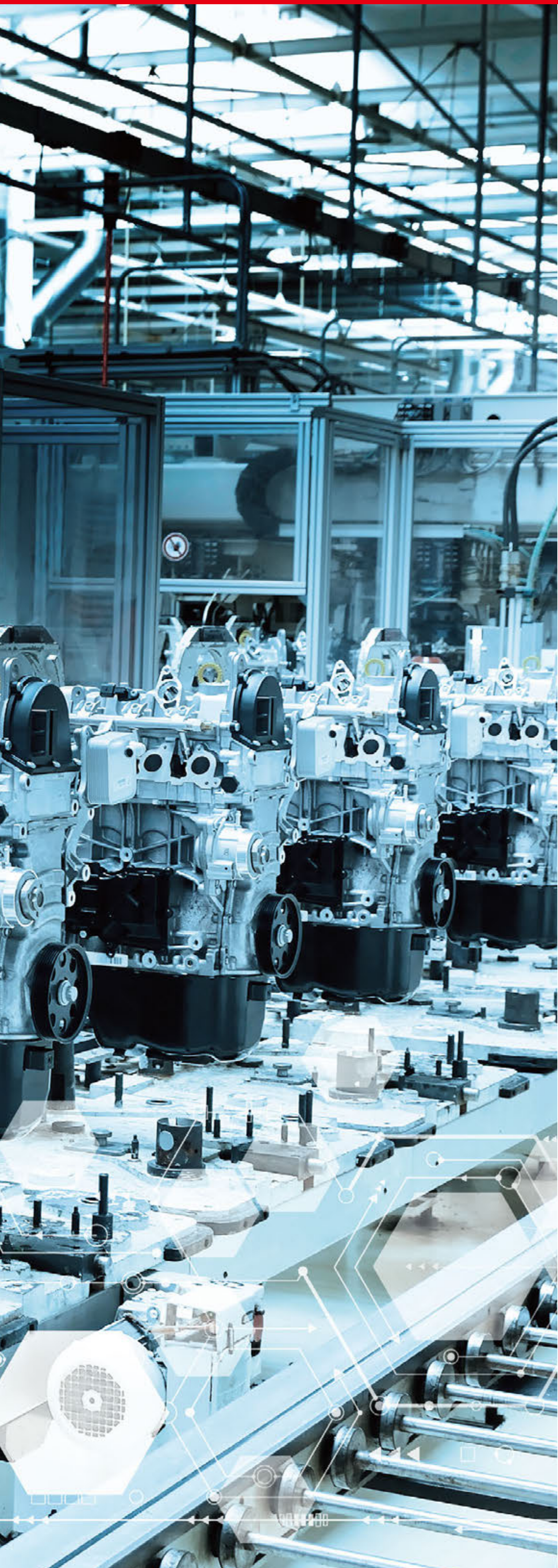
「Maisart」 is Mitsubishi Electric’s AI technology brand
under the corporate axiom "Original AI technology makes everything smart."
「Maisart」 is an abbreviation for
"Mitsubishi Electric's AI creates the State-of-the-ART in technology."

Manufacturing reform for the age of Digital Transformation utilizing machining IoT data of machine tools

Many issues exist with the varying-type/varying-volume production of machine tools. Feedback expressing concern from the shop floor includes
“I focus so much on quality,
I do not know the appropriate the time of tool change,”
“I can’t prevent quality defects caused by sudden tool abnormalities,”
and “It’s difficult to collect data from a wide-variety of machine tools,
and I don’t know how to analyze it.”

With this package, IoT data are collected and analyzed using Mitsubishi Electric’s independent technology to optimize tool operation control and support the easy detection of quality defects.





INDEX

Seven Use Cases Solving Tool Wear Issues

Use Case 1 Page.6	**Reduction in Annual Tool Costs and Labor Required for Tool Change Work**
Use Case 2 Page.7	**Reducing Costs by Detection of Machining Faults**
Use Case 3 Page.8	**10% Higher Productivity**
Use Case 4 Page.9	**Utilization of Traceability**
Use Case 5 Page.9	**Predictive Diagnosis by Machine Monitoring**
Use Case 6 Page10	**Preventing the Outflow of Defects by Machining Quality Prediction**
Use Case 7 Page.11	**Accelerate Investigations into the Causes of Failures**

Page.12 High Reliability
Page.14 Function Overview
Page.16 Support Tool
Page.18 Prodcution Specifications
Package Specifications
Page.21 Partner Products

Reduction in Annual Tool Costs and Labor Required for Tool Change Work by Reducing the Frequency of Tool Change!

Problem

We change tools based on tool usage time/count, but I am unsure of the appropriate tool change timing in the case of varying-type/varying-volume production.

Have you ever experienced this?

Assume the same tool is used to machine Product A and Product B. When a high volume of Product A is being manufactured, there were no product defects when tool change was carried out as it had been until now. However, when the production percentage of new Product B was increased, product defects began occurring, therefore the operator had no choice but to revise the setting for the regular tool change timing for a shorter period referring to the count when defects occurred.

Solution

Predict optimal tool change timing even in the case of varying-type/varying-volume production.
Reduce tool change count as well as tool cost and labor.

Features

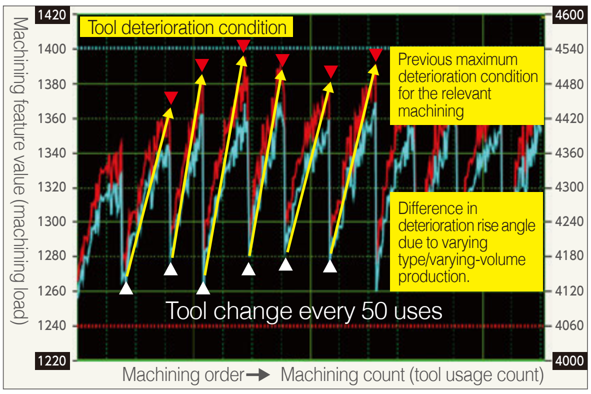
Simultaneous collection of IoT machining data and machining conditions from machine tools to visualize changes in trends with identical machining conditions.

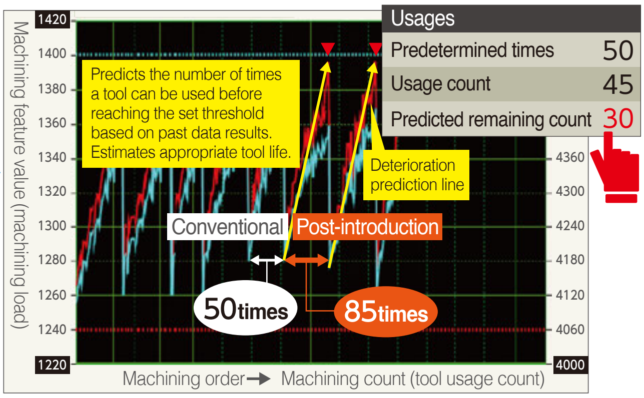
● Trend with regular tool change

In the past,TBM(tool usage count)was the basis for tool change,however it became apparent that tools were being changed prior to life expiration despite the potential to be used close to the maximum load for tool change results.

● Trends when tools are replaced at usage limit (wear)

The optimal tool life in varying-type/varying-volume production was determined and tool maintenance was improved by switching from TBM(tool usage count)to condition-based maintenance CBM(wear state). As a results in the reduction of tool replacement, saving tool costs by 40%.





● Annual tool cost by tool optimal tool change(example)

	New tool price	Re-grinding price	Annual tool cost
Conventional	1.29 mill yen (15,000 yen × 86 tools)	1.04 mill yen (6,000 yen × 174 tools)	2.33 mill yen/tool
Post-introduction	765,000 yen (15,000 yen × 51 tools)	612,000 yen (6,000 yen × 102 tools)	1.38 mill/tool

40%DOWN

Cut by 950,000 yen

Use Case
2

Reducing Loss Cost by Preventing Leakage of Products with Quality Defects Due to Machining Faults

Problem

Quality defects occur due to sudden tool abnormalities or manufacturing abnormalities in the upstream process.

Have you ever experienced this?

Sudden tool defects create a large volume of defective products up until quality inspection.
A large volume of defective products is produced due to mold deformation in the upstream process(casting).

Solution

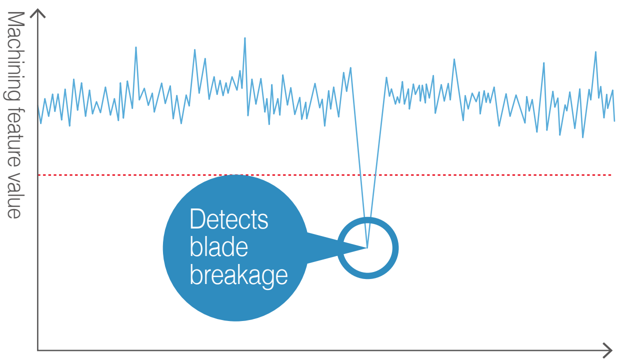
Immediately after machining, detects Abnormalities by identifying things that "Differ to the norm!" based on change from machining feature value in normal times.

