EDIM
Edge & Data · Innovate · Manufacture

61.389 ▼ 2%
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71%
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed my.
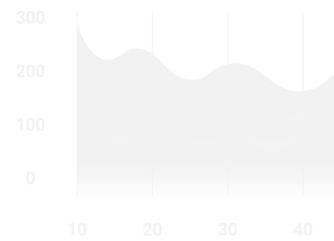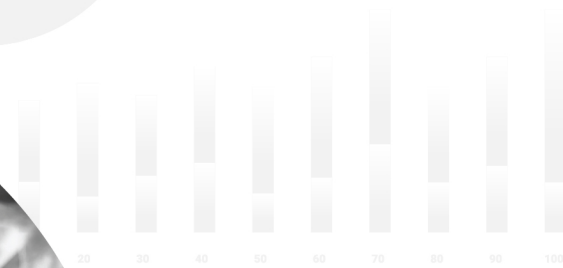
SMART
CUTTING

Smart Cutting System brings RE100 Fast!

Digital Transformation
by Advanced Machining Solutions

Edge Device

Data acquisition from machine tools and sensors by OT and IoT modules
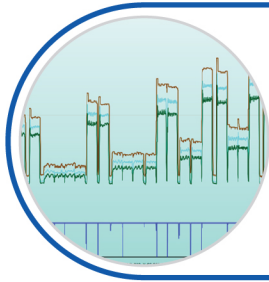
Digital Transformation
Digital Twi

Monitoring Data Acquisition

Create synchronized machine history data
Automatic feedrate control
Tool state detection
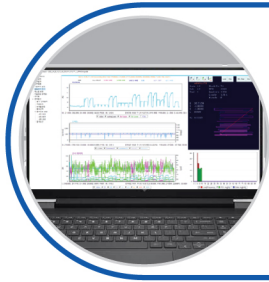
Data Analysis

Analyze machine history data
Diagnosis cutting conditions
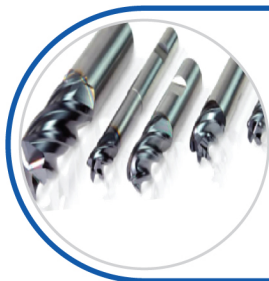Calculate efficient of NC data

Reference Data

Reference load control curve
Automatic feedrate control
Tool wear and breakage detection

On–Machine CNC Control

Feedrate and spindle speed control

Tool Life Management

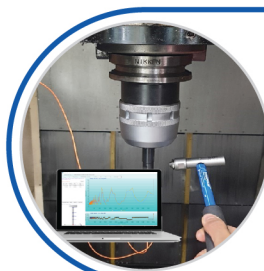Tool wear, breakage and collision design tool geometry

Machine Tool Dynamics

Data Dri

Digita
Plat

Data Analysis

Smart Cutt
brings RE

in CNC Machining
n Platform

ven Learning

Optimization

al Twin
tform

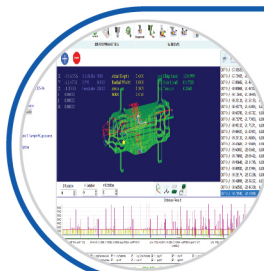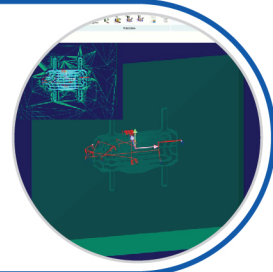**Simulation**

ing System
100 Fast!

Machine Tool Dynamics

Measure and analyze
machine tool dynamics
CutPro Engine

Cutting Simulation

Predict cutting physics
MachPro Engine

Optimization

NC program optimization
MachPro Engine
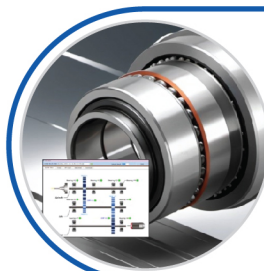
Condition−Based Monitoring System

Analyze defect frequency of the
spindle bearings and gears
predict spindle maintenance

Smart Monitoring

Total management of all
edge device installed in
machine shop.

nine
ory data

Data Learning

ref. Data for Diagnosis & Cont

Data Learning

Increase precision of
control/diagnosis
Optimize parameters
and reference data

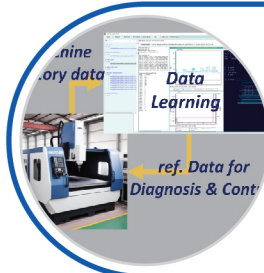# What is Smart Cutting ?

Smart Cutting (SC) supports the advanced digital transformation of CNC machining for the innovative manufacturing. Cutting operations are monitored and controlled during on−machine and post−machining processes. The main areas of SC are as follows.

– Data acquisition from machine tools and sensors by IoT modules
– Analysis by data learning
– Diagnosis abnormal cutting
– Optimizing cutting conditions

SC systems have been successfully adapted to many CNC machining centers, increasing the productivity and quality. The main functions of SC are as follows.

