Improving Quality and Factory Performance with Real data

2015 Oracle OpenWorld

2015. 10. 27

Daejung (Joseph) Ahn

Samsung SDS
I. Issues of Manufacturing field
II. Directions for Future Factory
III. Review useful Practices
IV. Opinion for Success
1.1 Factory says a lot through data

**Increasing importance of data analytics** to maintain maximum equipment performance and product quality

---

**Processing Steps & TAT**

- **Total TAT**
- **# of Total Step (Main Step)**

- **20nm Process (2014~)**
  - Lot: 4,000 (600)
  - Shot: 25,000
  - Chip: 10,000
  - Wafer: 300

- **35nm Process (~2013)**
  - Lot: 2,000 (400)
  - Shot: 400

- **2x**

---

**Machine Data Utilization Status**

- **Current Manufacturing Data**
  - Million times

- **Photo Machine**
  - Available in Database
  - 65.8%

- **Vanishing Data**
  - 34.2%

---

※ TAT: Turnaround Time

※ Semiconductor, Display company case
1.2 What is required capabilities?

For general company, Equipment data summary and analysis capabilities are needed in order to control their production process in stable condition.

---

**Data-driven manufacturing capability**

- **Top-tier company:** 3.6
- **General company:** 2.6

- Energy device company case

---

**Gaps between Top to General**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Top-tier</th>
<th>General</th>
<th>GAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine data collection</td>
<td>3.8</td>
<td>1.9</td>
<td>-1.9</td>
</tr>
<tr>
<td>Data gathering and store</td>
<td>3.5</td>
<td>2.1</td>
<td>-1.4</td>
</tr>
<tr>
<td>Data Search</td>
<td>4.0</td>
<td>1.8</td>
<td>-2.2</td>
</tr>
<tr>
<td>Virtual item data</td>
<td>3.5</td>
<td>2.0</td>
<td>-1.0</td>
</tr>
<tr>
<td>Data summary</td>
<td>4.0</td>
<td>1.8</td>
<td>-2.2</td>
</tr>
<tr>
<td>Anomaly detection</td>
<td>4.0</td>
<td>2.4</td>
<td>-1.6</td>
</tr>
<tr>
<td>Machine sensor monitoring</td>
<td>4.0</td>
<td>1.8</td>
<td>-2.2</td>
</tr>
<tr>
<td>Automatic yield/defect monitoring</td>
<td>4.0</td>
<td>3.0</td>
<td>-1.0</td>
</tr>
<tr>
<td>Root cause analysis of anomaly</td>
<td>3.3</td>
<td>2.5</td>
<td>-0.8</td>
</tr>
<tr>
<td>Analysis of the cause of anomaly</td>
<td>3.0</td>
<td>3.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Analysis of Machine maintenance</td>
<td>4.0</td>
<td>2.0</td>
<td>-2.0</td>
</tr>
<tr>
<td>Facilities abnormal pre-analysis</td>
<td>3.0</td>
<td>2.5</td>
<td>-0.5</td>
</tr>
<tr>
<td>Machine master data</td>
<td>3.3</td>
<td>3.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Machine code standardization</td>
<td>3.0</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Sensor code standardization</td>
<td>3.0</td>
<td>3.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Sensor Limit line selection</td>
<td>4.0</td>
<td>3.5</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

※ Some items are omitted

---

**What are you making an effort for improving quality and performance of manufacturing?**
“intelligent manufacturing” is the keyword for next generation factory to improve performance and quality through Mobility, Analytics, IoT.

2.1 Directions for Future Factory

**System Based Manufacturing**

- **Operator Dependency**
- **Full-automated Production**
- **Yield & Effectiveness**

- **Production automation**
  - Machine On-line
  - Semi automated Operation

- **Material Handling automation**
  - Auto Scheduling & Dispatching

- **Quality Analysis automation**
  - Anomaly Detection & Failure Analysis
  - Feed-Back/Forward Control

※ Semiconductor → Display → PCB, Battery, Mobile Assembly, etc

2014~

**“intelligent Manufacturing”**

- Smart machine care (Real-time Analytics)
- Big data analytics for unknown yield loss
- Real-time detection & corrective action
- Unmanned surveillance for safe factory

‘1990~2013

- Mobile Surveillance for safe factory
- Big data analytics for unknown yield loss
### Our questions for innovation