Features

Capture changes with machining feature value during normal machining, to support extraction of diagnosis thresholds for judging abnormal machining.

● Detection of tool breakage

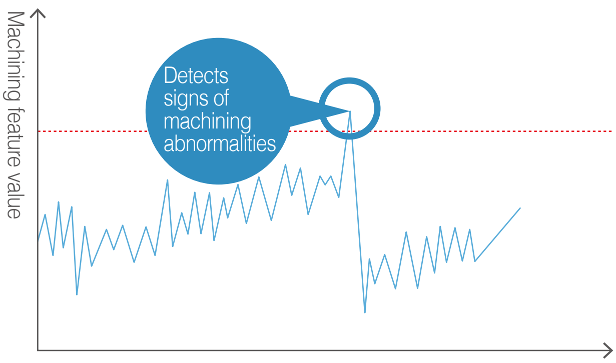
Detects sudden reductions in machining feature value caused by blade breakage.



Blade breakage detection

● Detection of machining abnormalities due to mold deformation

Detects sudden increases in machining feature value caused by machining faults.



Machining abnormality detection

● Prevents defective products into the market by detecting sudden tool abnormalities!

● Identifies upstream process defects by detecting machining abnormalities and reduces loss cost!

Productivity Increase by 10% or Higher Due to Shorter Breakage Detection Time

Problem

I want to eliminate tool breakage detection (breakage detection) time, which is a waste of operating time.

Have you ever experienced this?

It takes breakage detection time for each machining, each affecting the cycle time.

Solution

By leveraging IoT machining data, cycle time was significantly improved!

Features

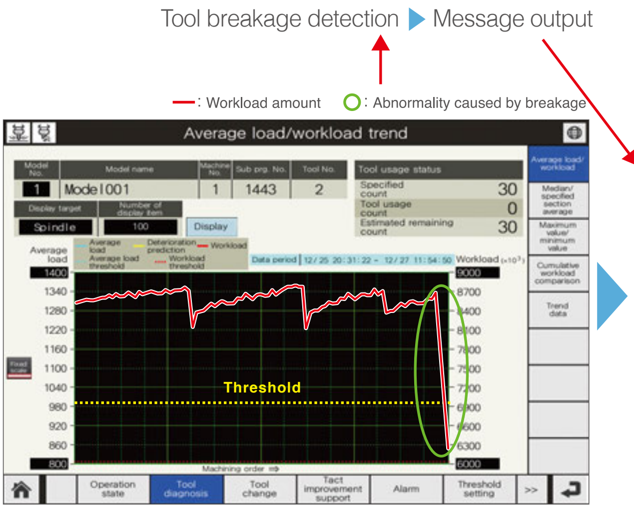
Able to detect tool breakages using IoT machining data only,
making sensor-less tool breakage possible.

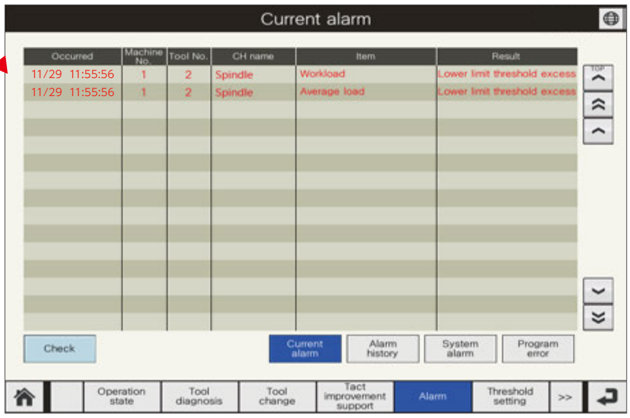
● Change of feature value trend at tool breakage

● Alarm output at tool breakage

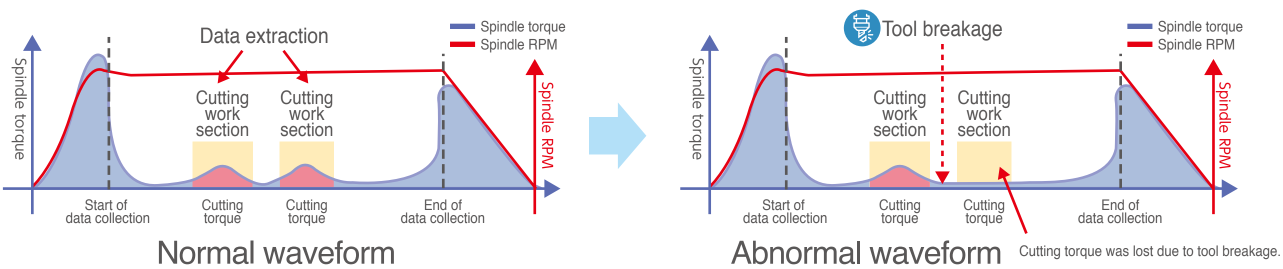
When a tool breakage is detected, an alarm message is outputted and the signal tower*1 illuminates!

*1: If external abnormality input terminal has been prepared on the machine tools





● By extracting section data from machining IoT data, slight changes in tool breakage can be detected, resulting in easier abnormality detection.



Normal waveform

Abnormal waveform

Use Case 4

Use Case 5

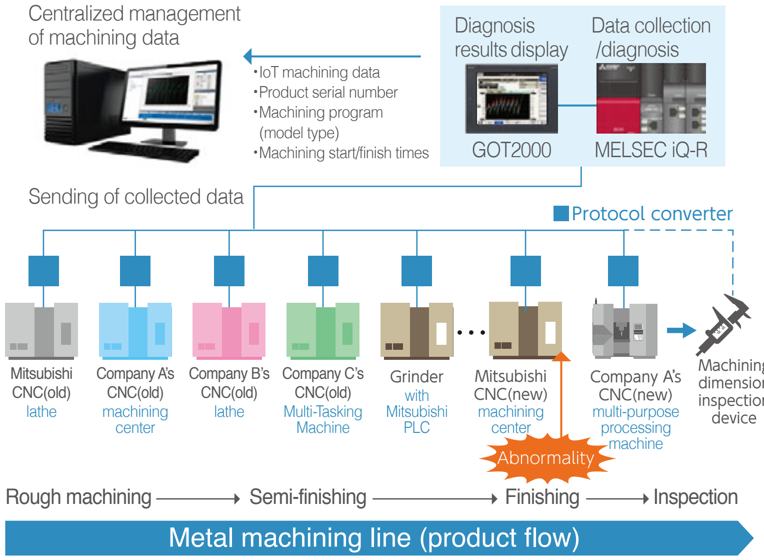
Centralized Management of Machining Data Contributing to Traceability

Problem

- A machining line may consist of a variety of new and old machine tools such as machining centers, lathes, Multi-Tasking Machine, and grinders, which makes data collection difficult.
- Even when a product does not meet the quality standard, the process that caused the abnormality is unclear.

Solution

- By collecting machining data from up to 10 machine tools equipped with CNC of different manufacturers, uniform control of machining diagnosis and tool change operations becomes possible.
- The collected data includes product types, processing conditions (machining program), product serial numbers, and tool numbers and secures traceability. The reference of product serial numbers is also useful to connect inspection data.



Please contact your local branch or dealer for details on connectable CNC models and machine tools without CNC.

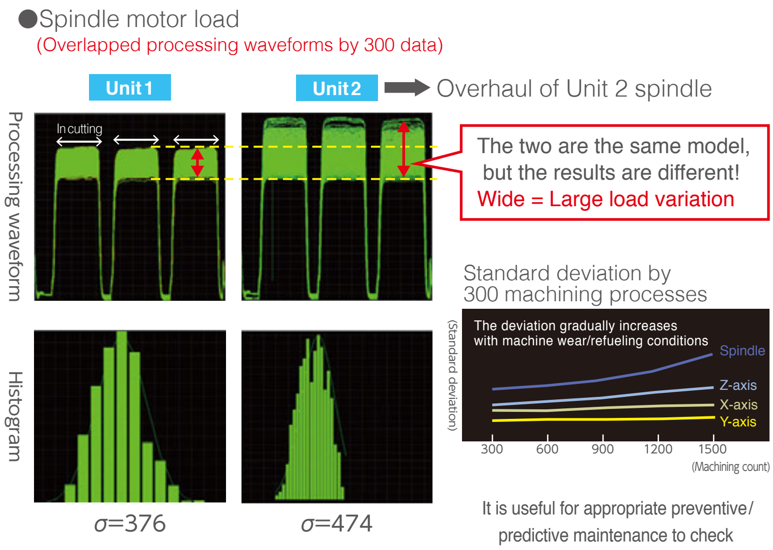
Support for predictive diagnosis through monitoring mechanical errors

Problem

- Regular maintenance cannot prevent unplanned outage due to failure to detect signs of machine deterioration.

Solution

- Machine deterioration can be visualized by calculating the standard deviation of the varied machining loads from the spindle deflection for each fixed number of machining operations.



It is useful for appropriate preventive/predictive maintenance to check mechanical errors and aging deterioration trends with standard deviation values.

Use Case 6

Predicting Geometrical Tolerances and Process Quality from IoT Data to Prevent the Outflow of Machining Defects

Problem

I want to prevent the outflow of machining defects.

