6 steps to improve paint process quality using environmental data

Human inspection of complex products and manual subjective process changes ultimately leads to high failure rates and millions in revenue losses due to scrap, warranty and liability issues for manufacturers.

The Internet of Things (IoT) and advanced analytics have created opportunities to break through efficiency barriers by discovering insights and optimizations that can improve quality and yield for manufacturers.

A connected IoT solution that optimizes Edge-based analytics with the power of cloud-based advanced computing gives manufacturers the ability to maximize their in-process or real-time quality control (RtQC) by providing the following benefits:

• Actioning perishable data in line with manufacturing process
• Retaining insights from production engineering to optimize in-process manufacturing
• Learning and adapting continuously from product output
• Optimizing for production variance and process drift

Also, the advent of energy-efficient wireless-sensor mesh networks—combined with advances in edge analytics—makes it easier to deploy sensors in a manufacturing environment without the downtime, materials, and labor costs associated with physical cabling. This means manufacturers can get access to data not available before because of the following:

• Reduced wiring costs – in comparison with more established SCADA networks
• New devices are easily accommodated – adding new nodes is a simple admin task
• Physical partitions are rarely an issue – wireless nodes may be deployed to cope with physical partitions.
• Highly Fault Tolerant – mesh networks can still function reliably even if several nodes are unavailable.

Data collected from sensor networks (wireless or otherwise) offers valuable insights into how processes, and even individual assets, are performing.

Detecting external factors that can affect quality in Paint Booths

The following example illustrates how IoT is employed in ALPS Electric Ireland to determine the impact of changes in the external environment to the organization’s quality KPI’s.

[Diagram of monitoring external environmental variables]

Figure 1: Monitoring external environmental variables
6 best-practice steps to plan your quality control implementation (Based on implementation in ALPS Electric Ireland)

1. Develop an hypothesis of how your data can improve quality

The Paint & Lasering (PAL) process in ALPS Electric Ireland takes place in a tightly-controlled environment, yet there was an hypothesis that external environmental factors do have an influence on the process. Variance in temperature can affect the viscosity of certain paints which may cause quality issues if not countered. With this in mind, the team decided to track environmental factors through additional instrumentation. This resulting dataset was overlaid with production information from the ALPS Traceability System to determine if there was a correlation between failures/scrappage and changes in air temperature, pressure or humidity.

2. Identify events/actions influenced by environmental parameters

Temperature & humidity sensors were placed in the main PAL area and temperature, humidity, and pressure sensors were placed in two of the paint booths. The team also deployed temperature and humidity sensors on the roof of the building to track external data and placed two sensor nodes on the Surface Mount Technology (SMT) line.

<table>
<thead>
<tr>
<th>Type</th>
<th>Almost Real Time Structured data (Sent from mesh network)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What</td>
<td>Temperature, Pressure &amp; Humidity readings</td>
</tr>
<tr>
<td>Where</td>
<td>Sensors deployed as part of a wireless mesh network</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structured Dataset (Traceability Database)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events and Actions associated with the movement of each component through its manufacturing process</td>
</tr>
<tr>
<td>ALPS Traceability System (MS SQL Server)</td>
</tr>
</tbody>
</table>

3. Collect environmental data

The environmental sensors were deployed as part of a wireless mesh network. Each wireless node has three external sensors and takes timestamped readings at five-minute intervals. The nodes send these readings to the mesh coordinator, which then publishes them to an MQTT queue on a Dell Edge Gateway 5000. ActionPoint software running on the Dell gateway picks the messages from the queue and stores them in a REDIS in-memory database. In this instance, the sensor mesh network bridge is also an MQTT client; and messages are sent to the MQTT server on the Dell gateway. However it should be noted that the Dell Edge Gateway could equally perform the translation task from an alternative sensor protocol to MQTT if so required.
4 | Query traceability system (data subset)

The Dell gateway contains a second separate service that wakes up every 30 minutes and reads the unprocessed environmental data readings from the REDIS database. It takes the start time and end time from its dataset, applies a five-minute offset, and queries the traceability system for any related events within the time range (excluding those not in scope).

5 | Merge environmental data with traceability logged events

The chance of an environmental reading taking place at the same time as an event being triggered in the traceability system is remote. So, to provide for this, the edge applies the following match rules:

- All events are in scope
- If there is <= 5 second difference, match as an ‘actual’ reading
- If readings exist before and after an event, use linear interpolation to calculate the ‘inferred’ reading and match this to the event

Once environmental readings are matched to traceable events on the edge device, the resulting dataset is posted to an API and persisted in a relational database ready for analytics. The Edge marks environmental readings as ‘processed’ and removes data > 24 hours old from its in-memory REDIS database.

6 | Gain insights and take action

Visual inspection processes—both manual and automatic—are used to determine scrap and rework, and are recorded in the Action Point traceability system as events against which the environmental data is matched. The Statistica dashboard the visualizes this process so the cause and effect can be identified and remedied for subsequent production.
Quality Anomaly Investigation Solutions Example

A brief description of a custom end-to-end solution provided by industry-leading partners Action Point, Dell, and Statistica

At its simplest, this solution takes readings every few minutes and sends them to an MQTT queue hosted on a Dell Edge Gateway 5000. The gateway runs 2 processes; first, it takes the messages from the queue, completes data cleansing and transformation and stores them in a Redis in-memory database for further processing. The second process is triggered on a timer. It takes the readings from Redis and processes them through a rules engine. The rules match all relevant readings with "events" stored in a separate Action Point developed traceability system. Only matched readings are persisted in the private cloud; the rest being discarded to avoid unnecessary network, storage and compute overhead.

Statistica pulls from both datasets in the private cloud and overlays the data to highlight environmental readings during quality-related events (e.g. scan to re-work or scan to scrap). Statistica also provides dashboards relating to efficiencies/throughput of the existing traceability system.

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