

F - RPN(Failure - RPN)

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A Study on Machine Failure Improvement Using F - RPN(Failure - RPN): Focusing on the Semiconductor Etching Process

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Abstract

The purpose of this study is to present a novel indicator for analyzing machine failure based on its idle time and productivity. Existing machine repair plan was limited to machine experts from its manufacturing industries. This study evaluates the repair status of machines and extracts machines that need improvement. In this study, F - RPN was calculated using the etching process data provided by the 2018 PHM Data Challenge. Each S(S: Severity), O(O: Occurrence), D(D: Detection) is divided into the idle time of the machine, the number of fault data, and the failure rate, respectively. The repair status of machine is quantified through the F - RPN calculated by multiplying S, O, and D. This study conducts a case study of machine in a semiconductor etching process. The process capability index has the disadvantage of not being able to divide the values outside the range. The performance of this index declines when the manufacturing process is under control, hereby introducing F - RPN to evaluate machine status that are difficult to distinguish by process capability index.

Keywords : F - RPN, Repair Status of Machine, Process Capability Index

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F - RPN

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F - RPN

[4].

가

. RPN

USL,

LSL,

F - RPN S, O, D

σ

<Table 1 >

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<Table 1> Process Capability Index

Condition	Formula
Only upper standard limit	$\frac{USL - Mean}{3\sigma}$
Only lower standard limit	$\frac{Mean - LSL}{3\sigma}$
Both upper, lower standard limit	$\frac{USL - LSL}{6\sigma}$

2.

2.1 (Etching)

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<Table 2 >

<Table 2> Evaluation for PCI[5]

C_p	Stage	Evaluation
$C_p \geq 1.67$	Level 0	Very Sufficient
$1.67 > C_p \geq 1.33$	Level 1	Sufficient
$1.33 > C_p \geq 1.0$	Level 2	Suitable
$1.0 > C_p \geq 0.67$	Level 3	Poor
$0.67 > C_p$	Level 4	Very Poor

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[1].

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[2].

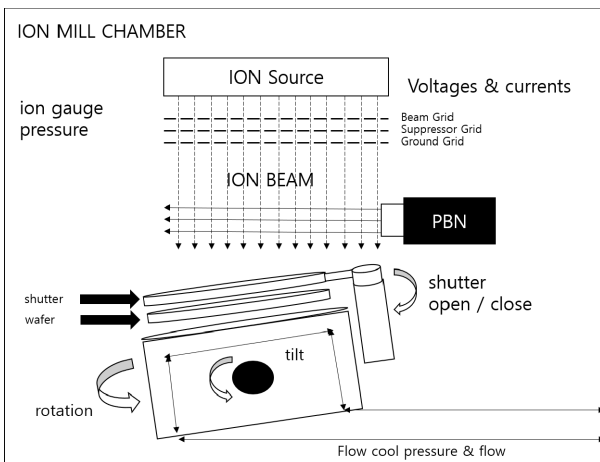
Ion Mill Etching

[Figure 1]

[3].

F - RPN

F - RPN



[Figure 1] Process of Ion Mill Etching

2.2

(Process Capability Index, PCI)

가

USL, LSL, σ

2.3 RPN(Risk Priority Number)

RPN

가

. RPN

(Severity: S),

(Occurrence:

O),

(Detection: D)

가

[6]. RPN

10

RPN

가

<Table 3 >

[7]. RPN 가

가

RPN 가

가

[8].

S, O, D

가

가

S, O, D

/ / 가

가

<Table 3> Conditions of High Risk

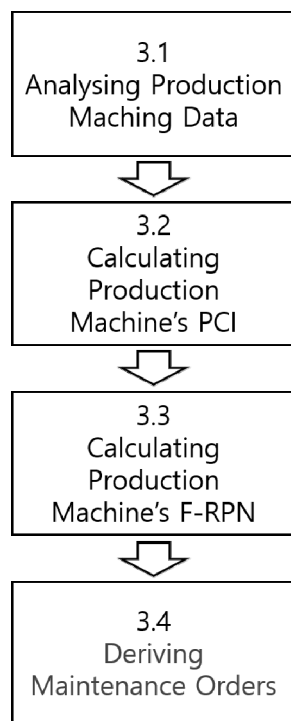
Conditions	Judgment Criteria
Condition1	$S \geq 8$
Condition2	$O \geq 8$
Condition3	$D \geq 8$
Condition4	$RPN \geq 100$

3.