Have you ever experienced this?

Although quality is guaranteed by performing sampling inspections, we don't know how much of an impact is present when a part fails an inspection. Sampling inspections are also unable to detect sudden defects and or defect trends.

Solution

Machine learning is applied to the relationship between measurement results and IoT data to create a predictive model for the measurement results. This predictive model is used to calculate the level of quality immediately after machining to prevent the outflow of defective parts to the subsequent process.

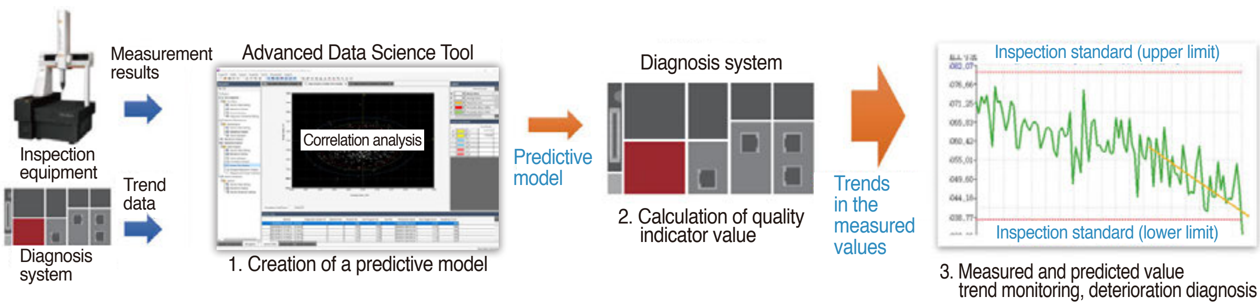
Features

1. The Advanced Data Science Tool*1 is used to analyze the correlation between IoT data (feature values) and measurement results.
   The results of this analysis are fed into a machine learning algorithm and feature values and measurement results that have a strong degree of correlation are used to create a predictive model.

2. This predictive model is incorporated into the diagnosis system to calculate the level of quality (measured value) after each machining process.

3. Trends in quality indicators are displayed on the GOT screen, which allows easy threshold monitoring and trend diagnosis.
   This makes it possible to predict the number of times the current tool can be used before you will see a deviation in quality indicators and allows you to detect sudden changes in quality.

*1: For more details regarding the Advanced Data Science Tool, please refer to pages 16-17.



Use Case 7

Utilization of IoT Data to Accelerate Investigations Into the Causes of Sudden Inspection Failures

Problem

When there is an inspection failure,
I want to quickly check the IoT data of the failed part and investigate the cause.

Have you ever experienced this?

In the event of a nonconforming part, I want to use defect data correlation and machining waveform data comparisons to quickly determine the mechanism that caused the inspection failure.

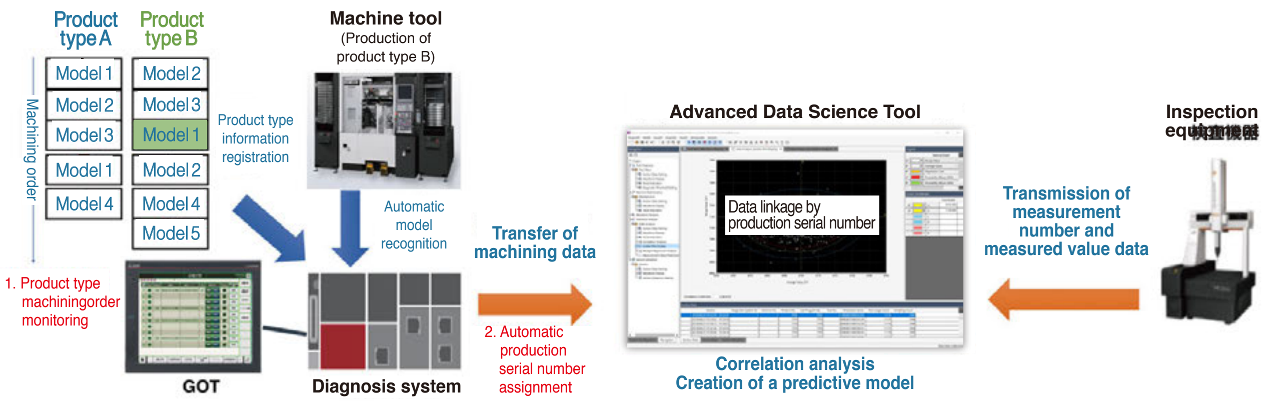
Solution

The Advanced Data Science Tool enables you to manage and link the IoT data with measurement results.
This makes it easier to search for data indicating a failure.

Features

1. Even when performing a series of machining process using several machining programs, the same production serial number*1 is automatically assigned to the entire series of IoT data.
   Furthermore, by registering the product type information on the diagnosis system in advance, it is possible to assign different production serial numbers to each product type, even if different product types use the same machining program.

2. With the Advanced Data Science Tool, it is possible to display a list of the IoT data with its assigned production serial numbers and the corresponding inspection data for the same product type in parallel, as well as to link the both data on the tool.



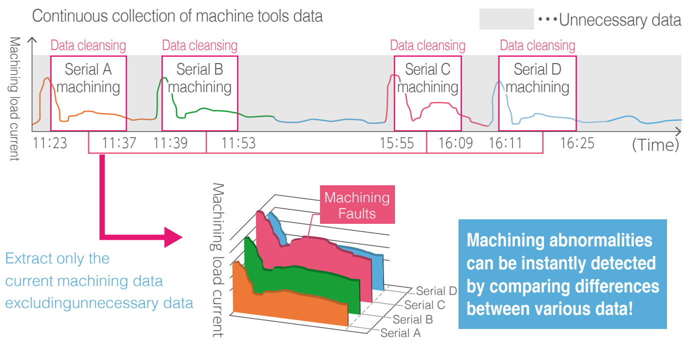
*1: The lot number or Two-dimensional code equivalent to the product serial number is scanned with a dedicated reader.
When it is possible to notify the diagnosis system, this code can be assigned to the IoT data.

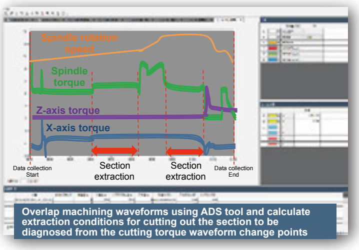
Wide-array of Analysis Technology Leveraging Data to Achieve Reliable Tool Diagnosis

Automatic Detection of Machining Load

Automatic extraction of the target machining selection from collected data

Analog data is collected at high speed during machining and only the data related to the machining load is automatically extracted.The feature value is then calculated from this extracted data.The conditions for automatic extraction of the specified data can be set while checking the waveform using the Advanced Data Science Tool.

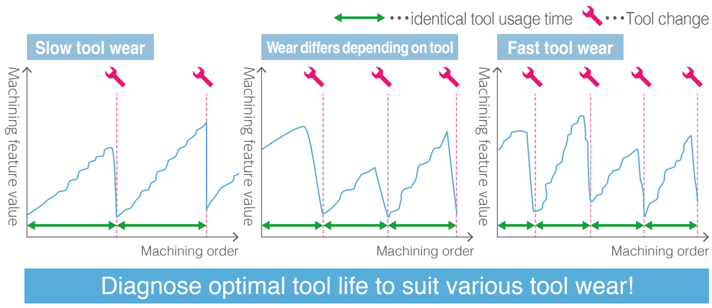




Optimization of Tool Change Timing

Use tools for the full life even in the case of multi-product variable-quantity production

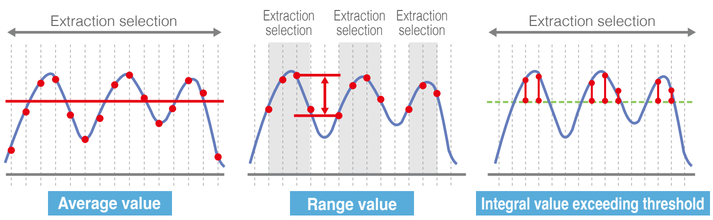
By making "models" from machining program number and tool number combinations, tool life can be diagnosed in relation to various machining conditions incorporated in the model, such as machined material, workpiece shape, spindle speed, cutting depth, and feed. As such, even if one type of tool is used for production under various machining conditions, tool life for individual models can be stipulated, and tool diagnosis in multi-product variable-quantity production is possible by predicting deterioration to suit the progress of tool wear.



Selection of Optimal Feature Values for Diagnosis

Selection of feature values with strong correlation according to the purpose of the diagnosis

Depending on the particular purpose of the tool wear or machining abnormality diagnosis, it is possible to select appropriate feature values (average value, integral value, maximum value, minimum value, range value, median value, selection length, count of threshold passing, counts of exceeding thresholds, threshold exceeded time/average value/integral value).