– Tool wear/breakage detection and automatic tool change
– Automatic feedrate control for cutting load optimization
– Automatic spindle speed control for chatter removal
– Supporting data interchange with PoP, MES, and ERP
– Database organization for machining history
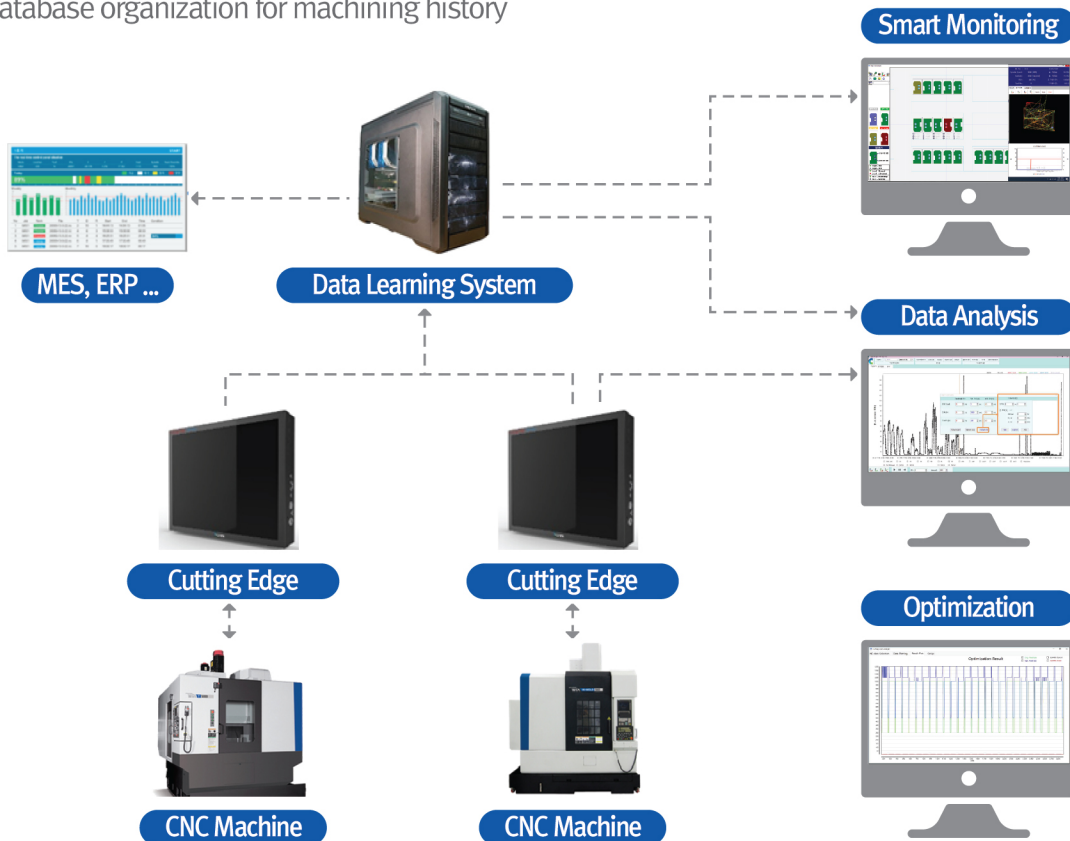
Edge Device

■ Cutting Edge(Advance2/4)
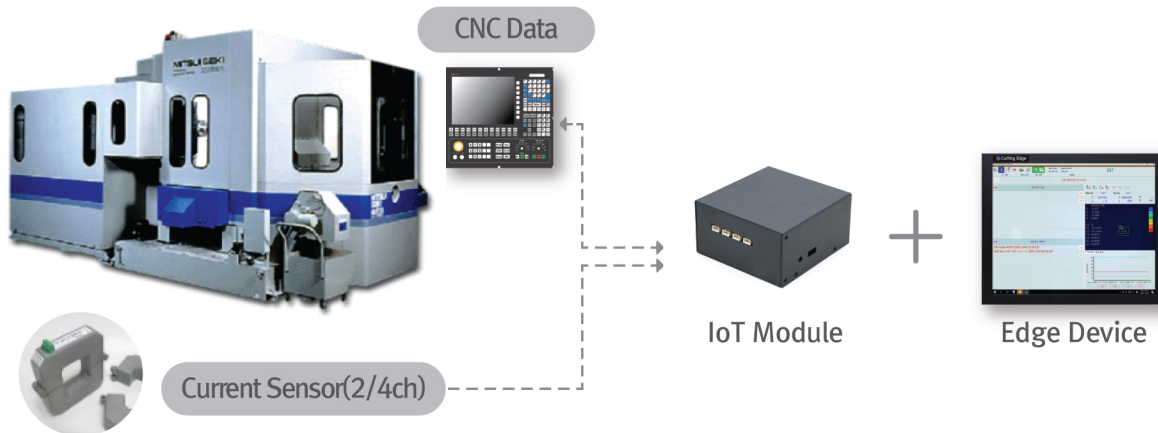
CNC Data

IoT Module

Edge Device

Current Sensor(2/4ch)

- On-maching monitoring and the synchronization of CNC and sensory information
  · cutting load, feed rate, spindle speed, tool position, signal processing data
- Automatic feedrate control: adaptive feed control using the cutting load
- Tool wear and breakage detection