F - RPN

[Figure 2]

4



[Figure 2] Process of Methodology

3.1

F - RPN 가
 2018 PHM Data Challenge
 [9]. 10
 20

(Flowcool Pressure Dropped Below Limit, Flowcool Pressure Too High Check Flowcool Pump, Flowcool leak) 3가

<Table 4>

<Table 4> Count for Each Type of Fault

Type of Fault	Count
Flowcool Pressure Dropped Below Limit	328
Flowcool Pressure Too High Check Flowcool Pump	128
Flowcool Leak	66

3.2

F - RPN

F - RPN

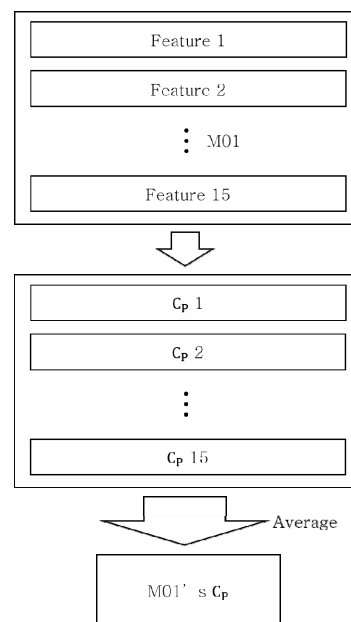
가

가

USL LSL

<Table 1>

[Figure 3]



[Figure 3] Process for Calculating PCI

3.3 F - RPN

[10].
F - RPN 가

RPN 가 F - RPN 가 F - RPN
F - RPN S, O, D

<Table 5>

<Table 5> Definition of S, O, D Index

	S	O	D
RPN	Severity	Occurence	Detection
F - RPN	Idle Time	Fault Data	Failure Rate

4.

4.1

<Table 5> F - RPN 가 F - RPN
S ()

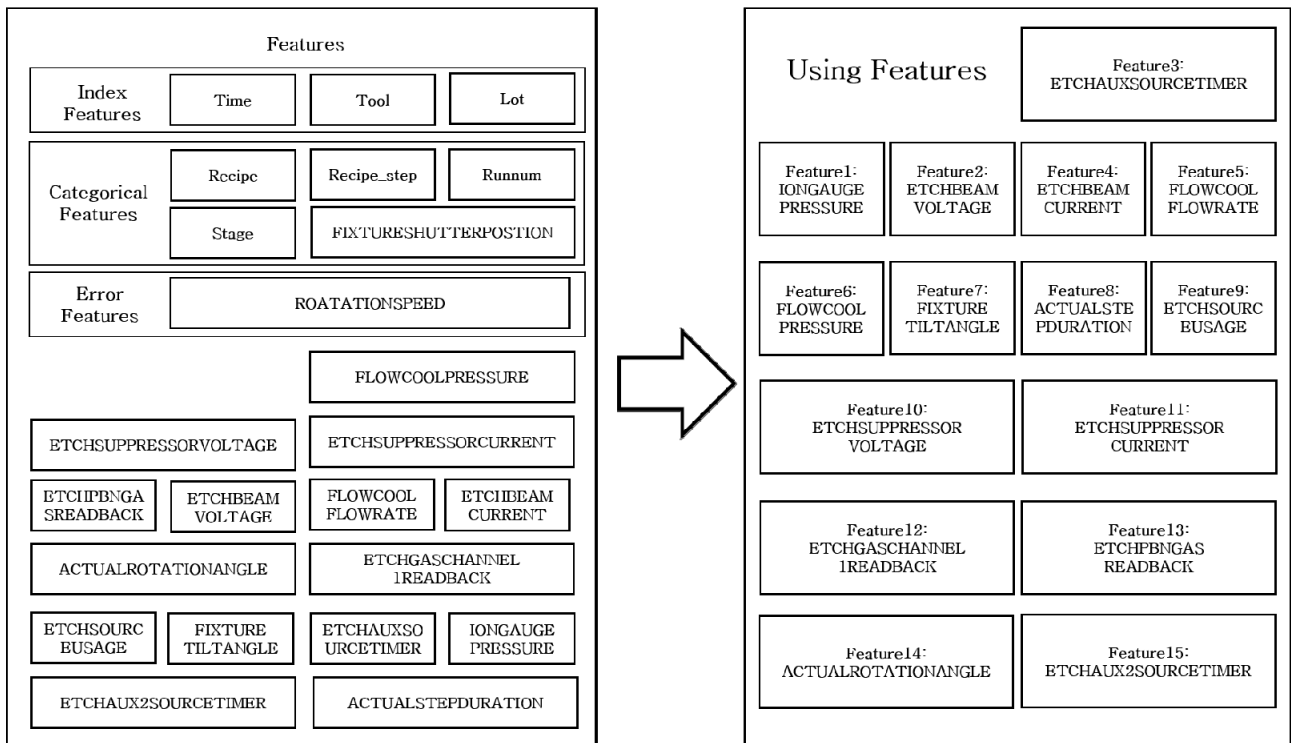
. O , D F - RPN
10 , F - RPN

F - RPN 가 (Stage, Runnum, Recipe, Recipe_step, FIXTURESHUTTERPOST ION)
S, O, D , (Time, Tool, Lot)

3.4

가 ROTATIONSPEED 가
F - RPN Cp . 15

F - RPN F - RPN 가
가 [Figure 4]