<table>
<thead>
<tr>
<th>Equipment Performance</th>
<th>Product Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>① Can you detect abnormal condition of machine in real time using all machine data, e.g., sensor, transaction, event data, and so on?</td>
<td>① Is there an alternative to identify root causes of chronic and unknown defects, not able to solve with conventional statistical approaches?</td>
</tr>
<tr>
<td>② How to maintain optimal condition of machine considering its health condition, not only a number of usage?</td>
<td>② What is the way of dealing with manufacturing big data, such as all factory data during a long time, e.g., for one year?</td>
</tr>
</tbody>
</table>
3.1.1 Intelligent Machine Care - Furnace, Coating Machine

for Equipment Performance

- Data driven machine control using a single EQP health index
  - Optimize machine condition with health diagnosis and maintenance

Data Collection > Monitoring > Anomaly Detection > Analysis > PM Recommend

How Resolved

- **Data Collection and Real-time Monitoring:** Machine anomaly is detected through real-time sensor data collection, data pre-processing

- **Machine Health Diagnosis:** The condition of machine is diagnosed by a health index. Once machine anomaly is detected, root cause investigation takes place immediately

- **Preventive Maintenance Prediction:** The aging level of each module is quantified to predict the best timing for preventive maintenance

- **A Single Intelligent Device, Anytime, Anywhere:** Data collection, anomaly detection and machine diagnosis are all available from a single device. You can also check the condition of machines anytime, anywhere from your mobile device

※MLCC: Multi Layer Ceramic Condenser, TBM: Time based Maintenance
Cluster has been classified by the sensor patterns and the cluster with high failure rate products can be identified.
3.1.3 Pump Breakdown Prediction – Diffusion Pump

**Problem Features**

- Irregular lifespan of pump (1 ~ N months)
- Working under abnormal condition (Limitations of cognitive against pipe blockage)

**Breakdown Prediction Results**

- Two-step detection procedure: Detect abnormal conditions → Detect breakdown signs → Predict breakdown point 13 days before failure with prediction accuracy 80%

**Increase breakdown preventions with productivity & quality risk indicators**

→ Failure feature extraction and abnormal condition detection
### Explain chronic failure root causes with high accuracy
- Micro sensor pattern differences against time series of sensor data

#### Problem Features

<table>
<thead>
<tr>
<th>Semiconductor Low Yield Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display Low Yield Problem</td>
</tr>
</tbody>
</table>

#### Failure root-cause

<table>
<thead>
<tr>
<th>Identified profile pattern difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in torque profile</td>
</tr>
<tr>
<td>between pass and failed products</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pattern comparing with Golden Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Signal</td>
</tr>
<tr>
<td>Difference in temperature profile</td>
</tr>
<tr>
<td>between pass and failed products</td>
</tr>
</tbody>
</table>

Able to increase possibilities of identifying unknown factors to explain chronic failures
3.2.2 Defect Pattern Analysis – Flat Panel Device FAB

for Product Quality

- Increase fault detection analysis coverage from under 50% to more 90%
- Automatic root cause analysis with defect pattern segmentation

**Defect Segmentation**

- Fault Detection
- Fault Type Classification
- Root Cause Analysis

**Unmanned Analytics for Defect Reduction**

- Full-automated Analytics (Accounting for 80%)

**Result I**

- Full-automated Analytics
- Accounting for 80%

**Result II**

- ADC: Automatic Defect Classification, RCA: Root Cause Analysis

**Systematic Analysis**

- Engineer knowledge-based fault classification
- Clustering-based fault classification

**Automated Analysis Reports**

- SUMMARY
- CLUSTER
- Result I
- Result II

※ ADC: Automatic Defect Classification, RCA: Root Cause Analysis
Derive a paradigm shift of fault analysis by micro-specific quality grades

→ Predict defective product trends not only monitoring but optimization
3.3 Big data Analytics Architecture
for Semiconductor, FPD, Energy, Mobile Assembly, Steel industry

- Accelerate big data performance with high-speed parallel and distributed computing technologies

- **Hadoop** enables deployment of big data analytics system at a remarkably low cost.

- **Wide range of statistical functions** based on in-memory parallel computation.

- **Workflow type modeling tool** is utilized to make it easier to build analytical model and share the results.

- User can work interactively with various types of charts in the graphical user interface.

Value

Enjoy an economical, efficient, compatible and scalable option by using analysis functions with large-scale and high-speed parallel and distributed computing technologies based on in-memory.
If you clearly understand your goals and objectives, you can come up with a substantial problem.

In order to solve the problem, outstanding question is required. What are your questions?
Thank you
Joseph Ahn (ahndj@samsung.com)