■ Cutting Edge(Premium2/4)
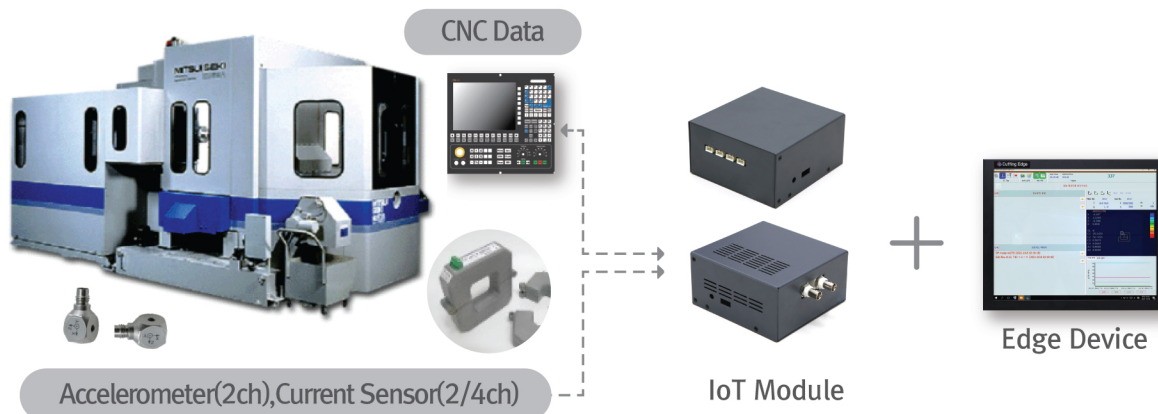
CNC Data

Edge Device

Accelerometer(2ch),Current Sensor(2/4ch)

IoT Module

- On-maching monitoring and the synchronization of CNC and sensory information
  · cutting load, feedrate, spindle speed, tool position, signal processing data
- Automatic feedrate control: adaptive feed control using the cutting load
- Automatic spindle speed control: chatter detection and removal
- Tool wear and breakage detection: available for tiny tools under $1\Phi \sim 0.1\Phi$

Data Learning

■ Usage of RLCC data

– Area (A) → decrease the feed rate → avoid overloading and improve the surface quality
– Area (B) → increase the feed rate → reduce machining time and improve productivity
– Reference load control curve (RLCC) effect: machining time reduced by 11.5%, cutting load reduced by 38.2% with 12.2% improved feed rate
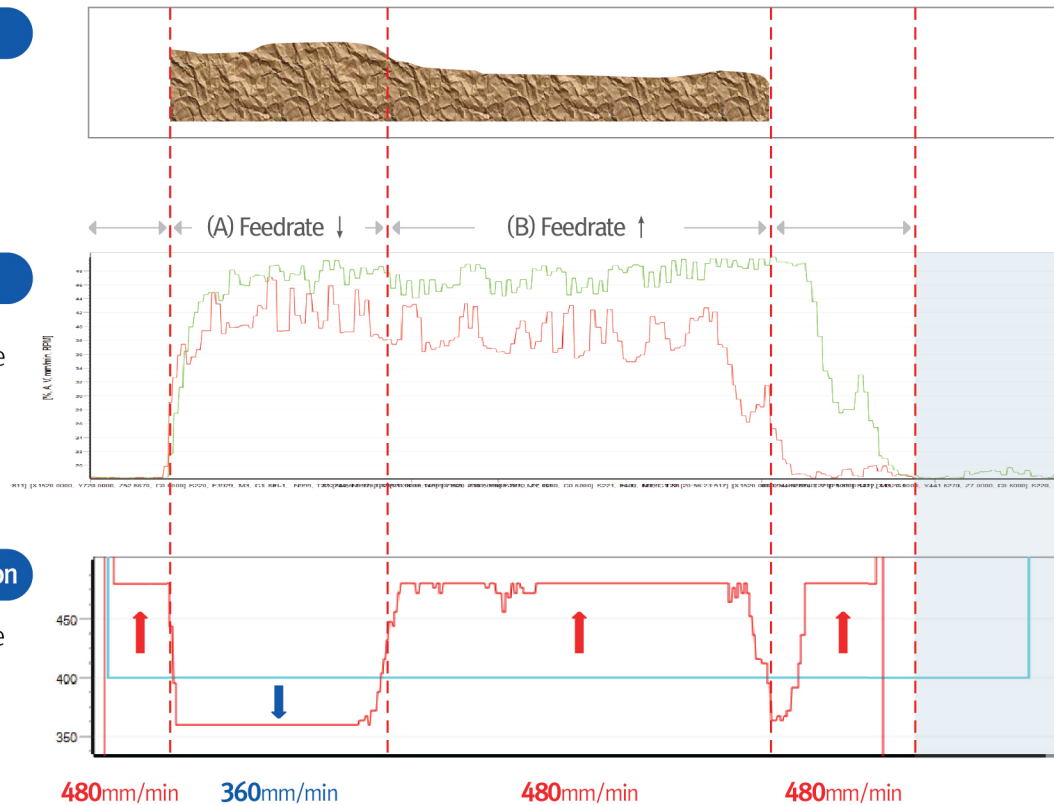
Material

Casting Material
(Irregular Shape)

(A) Feedrate ↓　　(B) Feedrate ↑

Load Comparison

— Org. NC–code
— 3rd RLCC

Feedrate Comparison

— Org. NC–code
— 3rd RLCC

480mm/min　360mm/min　480mm/min　480mm/min

Effect

| Tact Time (time)		Avg. Feedrate (mm/min)		Avg. Cutting Load (A)	
Org. NC–code	19m 45s	Org. NC–code	400	Org. NC–code	29.99
	−1.1% ↓		0.2% ↑		−4.5% ↓
1st RLCC	19m 32s	1st RLCC	400.77	1st RLCC	28.63
	−6.3% ↓		7.2% ↑		−21.2% ↓
2nd RLCC	18m 18s　−11.5%	2nd RLCC	429.66　12.2%	2nd RLCC	22.56　−38.2%
	−4.4% ↓		4.5% ↑		−17.8% ↓
3rd RLCC	17m 30s	3rd RLCC	448.78	3rd RLCC	18.55