[Figure 4] Feature Extraction for the Experiment

4.2

3.2

M05 Feature 1([Figure 4])
 USL, LSL, Sigma 21.87,
 -1.91, 1.02 Feature 1
 3.89

$$\frac{USL - LSL}{6\sigma} = \frac{21.87 - (-1.78)}{6 * 1.02} \quad (1)$$

15 Feature([Figure 4])

2.6464
 <Table 6>

<Table 6> Result of Machine's Cp

Machine	Cp
M01	2.6360
M02	2.4370
M03	2.6908
M04	2.4959
M05	2.6464
M06	2.6478
M07	2.5099
M08	2.3705
M09	2.4090
M10	2.7511

4.3

F - RPN

3.3 S, O, D

()
 Algorithm 1
 가가
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Algorithm 1 : Idle Time Calculation

Input: FD: Fault Data of each Machine
 TD: Total Data of each Machine
Output: IT: Idle Time(sec)

Procedure:

- for time in range(FD):
- 1. tmp1=first TD[time] over FD[time]
- 2. tmp2=TD[time] previous tmp
- 3. IT = tmp1 - tmp2

() 10
 S ,
 () S
 O D , 10
 F - RPN
 S, O, D M05 ,
 F - RPN [Figure 5]
 () 1,472,016 , 7
 O D 가 2
 , F - RPN 28
 10 S, O, D F - RPN <Table 7>

Rank	Severity(S)	Occurrence(O)	Detection(D) (X10 ⁻¹²)
	Score Range	Score Range	Score Range
1	0 ≤ X ≤ 230571.8	0 ≤ X ≤ 23.4	0 ≤ X ≤ 3351145
2	230571.8 ≤ X ≤ 461143.6	23.4 ≤ X ≤ 47.8	3351145 ≤ X ≤ 6702290
3	461143.6 ≤ X ≤ 691715.4	47.8 ≤ X ≤ 52.2	6702290 ≤ X ≤ 10053434
4	691715.4 ≤ X ≤ 922287.2	52.2 ≤ X ≤ 66.6	10053434 ≤ X ≤ 13404579
5	922287.2 ≤ X ≤ 1152859	66.6 ≤ X ≤ 81	13404579 ≤ X ≤ 16755724
6	1152859 ≤ X ≤ 1383431	81 ≤ X ≤ 95.4	16755724 ≤ X ≤ 20106869
7	1383431 ≤ X ≤ 1614003	95.4 ≤ X ≤ 109.8	20106869 ≤ X ≤ 23458013
8	1614003 ≤ X ≤ 1844574	109.8 ≤ X ≤ 124.2	23458013 ≤ X ≤ 26809158
9	1844574 ≤ X ≤ 2075146	124.2 ≤ X ≤ 138.6	26809158 ≤ X ≤ 30160303
10	2075146 ≤ X ≤ 2305718	138.6 ≤ X ≤ 153	30160303 ≤ X ≤ 33511448

[Figure 5] Process of Calculating F - RPN

<Table 7> Result of Machine's F - RPN

	S	O	D	F - RPN
M01	1	1	6	6
M02	2	1	2	4
M03	5	6	9	270
M04	1	1	1	1
M05	7	2	2	28
M06	2	1	2	4
M07	3	2	2	12
M08	10	8	10	800
M09	9	10	10	900
M10	1	2	4	8

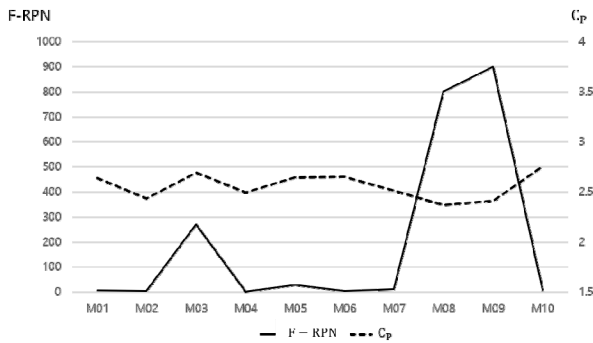
4.4

F - RPN Cp <Table 8>

[Figure 6] C_p M01~M10
 (C_p 가 1.67, <Table 2>
) F - RPN M03, M08, M09
 F - RPN 3.4
 F - RPN M03, M08, M09

<Table 8> Rank for Machine's C_p and F - RPN

Machine	C_p	F - RPN
M01	2.6360	6
M02	2.4370	4
M03	2.6908	270
M04	2.4959	1
M05	2.6464	28
M06	2.6478	4
M07	2.5099	12
M08	2.3705	800
M09	2.4090	900
M10	2.7511	8



[Figure 6] Correlation of F - RPN and C_p

5.

F - RPN
 F - RPN
 8
 2018 PHM Data Challenge

() S
 () 가가
 . O D
 RPN
 S, O, D
 RPN 10
 F - RPN
 RPN
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 F - RPN
 (M01~M10)
 가
 1.67 가
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 F - RPN M03,
 M08, M09 100
 가
 F - RPN
 가 10
 Case Study
 F - RPN
 F - RPN
 Trade - off
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