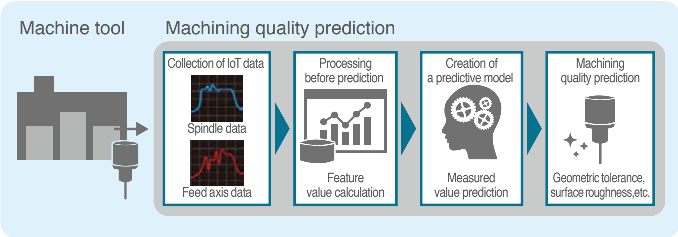


If the machining conditions result in a very small load, any noise in the collected data may greatly affect the accuracy of the diagnosis. Therefore, primary processing techniques such as maintaining a moving average can be utilized to improve the S/N (signal/noise) ratio of the data to be diagnosed and the calculation accuracy of the feature value.

Machining Quality Diagnosis Using a Measured Value Predictive Model

Diagnosis for complicated machining geometries such as curved surfaces

When machining parts that interact with fluids or have an intricate design, it is often necessary to perform simultaneous control of multiple axes such as when performing precision finishing of curved surfaces. In such cases, torque is applied not only to the spindle but also to various feed axes for machining.For these case, it is not possible to perform wear diagnosis by only looking at trends on a single axis.



To solve this problem, we apply machine learning to the general relationship between trends of the feature values for each axis and the trends of measured values (quality indicators) and create a measured value predictive model. By appropriately managing trends immediately after machining, it is possible to perform wear diagnosis even in the case of complicated geometries such as curved surfaces.

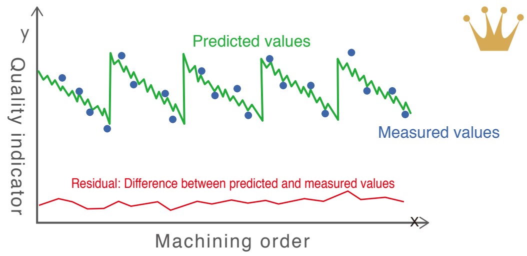
Evaluation of Machine Learning Prediction Accuracy (Learning Target Optimization/Cross-Validation)

Creating an environment for easy AI (machine learning) utilization

Basic knowledge of concepts in data science such as overtraining and multicollinearity problems is generally required for machine learning.
However, in order to prevent these problems from occurring, this package automatically displays recommended machine learning feature values after it determines the data (quality indicators: measured values, inspection values) to be applied to learning.
Furthermore, the learning target data can be divided into multiple blocks, and the system can then automatically verify which block contains a trained predictive model with high accuracy.

Example of learning data grouping using cross-validation

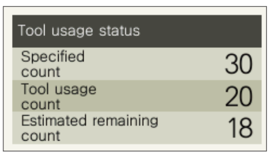
Validation data	Learning data1	Learning data1	Learning data1	Learning data1
Learning data1	Validation data	Learning data2	Learning data2	Learning data2
Learning data2	Learning data2	Validation data	Learning data3	Learning data3
Learning data3	Learning data3	Learning data3	Validation data	Learning data4
Learning data4	Learning data4	Learning data4	Learning data4	Validation data
Accuracy1	Accuracy2	Accuracy3	Accuracy4	Accuracy5



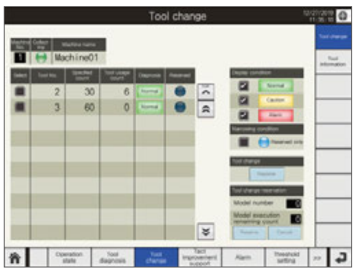
Tool Change Operation

Present tool life with the available usage count

Based on post-tool change differences in tool cutting performance and the status of varying-type/varying-volume production, displays predicted remaining count as available usage count to show how many more times a tool can perform machining until it reaches its life.
Able to set abnormality output in the two stages of “caution” and “warning” based on predicted remaining count to enhance user-friendliness. If an abnormality occurs, an abnormality output can be sent externally also, enabling abnormality display on the machine tools, etc.*1



Display tool life with predicted remaining count!



Manage each tool’s usage status in one list!

*1 If external abnormality input terminal has been prepared on the machine tools

Function Overview

We Provide Various Functions to Support the Realization of Digital Transformation

System Installation

Set the parameters for connection and data collection according to the target device and then perform data collection.

Settings during installation

System settings

Configure the common settings for the diagnosis system (diagnosis system ID and password settings).

Common settings screen

Machine settings

The machine tool communication method and data cleansing conditions can be set for each machine to enable the collection of machining status data.

Machine settings screen

Model settings

Register the diagnosis model for each machining condition.
The automatic model registration function allows you to automatically register models according to the received machining conditions.

Model settings screen

Collection of machining data

Collection of machining data

Collect machining data of each machine tools in real-time for storage or comparison purposes. (compare differences between deteriorated tools and new tools)

Machining data collection screen

Machine status monitoring

On the Machine state detail display, the data received from the CNC and the collected data are displayed in real time.

Machine details status screen

Data transfer

ADS tool*1

Waveform and trend display function (ADS tool*1)

The Advanced Data Science Tool allows you to display stored waveform and trend data over a specified selection data. This allows you to check the wear state of the tool.

Preparation

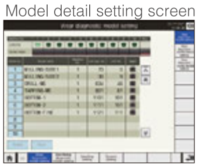
The set threshold is automatically calculated from the collected data, and the optimized diagnosis threshold is then set in the system.

Diagnosis threshold setting

Model detail setting

It is possible to set the data cleansing conditions, data processing conditions, and diagnostic feature values for the model according to your diagnostic requirements.

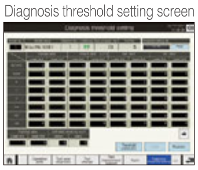
Model detail setting screen



Diagnosis threshold setting

It is possible to use the values calculated by the ADS tool*1 or custom values from the user.

Diagnosis threshold setting screen



Transfer of settings

ADS tool*1

ADS tool*1

Section extraction setting

While checking the cutting torque waveform, it is possible to set the selection extraction conditions from the collected waveform data.

Diagnosis threshold extraction

The statistical analysis function automatically calculates recommended thresholds from trends in the feature values.

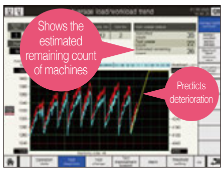
Start of Operation

Tool wear diagnosis

Analyze Management of Trend Data for Various Feature Values

Various feature values are automatically calculated, and their trend data is displayed.The threshold deviation is then determined according to the calculation results.

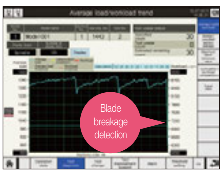
Visualization of tool wear



Tool wear diagnosis

The system can predict the tool service life according to the state of wear and notify the user of the estimated remaining count of machines of the tool.

Visualization of tool abnormalities



Machining abnormality diagnosis

In the case of a tool or machining abnormality, a threshold deviation judgment is made and an alert is issued.

Visualization of trend data for various feature values

*1: ADS Tool: Advanced Data Science Tool (Refer to pages 16-17)

Accurate Diagnosis

Machine learning algorithms are applied to inspection and machining data to enable the prediction of machining quality.

Quality prediction

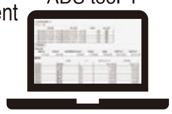
Transmission of internal measurement values from machine

Dimension data measured by a CNC can be transmitted to the ADS tool*1.

Internal measurement value transmission screen

Transfer of measurement values from a device

ADS tool*1



Analysis of the relationship between inspection and machining data

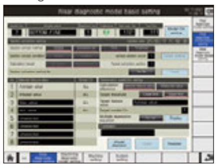
In the Advanced Data Science Tool, the machining and measurement data (machining quality) are linked according to the production serial number information*2.

*2: Production serial numbers can be automatically assigned when machining data is collected.

Predictive model and diagnosis threshold settings

The Advanced Data Science Tool allows you to set the calculated predictive model and the diagnosis threshold calculated from feature value trends.

Wear diagnosis model settings screen



Transfer of the predictive model

ADS tool*1

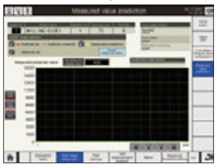
Model creation and evaluation

From the results of correlation analysis between the machining quality and the collected machining data, the feature values of the optimum target for learning are automatically selected, and a predictive model is automatically created by machine learning.

Measured value prediction

Immediately after machining, the predicted measured value (quality indicator) is calculated from the predictive model. The system then calculates the threshold deviation and the estimated remaining count of machines.

Measured value prediction screen



Diagnosis system main menu

Operational Support

Provides support for tool replacement that utilizes tools up to the end of their service lifeAa

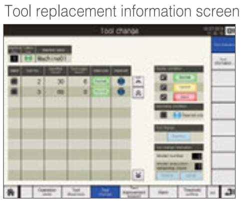
Tool replacement information

The system is able to display the tool usage status.
(To help with the tool change process, the system can trigger an alarm when it is time to change the tool.)

Alarm history

The system is able to display tool error messages and tool change alarms.

Tool replacement information screen



Alarm history screen

Improvement

Improvement of cycle time and tool life through optimization of machining conditions

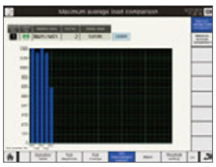
Maximum Average Load Comparison, Maximum Workload Comparison

By comparing machining condition for the same tool between machining programs, optimizes machining conditions such as cutting speed, feed amount,cutting depth, etc. to support improvement of cycle time.