■ Feedrate Optimization

· Reference load control curve (RLCC) generation

Step 1. From pre-machining history data

Step 2. Based on the tool trajectory

Step 3. Analyse the pre- and post-machining load

Step 4. Enwrap the attribute data

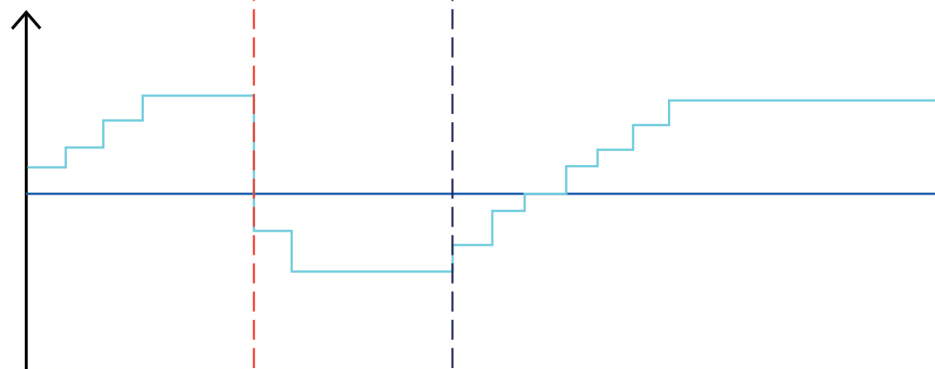Step 5. Control the feed rate to place the cutting load between the upper & lower limit curves

| Cutting Load Monitoring | → | Feedrate ↓ | → | Feedrate ↑ | → | Ideal Cutting Load | → | Productivity ↑ Quality ↑ |
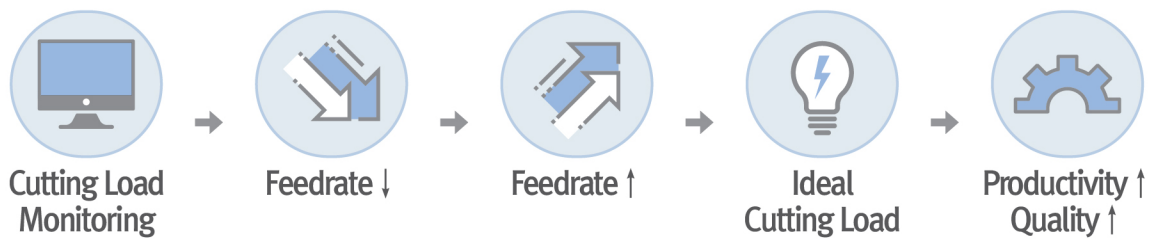
Cutting Load

— Upper Limit
----- Lower Limit
— Actual load
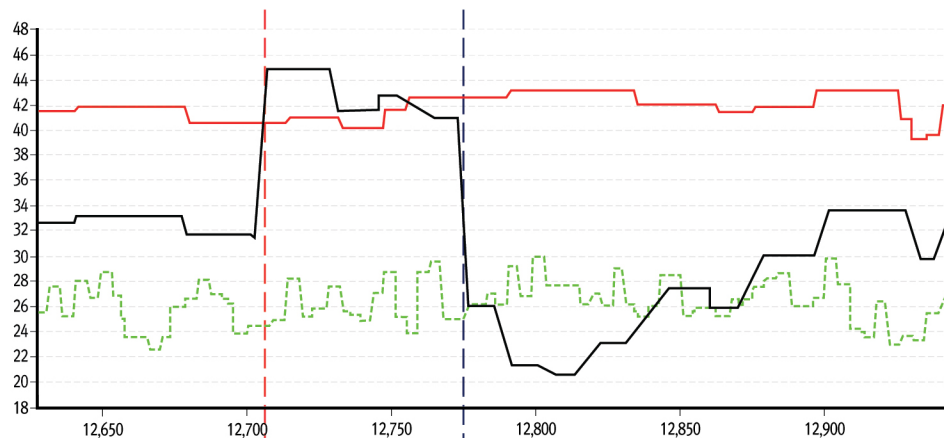
Feedrate

— Command Feed
— Adaptive feed

■ Chatter Detection and Removal

- Tool chatter can be detected by acoustic and vibration sensors during the cutting process, being removed by changing the spindle speed.
- The Edge device with adaptive spindle speed control monitors machine tool vibration and detects tool chatter. If chatter occurs, the Edge device calculates the chatter-free RPM to change the spindle speed. Finally, eliminating chatter improves surface finish.
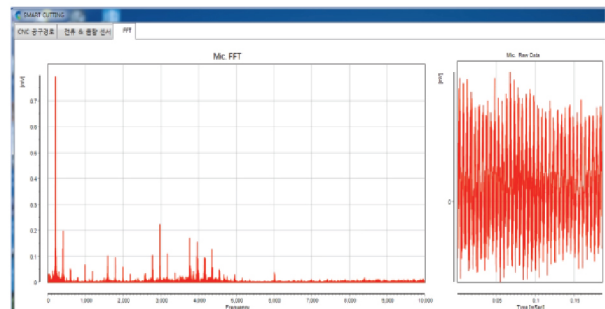
On-Machine Diagnosis → Detect Chatter → Find Chatter Free New-RPM → Adopt New-RPM & Remove Chatter → Productivity ↑ Quality ↓

| Unstable Cutting	Stable Cutting
Chatter	**No Chatter**
6,000 RPM	5,936 RPM

Unstable Cutting
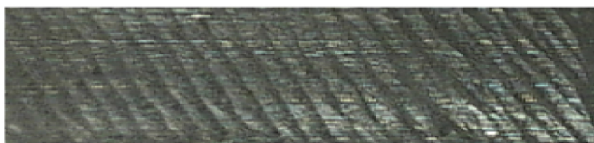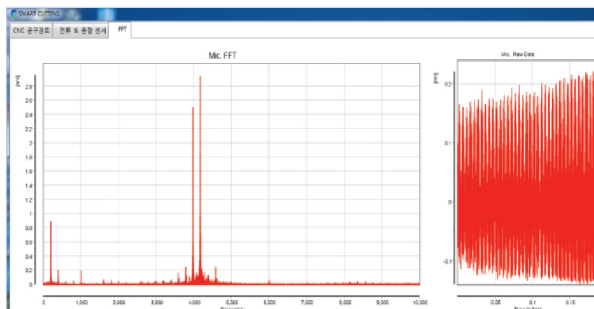
Stable Cutting
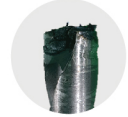
■ Tool Breakage Detection

- In mass production or small batch production, the cutting load shows almost the same pattern. The Edge device identifies the cutting load pattern and alarms if the cutting load deviates from the normal pattern.
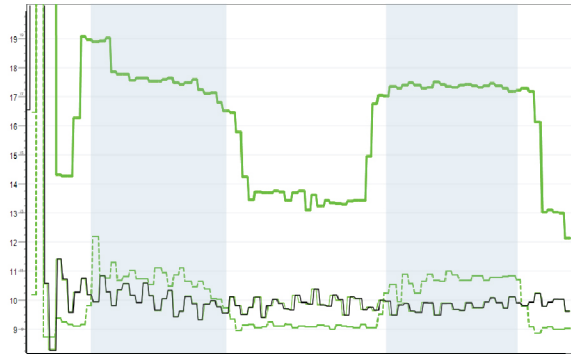
Cutting load of normal tool

cutting load pattern of normal tool
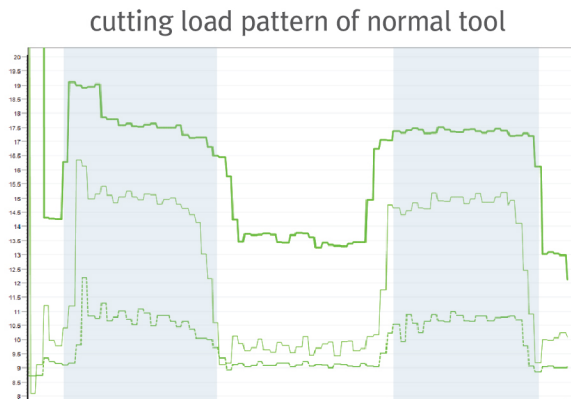
—— cutting load   —— upper limit   ---- lower limit

Abnormal cutting load when tool is broken
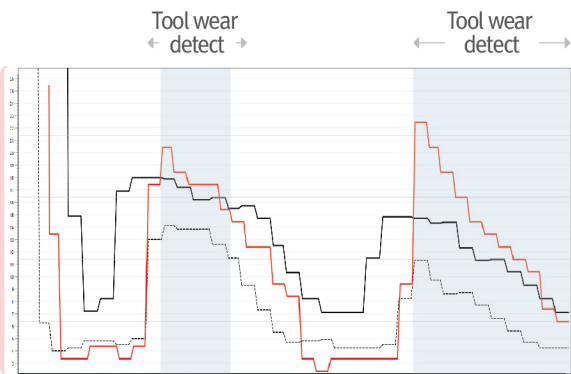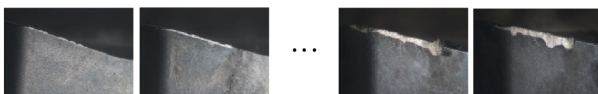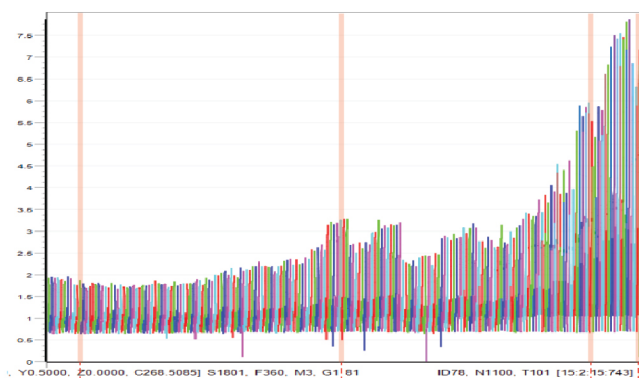
cutting load pattern of broken tool

—— cutting load   —— upper limit   ---- lower limit

■ Tool Wear Diagnosis

- The tool breakage detection process is used to detect tool wear.
- Long–term patterns and the full range of cutting loads can be analysed.
- The Edge device monitors tool life, alarming tool change time.