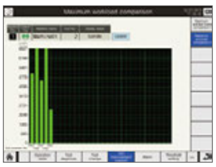
Waveform Comparison

Optimal machining conditions can be confirmed by comparing the change in load applied to the tool over time.

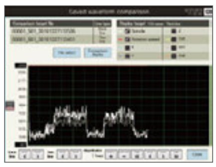
Maximum Average Load Comparison



Maximum Workload Comparison



Waveform Comparison



Advanced Data Science Tool
(Engineering environment that promotes digital transformation)

The Advanced Data Science Tool is a software that links to iQ Monozukuri Tool Wear Diagnosis for Machine Tools to utilize IoT data for the support of tool diagnosis, equipment maintenance, and statistical analysis.

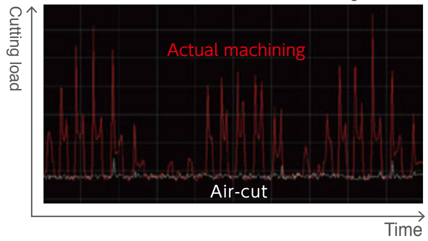
Use Case (1)

Problem: I want to check for any changes to the system state when a machining abnormality occurs.

Solution

1. By comparing the waveforms of air-cut data and actual machining data, it is possible to determine differences in cutting load. This information can then be used to diagnose tool abnormalities.
2. Comparing the waveforms allows you to better understand the difference between worn and new tools, as well as normal and abnormal machining.
3. It is possible to check any tool deterioration trends and confirm any differences between molding (lots).

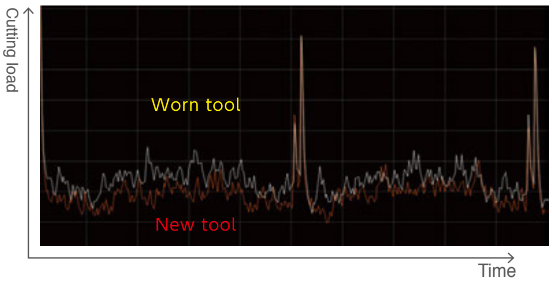
1. Understand the difference in waveforms between an air-cut and actual machining



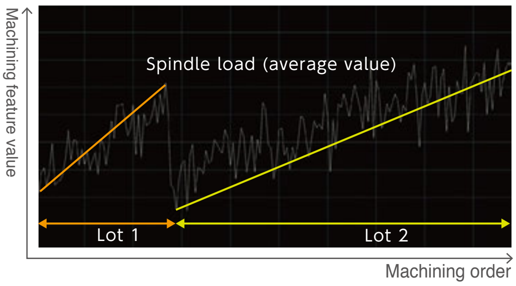
Features

By utilizing IoT data and comparing waveforms, it is possible to better understand various states during machining.

2. Understand the difference in waveforms between worn and new tools



3. Comparison of deterioration trends due to differences between lots



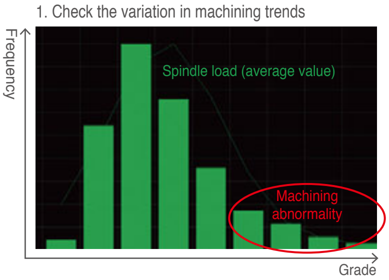
Use Case (2)

Problem: I want to utilize big data to detect machining and equipment abnormalities

Solution

1. By plotting the same machining feature value on a histogram, it is possible to check for any variations in tool wear and better grasp any trends in machining abnormality data.
2. It is possible to check the correlation between feature values and machining quality (measurement/inspection values) by plotting them on a scatter diagram. This can help you to detect any machining abnormalities by easily identifying outliers.
3. By comparing the feature value histograms of the same machining process between different equipment, it is possible to identify equipment differences and deterioration trends and easily detect equipment abnormalities.

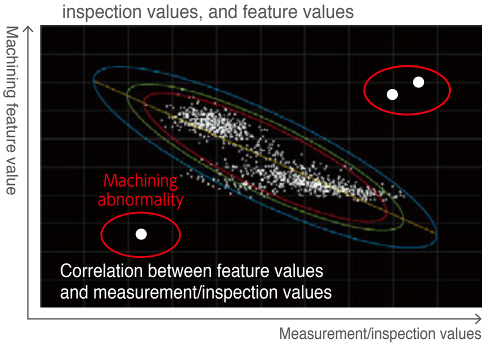
1. Check the variation in machining trends



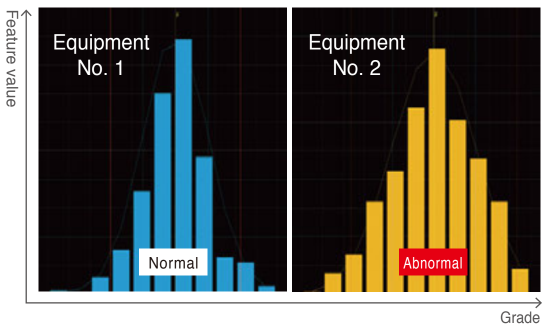
Features

Statistical analysis utilizing big data allows you to easily identify machining and equipment abnormalities.

2. Check the correlation between measurement values, inspection values, and feature values



3. Check the variation of feature values between devices



Use Case (3)

Problem: I want to utilize IoT data to more accurately predict machining quality

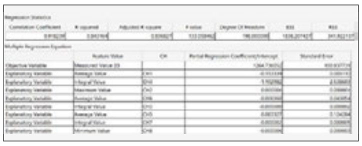
Solution

1. Machine learning is applied to the relationship between IoT data and machining quality (measurement/inspection values) and a predictive model is automatically calculated.
2. Through cross-validation of learning and validation data that has been divided into blocks, it is possible to confirm the validity from the predictive model's regression analysis results. This improves overall calculation accuracy.
3. It is possible to check the prediction accuracy by comparing the calculated predicted values of the model with the actual measurement values.

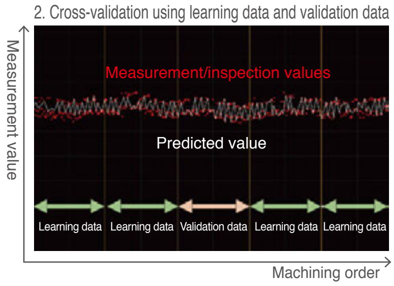
Features

The combination of machine learning and IoT data can be used to create a highly accurate quality predictive model which minimizes machining abnormalities and defects.

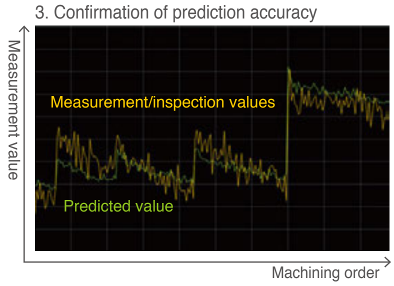
1. Automatic calculation of a predictive model



2. Cross-validation using learning data and validation data



3. Confirmation of prediction accuracy



Main Functions

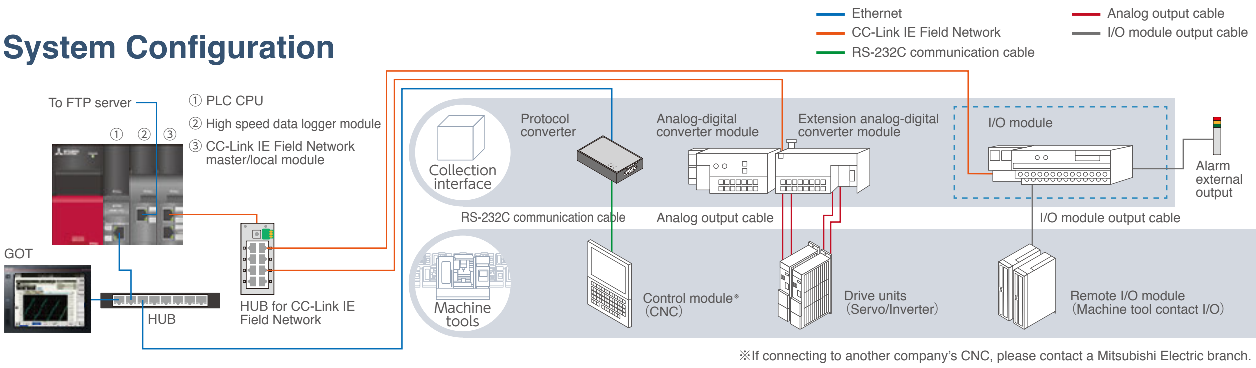
Function type	Function details
Management of collected data	Display of a list of collected section data
	Filtering the analysis target section data (by machining program or tool used)
	Deleting data that is not subject to analysis
	Temporary exclusion of data that is not subject to analysis
Waveform display	Graphical display of machining waveform in chronological order
	Parallel/normalized display of multiple channels
	Display of multiple section data superimposed
	Fixed display of section data
Display of trends	Graphical display of selected feature values, measurement data, and prediction values
	Parallel/normalized display of multiple feature values
	Display of tool change history
Diagnosis threshold settings	Automatic threshold calculation for tool wear and machining abnormality diagnosis
	Transfer of diagnosis threshold settings data
Statistical analysis	Display of a list of measurement data and feature value correlation coefficients
	Scatter plot display of measurement data and selected feature values
	Grouping of interval data for learning/validation
	Automatic creation of predictive models by machine learning
	Cross-validation by group
	Graphical display of predicted measurement values (quality indicators)
	Transfer of predictive model data
Interval extraction settings	Machining waveform extraction (cleansing) condition settings
	Transfer of interval extraction settings data
Data collection	Waveform/trend data collection and database construction
	Automatic transfer of measurement data

Operating Environment

Item		Description
Personal computer	—	Personal computer where Microsoft® Windows® operates
	CPU	Intel® Core™i5 processor 2 GHz or more is recommended
	Required Memory	8 GB or more is recommended
Hard disk free capacity		128 GB or more is recommended
Display		Resolution 1024 × 768 dots or higher
OS(32-bit version, 64-bit version) (Japanese, English, Chinese (Simplified))		Windows 10 (Pro, Enterprise, IoT Enterprise 2016 LTSB)
.NET Framework		.NET Framework 4.0 or later

Product Specifications

System Configuration



※If connecting to another company's CNC, please contact a Mitsubishi Electric branch.