Cutting load pattern as to tool wear

Tool wear ← detect →   Tool wear ← detect →

—— cutting load of worn Tool   —— upper limit   ---- lower limit

■ Tiny-tool Breakage Detection

- The breakage of tiny tool under 1Φ can be detected by the vibration sensor. Threshold level is calculated after signal processing. When tool breakage is detected, the feed hold function is working and current tool position is stored for re-engagement.
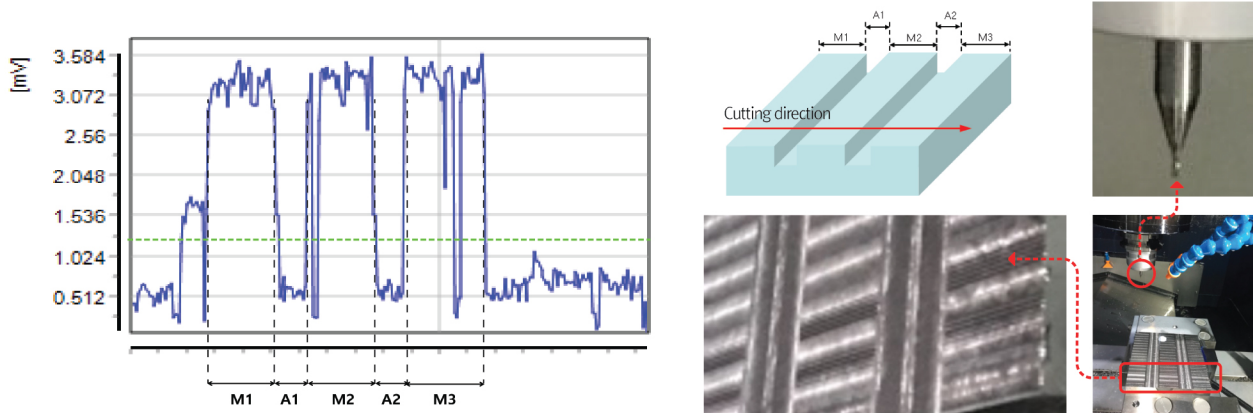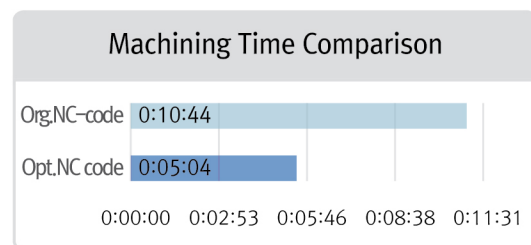

■ NC-code Optimization

- Machining History (MH) data stored in the Edge device is used to optimise the NC code. Edge data includes cutting load and tool vibration information according to the tool path. NC codes are optimised by comparing the MH data with the original NC block data.
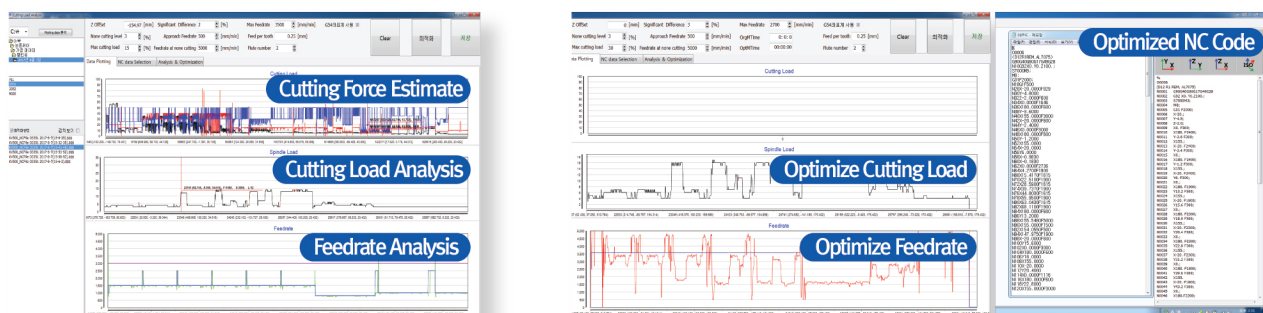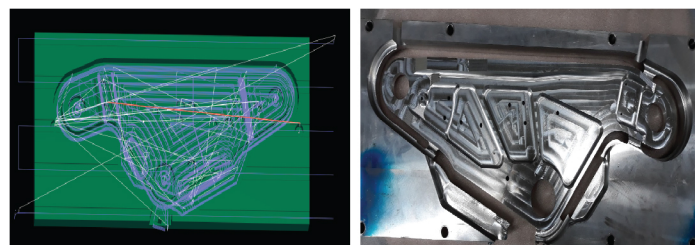

Machining history analysis

NC code optimization

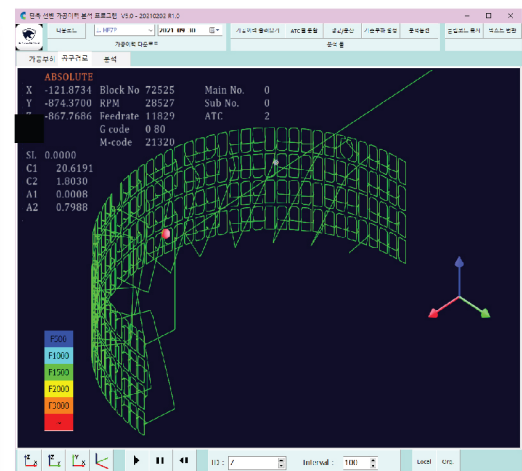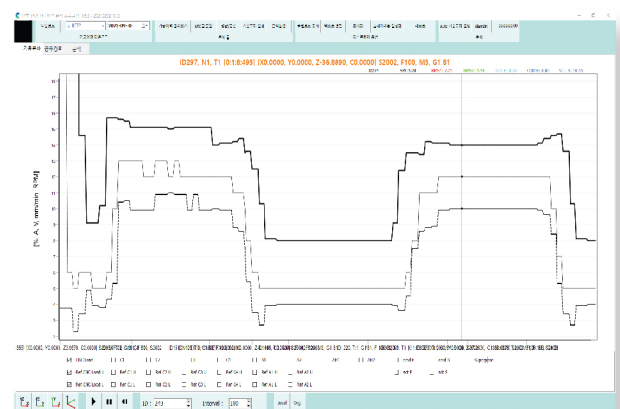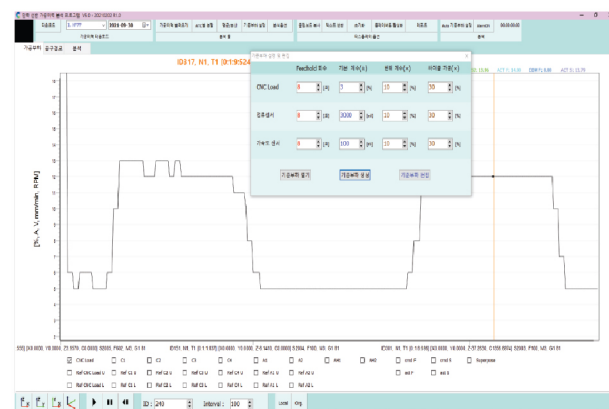

Reduction machining time

Cutting application

■ MH Data Analysis

– Verify the cutting condition

– Identify cutting loads from tool wear

– Conduct tool life management

– Optimise the NC code

– Create reference load control curves (RLCCs) for adaptive control

– and more: statistical analysis, check the whole machining condition and error factors

MH Data Analysis

RLCC Generation

■ Spindle Monitoring

- A predictive maintenance function of the Edge device monitors the spindle by analysing the defect frequency of the spindle bearings and gears.
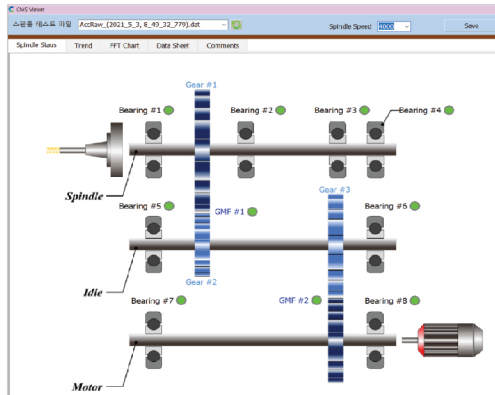
Spindle Model

Defect Frequency Analysis
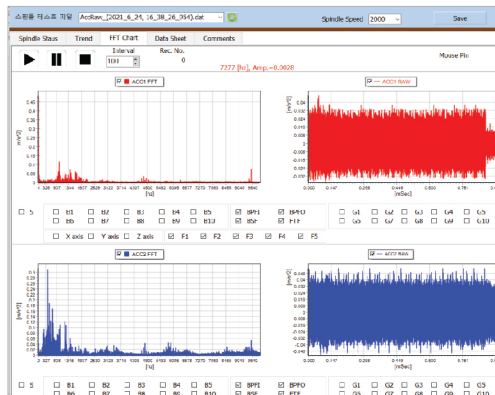
Acquisition Raw Data

Spindle Diagnosis Result

■ Machining Floor Monitoring

- Individual Edge device for a product line sends online data to a data server, providing information for the digital twin of CNC machining floors, such as simultaneous monitoring of machine tool status and machining information.

Tool Path Display

Machine Status & History

Machine Event & Massage
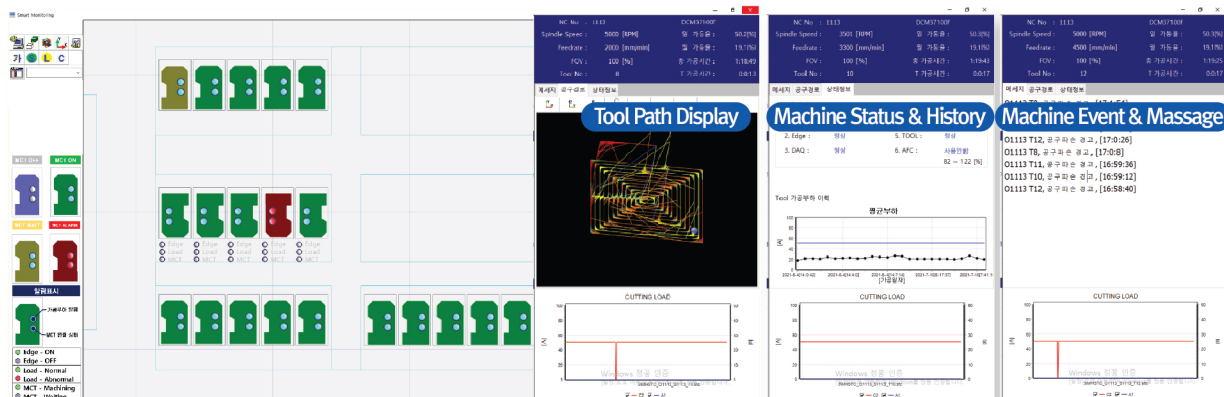
Digital Twin Platform

■ **Provide application based on smart cutting data and digital twin**

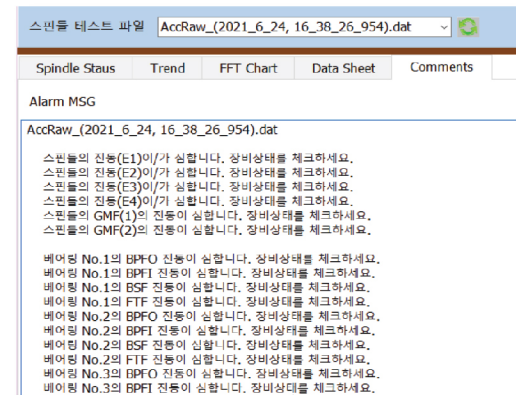| Function	Effect
Machine history data analysis linked to smart cutting	Improve the machining by analyzing data
Analysis of machine tool dynamics	Optimized cutting conditions
Data learning	Improve the reference data and parameters
Cutting simulation	Predict cutting physics
Optimization	Optimized NC program