System Specifications

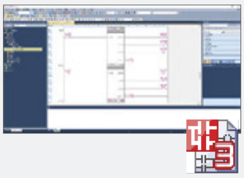
Items		Content
Maximum no. of machine tool connections		Up to 10 machines*1
Data collection	Input channel	8 channels per machine tools Voltage input range: DC -10 to +10V, DC 1 to 5V, DC 0 to 5V Current input range: DC 4 to 20mA, DC 0 to 20mA
	Analog data collection interface	Conversion speed: 100μs/CH
	Machining condition collection interface	RS-232C (DPRNT output), LAN (incorporate various CNC variables)
	Input data	Spindle torque current feedback, spindle motor RPM, motor torque current feedback for other 6 axes, or analog input for 6 channels
	Sampling start trigger	Analog triggers or external DI triggers
	Data section extraction	Extraction bit specification, Time specification, Threshold specification
	Data collection time	Maximum of 30 min per machining operation
Model	No. of models	Wear diagnosis: 150 models, Machining diagnosis:1,000 models
	No. of trends that can be displayed on GOT	400 per model (various feature values)*1
	Model registration	Targets of diagnosis can be arbitrarily changed by setting target tools/target machining operations.
Diagnosis function	Tool wear diagnosis	Wear diagnosis to match characteristics of relevant tool from post-tool change (use tool until the end of its life with a remaining usage count display)
	Measured value prediction	Realizes automatic generation of prediction models by machine learning, evaluation of prediction performance, transfer of prediction models, measurement value prediction by machining data, and use until tool life (diagnosis system) by displaying the remaining count of uses.
	Machining abnormality diagnosis	Diagnosis of deviation from regular machining trends (monitoring of sudden reduction in machining load caused by blade breakage)
Tool change registration function		Tool change registration, tool change reservation, tool change automatic judgment, importing the tool change timing by receiving the tool counter
Machining quality diagnosis function		Monitoring of machining feature value fluctuation with thresholds
Product management		Model trace by machining time registered in each product type models Automatic assignment of production serial
Cycle time improvement support function		Displays feature value with various machining programs by each tool to compare difference (support for improvement of machining conditions such as spindle RPM and feed rate)
Alarm display function	Alarm category	Alarm(warning) for deviation from feature value threshold, tool remaining count alarm(caution/warning), system status alarm
	Alarm display	Displays alarm history and currently active alarms
	External input/output	Alarm output: DO 1 point/device, Alarm clear DI 1 point/device
Operation status display		Displays machining/tool condition for each device
Waveform display (GOT)	Logging function	Trigger logging, continuous logging (sampling per 100 ms for a display in GOT)
	Save function	Maximum of 60 items to SD memory card
	Simple display function	Waveform display (channel is selectable for display) Comparison of waveforms for other machining data (start position can be offset for display)
Data transfer	Transfer method	FTP transfer
	File type	CSV file type (chronological data, feature value data, Internal measurement data)
	Maximum storage size	Depends on PC disk capacity Saves to SD memory card upon network disconnection (255 files)
Measurement data management	Internal measurement	Transfer of measured data from CNX to ADS Tool*3 via diagnosis system
	Instrument measurement	Transfer of measured data from a measuring instrument to ADS Tool*3
	Measurement data linkage	Use of ADS Tool*3 to link MFG serial numbers to the measurement data
User customization function	CNC communication customization	Able to build communication protocol customized to each company's CNC
	Customization of abnormal machining diagnosis	Able to build diagnosis rules specific to user environment, such as chipping
	Customization of collected data usage	Releases memory map of data being collected in real-time
System setting backup		Backup/restoration of system information in a USB memory device installed in GOT FTP Transfer of extraction setting information for all models

*1: Limitations exist depending on diagnosis conditions.   *2: Only for wear diagnosis   *3: Advanced Data Science Tool (Refer to pages 16 and 17.)

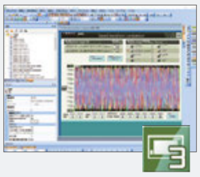
Contents of Package

iQ Monozukuri Tool Wear Diagnosis for Machine Tools Package includes the below contents.

■ Control program



■ Screen data



■ High speed data logger setting project

■ Communication protocol support data

■ Manual

※Advanced Data Science Tool is optional.

Software

Product Name		Model	Quantity	Software Version
Engineering Tool	MELSOFT GX Works3	SW1DND-GXW3-□	1	1.066U onwards
	MESOFT GT Designer3 (GOT2000)	SW1DND-GTWK3-□	1	1.240A onwards
	MELSEC iQ-R Series High Speed Data Logger Module Setting Tool	SW1DNN-RDLUTL-□	1	1.03D onwards

※Software used for startup.

Major Device The required quantity depends on configurations.

Product Name	Model	Quantity	Remarks
GOT	GT2512-STBA	1	—
Main base unit	R35B	1	—
Power supply module	R61P	1	—
PLC CPU	R16CPU、R32CPU、R120CPU	1	Firmware version "40" onwards
Extended SRAM cassette	NZ2MC-16MBS	1	For PLC CPU
High speed data logger module	RD81DL96	1	—
SD memory card	NZ1MEM-4GBSD	2	・For high speed data logger module ・For GOT ・For PLC CPU
CC-Link IE Field Network master/local module	RJ71GF11-T2	1	—
Protocol converter	*1	*2	—
CC-Link IE Field Network analog-digital converter module	NZ2GF2BN-60AD4	*2	—
CC-Link IE Field Network extension analog-digital converter module	NZ2EX2B-60AD4	*2	—
CC-Link IE Field Network remote I/O module	NZ2GF2B1-32DT	*3	Option/input type: DC input (plus common type), output type: Transistor output (sink type)
	NZ2GF2B1-32D	*3	Option/input type: DC input (plus/minus shared common type)
Analog output cable	*1		—
RS-232C communication cable	*1		—
24V power supply	*4		・For CC-Link IE Field Network remote I/O module ・For other devices
HUB	—	1	—
Hub for CC-Link IE Field Network	—	1	—

*1: Project setting change is required
*2: Please contact a Mitsubishi Electric branch.
*3: As optional, when connecting with external I/O devices, please select unit type and quantity for I/O points to be used.
*4: Please select module type and quantity for I/O points to be used.

Lineup

FA Application Package

iQ Monozukuri Tool Wear Diagnosis for Machine Tools

* These are the successors of the AP10-MTD001AA-M☐ models.
(Depending on the number of licenses, "☐" may contain the letters A to E.)

Product Name	Model	Number of licenses
FA Application Package iQ Monozukuri Tool Wear Diagnosis for Machine Tools	AP10-MTD001AB-MA	1
	AP10-MTD001AB-MB	5
	AP10-MTD001AB-MC	10
	AP10-MTD001AB-MD	15
	AP10-MTD001AB-ME	20

iQ Monozukuri Tool Wear Diagnosis for Machine Tools Upgraded Version

* To apply for a license key for the upgraded version, it is necessary to complete a license key application for your previously purchased "AP10-MTD001AA-M☐" model.
If you have yet to apply for a license for your "AP10-MTD001AA-M☐" model, please apply a license key for that model first.
(Depending on the number of licenses, "☐" may contain the letters A to E.)

Product Name	Model	Number of licenses
FA Application Package iQ Monozukuri Tool Wear Diagnosis for Machine Tools Upgraded Version	AP10-MTD001AB-MAV	1
	AP10-MTD001AB-MBV	5
	AP10-MTD001AB-MCV	10
	AP10-MTD001AB-MDV	15
	AP10-MTD001AB-MEV	20

iQ Monozukuri Tool Wear Diagnosis for Machine Tools Advanced Data Science Tool

Product Name	Model	Number of licenses
FA Application Package iQ Monozukuri Tool Wear Diagnosis for Machine Tools Advanced Data Science Tool	AP10-MTD001AB-MAV	1

List of CNC Equipment That Has Been Verified to Connect

Manufacturer	Connected CNC model
Mitsubishi Electric Corporation	M600～、C70～ etc.
FANUC Corporation	Series ** i etc.
Okuma Corporation	OSP etc.