Data Analysis

Optimization

Digital Twin Platform

Data Driven Learning

Data Simulation

Machine Tool Dynamics
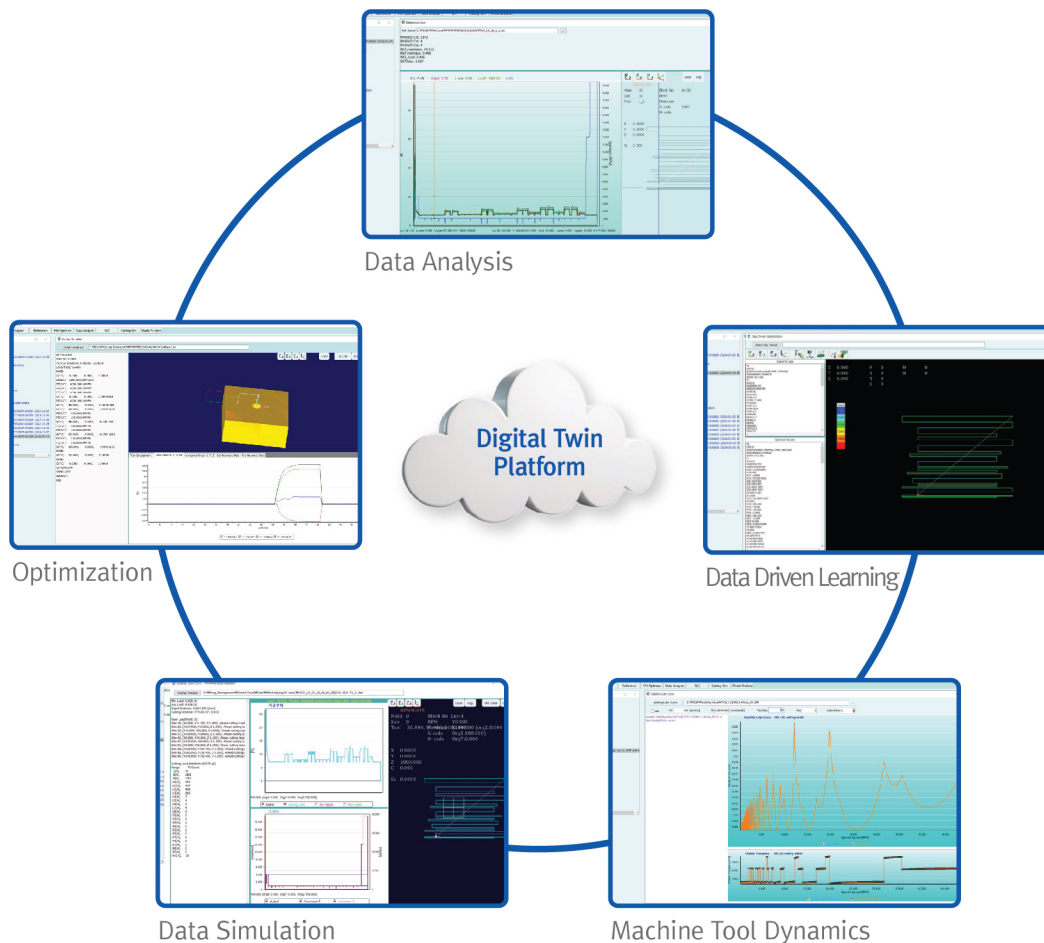
Product Line

■ Cutting Edge

Functions	Cutting Edge Advance2	Cutting Edge Advance4	Cutting Edge Premium2	Cutting Edge Premium4
Real time monitoring	●	●	●	●
Multi-spindle monitoring		●		●
Adaptive feed control	●	●	●	●
Chatter detection and removal			●	●
Tool breakage detection	●	●	●	●
Tool wear detection by learning	●	●	●	●
Tiny-tool breakage detection			●	●
IoT module	ADC(1)	ADC(1)	ADC(1), DAQ(1)	ADC(1), DAQ(1)
IoT sensor	current sensor(2 ch)	current sensor(4 ch)	current sensor(2 ch) accelerometer(2 ch)	current sensor(4 ch) accelerometer(2 ch)

■ Software

Functions	Learning System		Data-Based Module		
	Lite	Premium	Optimization	Data Analysis /RLCC	Smart Monitoring
PoP	●	●			
Edge management	●	●			
Process monitoring	●	●			●
NC-code optimization			●		
MH analysis/ RLCC data generation		●		●	
Spindle analysis		●			
Learning of RLCCs		●			

Clients

LG 전자	DN SOLUTIONS	KORLOY
MOTTROL	ILJIN	SUNGRIM ENGINEERING
HYUN JIN 주식회사 현진정공	PHC Valeo 브이피에이치메탈	B K
K2tech 케이투테크	iDG 주식회사아이지	(주)우남기공 WOONAMGIGONG CO .,LTD
GSM Global Standard Make	한국폴리텍대학 전북캠퍼스	SMIC
KERI	KITECH 한국생산기술연구원	
LG 전자 LG ELECTRONICS TIANJIN APPLIANCES.CO.LTD	MAL. anufacturing Laboratories	seioTec digital change
Fraunhofer IWU		

EDIM

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"Innovative Manufacturing with Edge Data"