We shall introduce connection methods and cables that are compatible with each model of CNC.
Please contact us for more information regarding the CNC you would like to connect to.

Validated Partner Products

Partner Products (protocol converter for CNC connection)

CONTEC CONPROSYS

Product name	CONPROSYS M2M controller, compact type (FANUC MT-Linki compatible product)
Model	CPS-MC341-ADSC1-931
Weight	2509
Size	188.0 (W) ×78.0 (D) ×30.5 (H) mm (excludes protrusions)
Input power supply specifications	12～24VDC
Environment specifications	-20 to 60°C (ambient operating temperature); Supports VCCI class A, FCC class A, CE marking (EMC directive class A, RoHS directive), KC, UL
I/O interface	2×LAN/4×DI/2×DO/2×AI/2×CNT/1×RS-232C/1×RS-485/1×USB/1×SD card slot
Data input communication protocol	CNC communication, MTConnect, signal I/O
Data output communication protocol	OPC UA server, Modbus slave, signal I/O
Data for collection	Program No., Sub-program No., Tool No., S Code, Product Serial No. etc.

Manufacturer/Dealer: Contec Co., Ltd., 3-9-31 Himesato, Nishiyodogawa-ku, Osaka 555-0025, Japan
TEL: 06-6472-7130 INTL TEL: +81-6-6472-7130 www.contec.com

CIMX INITIATIVE Marimba M3

Product name	Marimba M3 FOCAS-SLMP version (FANUC compatible)
Model	MarimbaM-5FS02
Weight	0.15g
Size	7(W)x10(D)x4.2(H)mm
Input power supply specifications	DC9-36V
Environment specifications	0 to 60°C (ambient operating temperature)
I/O interface	LAN (10/100/1000 B ASE-T) × 1 , Rs232C
Data input communication protocol	FOCAS 2
Data output communication protocol	SLMP (MC protocol)
Data for collection	Program No., Sub-program No., Tool No., S Code, Product Serial No. etc., Error Code etc.

Manufacturer/Dealer: Cimx Initiative, Inc. 5F YSK Building, 1-3-11 Shiba Daimon, Minato-ku, Tokyo, Japan
TEL: 03-6402-2640 INTL TEL: +81-3-6402-2640 https://www.cimx-initiative.com

EMPRESS SOFTWARE JAPAN INC.	**FANUC CNC compatible gateway for overseas**	**Mitsubishi Electric CNC compatible gateway**
Product name	IoT Data Connector (compatible with FANUC for overseas)	IoT Data Connector (Mitsubishi Electric compatible)
Model	EMR120CL-FM1、EMR120CL-FM3	EMR120AW-MM1、EMR120AW-MM3
Weight	250g	950g
Size	188.0 (W) ×78.0 (D) ×30.5 (H) mm (excludes protrusions)	140(W)×110(D)×58.5(H)mm (excludes protrusions)
Input power supply specifications	12VDC (0.8Amax) -24VDC (0.4Amax)	6V ～36VDC max40W
Environment specifications	-20～60°C (ambient operating temperature)	0～+50°C (ambient operating temperature)
I/O interface	LAN (100Base-T) x2	LAN (100Base-T) x2、RS232Cx2
Data input communication protocol	FOCAS2	EZ-SocketNC
Data output communication protocol	SLMP (MC protocol)	SLMP (MC protocol)
Data for collection	Program No., Sub-program No., Tool No., S Code, Product Serial No. etc., Error Code etc.	Program No., Sub-program No., Tool No., S Code, Product Serial No. etc., Error Code etc.

Dealer: Business Unit No. 7, Solutions Business Headquarters, Ryoyo Electro Corporation, Konwa Bldg., 1-12-22 Tsukiji, Chuo-ku, Tokyo 104-8408, Japan
TEL (main line): 03-3546-6180
INTL TEL: 81-3-3546-6180
Contact:EMAIL empress_sales@ryoyo.co.jp

Manufacturer: EMPRESS SOFTWARE JAPAN, Inc., 6F Nihon Shashin Kaikan, 1-7-12 Yotsuya, Shinjuku-ku, Tokyo 160-0004, Japan
TEL (main line): 03-6457-8327
INTL TEL: +81-3-6457-8327
Contact:EMAIL esj-info@empressjapan.co.jp

Current Sensor

U_RD

Product name	Effective value calculation type current transducer	
Model	HCS-24-20-ASR	HCS-24-50-ASR
Size/Weight	45.0(W)x34.0(D)x74.5(H)mm (excludes protrusions), Approx. 145g	
Measurable wire size	AWG 20 to AWG 26, Wire passage holeφ24 max.	
Applicable current waveform	DC to AC 500Hz (including phase control/PWM waveform)	
Measurement current/Output voltage	0 to 20Arms/1 to 5V output	0 to 50Arms/1 to 5V output
Environment specifications	0°C to +50°C, 85%RH or less, No condensation	

Manufacturer/Dealer: U.R.D. Co., Ltd., 1-1-52 Suehirocho, Tsurumi-ku, Yokohama City, Kanagawa 230-0045
TEL: 045-502-3111 INTL TEL: +81-45-502-3111
www.u-rd.com

Flow until the start of operation

1 Preliminary Survey

- Select the device, machining type, tool for diagnosis
- Determine system configuration, secure installation environment

2 Equipment Installation

- Install, wire up equipment
- Set device parameters (communication means, data collection conditions, etc.), register diagnosis model
- Conduct trial operation check for data collection preparation
- Data collection to determine diagnosis threshold
 (data collection including 5 to 10 tool exchanges: Approx. 1 month)

3 Diagnosis Threshold Setting

- Confirm adequacy of settings from collection data
- Calculate diagnosis threshold from trend data
- Set calculation threshold

4 Operation

- Commence operation (check machine condition)
- Tool wear diagnosis, machining abnormality diagnosis, measured value prediction
- Tool change in line with diagnosis results/alarms
- Revise thresholds
- Optimization of machining programs using a Cycle time improvement support function

Related Products

iQ Monozukuri Rotary Machine Vibration Diagnosis

This software package is used to collect, analyze, and diagnose vibration data from equipment that contains rotating parts.
It then helps to visualize equipment status and predicts the location of abnormalities.

■ **Package Contents**

- **GX Works3 control program for the MELSEC iQ-R series**
- **GT Works3 screen data for the GOT2000 series**
- **Instruction manual (PDF)**

This product consists of the software package and its documentation. Separate hardware and engineering software packages are also required.
For more details, please refer to individual product catalogs [L(NA)16056].

Catalog

FA Application Package
iQ Monozukuri Rotary Machine Vibration Diagnosis
L(NA)16056

e-F@ctory Support Module

e-F@ctory Support Module

The e-F@ctory Support Module is a sample project for MELSEC iQ-R/iQ-F Series PLCs and GOT2000 Series HMIs. Because programs for visualization, easy analysis, and other functions are provided in a sample project format,implementing IoT at the production shop floor level can be accomplished using only basic configurations such as device allocation and parameter settings.
The e-F@ctory Support Module provides effective solutions for issues that may be encountered when adopting an IoT system such as examination time and budget limitations.

- **GX Works3 sample project for MELSEC iQ-R/iQ-F Series**
- **GX Works3 sample project for GOT2000 Series**
- **Instruction manual**

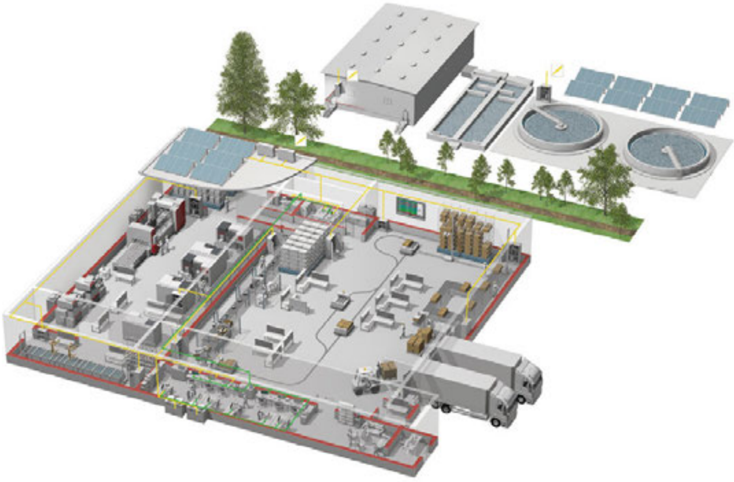
Catalog

Mitsubishi Electric e-F@ctory Support Module
E001JPN

Explanation of Terminology

Feature value (machining load, etc.)	Values converted to a single piece of data including the maximum/minimum/mean values, expressing the shape of waveform after extracting the waveform specific to the machining portion from spindle torque data, etc. (data cleansing *P10)
Workload amount	Integrated value of torque from motor collected for entire machining time by a certain frequency.
Machining conditions	This package collects program numbers and tool numbers as machining conditions. Actual analysis target data includes the following elements contained in programs: used tool, spindle RPM, feed rate, coordinates (cutting depth), machined material conditions of the command value.
TBM	TBM(Time Based Maintenance)means to perform periodic maintenance. For the purposes of this document, this refers to changing the tool periodically.
CBM	CBM (Condition Based Maintenance)means to perform maintenance according to condition. For the purposes of this document, this refers to changing the tool immediately before the predicted usage limit based on tool wear status.
Breakage detection	Tool breakage detection for drills, taps, reamers, etc. through mounting an inspection sensor on a machine tool.
Tool life	For the purposes of this document, "tool life" refers to the limit that a tool can be used without deviating from the user's quality control values, as well as the limit that a tool can be used according to tool durability. (differs to number of times a tool can be used under the recommended cutting conditions provided by tool manufacturers)
Internal measurement	Measurement of the workpiece using a tool head touch probe while it is inside the machine tool.
Primary processing	The collected data is subjected to processing such as normalization, scale conversion, specified channel deviation, previous value difference, moving average, and channel data combination to make it more suitable for feature value calculation.
Section extraction	Extraction of the data to be subject to diagnosis from the collected data according to the section extraction conditions measured for each model being diagnosed.

YOUR SOLUTION PARTNER



Mitsubishi Electric offers a wide range of automation equipment from PLCs and HMIs to CNC and EDM machines.

A NAME TO TRUST

Since its beginnings in 1870, some 45 companies use the Mitsubishi name, covering a spectrum of finance, commerce and industry.

The Mitsubishi brand name is recognized around the world as a symbol of premium quality.

Mitsubishi Electric Corporation, established in 1921, is active in space development, transportation, semi-conductors, energy systems, communications and information processing, audio visual equipment and home electronics, building and energy management and automation systems, and has 183 factories, laboratories and offices worldwide in over 140 countries.

This is why you can rely on Mitsubishi Electric automation solution - because we know first hand about the need for reliable, efficient, easy-to-use automation and control in our own factories.

As one of the world's leading companies with a global turnover of over 4 trillion Yen (over $40 billion), employing over 146,000 people, Mitsubishi Electric has the resource and the commitment to deliver the ultimate in service and support as well as the best products.

Low voltage: MCCB, MCB, ACB

Medium voltage: VCB, VCC

Power monitoring, energy management

Compact and Modular Controllers

Inverters, Servos and Motors

Visualization: HMIs

Numerical Control (NC)

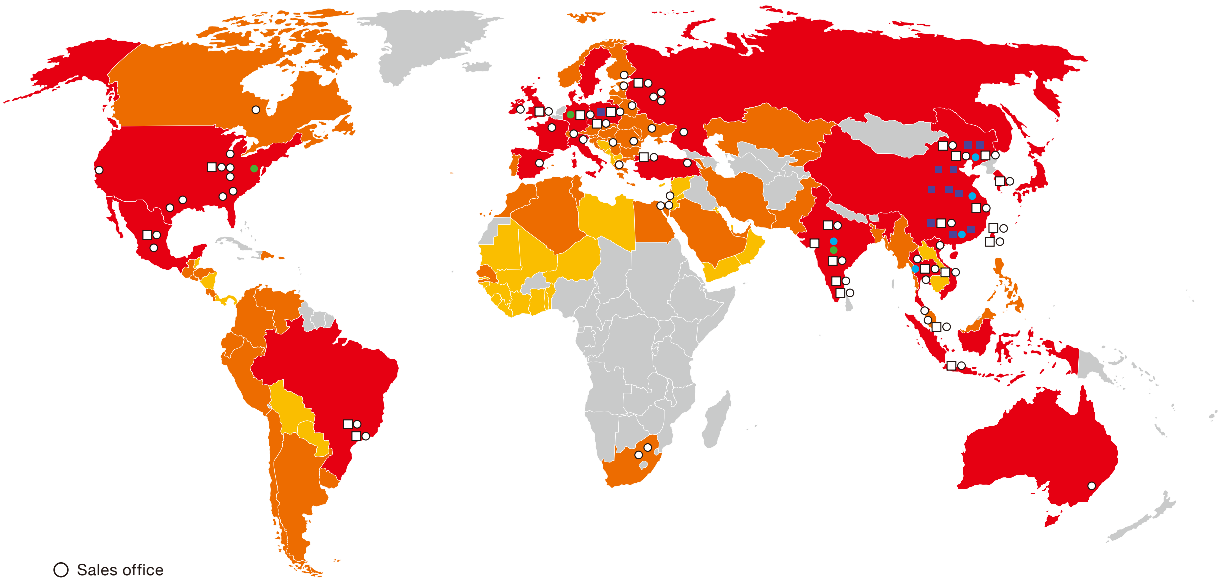
Industrial / Collaborative Robots

Processing machines: EDM, Lasers, IDS

Transformers, Air conditioning, Photovoltaic systems

* Not all products are available in all countries.

Global Partner. Local Friend.



○ Sales office
□ FA center
■ FA center satellite
● Production center
● R&D center

■ Country with a direct Mitsubishi Electric FA office
■ Country covered by distributors with “in-country” offices
■ Country covered by a sales network

Our service and support concept is ingrained in everything we do

Country/ Region	Sales office	Tel/ Fax
USA	USA MITSUBISHI ELECTRIC AUTOMATION, INC. 500 Corporate Woods Parkway, Vernon Hills, IL 60061, U.S.A.	Tel : +1-847-478-2100 Fax : +1-847-478-2253
Mexico	Mexico MITSUBISHI ELECTRIC AUTOMATION, INC. Mexico Branch Mariano Escobedo #69, Col. Zona Industrial, Tlalnepantla Edo, C.P.54030, Mexico	Tel : +52-55-3067-7511
Brazil	Brazil MITSUBISHI ELECTRIC DO BRASIL COMÉRCIO E SERVIÇOS LTDA. Avenida Adelino Cardana, 293, 21 andar, Bethaville, Barueri SP, Brazil	Tel : +55-11-4689-3000 Fax : +55-11-4689-3016
Germany	Germany MITSUBISHI ELECTRIC EUROPE B.V. German Branch Mitsubishi-Electric-Platz 1, 40882 Ratingen, Germany	Tel : +49-2102-486-0 Fax : +49-2102-486-1120
China	China MITSUBISHI ELECTRIC AUTOMATION (CHINA) LTD. No.1386 Hongqiao Road, Mitsubishi Electric Automation Center, Shanghai, China	Tel : +86-21-2322-3030 Fax : +86-21-2322-3000
Taiwan	Taiwan SETSUYO ENTERPRISE CO., LTD. 6F, No.105, Wugong 3rd Road, Wugu District, New Taipei City 24889, Taiwan, R.O.C.	Tel : +886-2-2299-2499 Fax : +886-2-2299-2509
Korea	Korea MITSUBISHI ELECTRIC AUTOMATION KOREA CO., LTD. 7F-9F, Gangseo Hangang Xi-tower A, 401, Yangcheon-ro, Gangseo-Gu, Seoul 157-801, Korea	Tel : +82-2-3660- 9629/9606/9607 Fax : +82-2-3664-0475
Singapore	Singapore MITSUBISHI ELECTRIC ASIA PTE. LTD. 307, Alexandra Road, Mitsubishi Electric Building, Singapore 159943	Tel : +65-6473-2308 Fax : +65-6476-7439
Thailand	Thailand MITSUBISHI ELECTRIC FACTORY AUTOMATION (THAILAND) CO., LTD. 12th Floor, SV.City Building, Office Tower 1, No. 896/19 and 20 Rama 3 Road, Kwaeng Bangpongpang, Khet Yannawa, Bangkok 10120, Thailand	Tel : +66-2682-6522 Fax : +66-2682-6020
Vietnam	Vietnam MITSUBISHI ELECTRIC VIETNAM COMPANY LIMITED Hanoi Branch 6-Floor, Detech Tower, 8 Ton That Thuyet Street, My Dinh 2 Ward, Nam Tu Liem District, Hanoi, Vietnam	Tel : +84-4-3937-8075 Fax : +84-4-3937-8076
Indonesia	Indonesia PT. MITSUBISHI ELECTRIC INDONESIA Gedung Jaya 8th Floor, JL. MH. Thamrin No.12, Jakarta Pusat 10340, Indonesia	Tel : +62-21-3192-6461 Fax : +62-21-3192-3942
India	India MITSUBISHI ELECTRIC INDIA PVT. LTD. Pune Branch Emerald House, EL -3, J Block, M.I.D.C Bhosari, Pune - 411026, Maharashtra, India	Tel : +91-20-2710-2000 Fax : +91-20-2710-2100
Australia	Australia MITSUBISHI ELECTRIC AUSTRALIA PTY. LTD. 348 Victoria Road, P.O. Box 11, Rydalmere, N.S.W 2116, Australia	Tel : +61-2-9684-7777 Fax : +61-2-9684-7245

MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE: TOKYO BLDG., 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN

www.MitsubishiElectric.com

L(NA)16092ENG-A 2106（IP）