Production Monitoring for Performance and Energy Efficiency Improvements

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Outline

Background: Manufacturing Challenges and Concerns

Overview of Production Monitoring and Asset Management Solutions

Energy and Power Modeling Research

Next Steps
Top Manufacturing Challenges

- Lack of collaboration across dept.: 34.2%
- ROI justification for improvement invest.: 25.8%
- Disparate systems & data sources: 25.8%
- Coordinating across supply & demand: 23.9%
- Timely visibility into MFG performance: 19.4%
- Lack of CI culture & processes: 14.2%
- Lack of executive support: 7.7%
- Lack of available talent: 5.8%

LNS Research (2014) “Smart Connected Operations: Capturing the Business Value of the Industrial IoT” (n = 500+)
Cybersecurity Concerns

Figure 2. When Cybersecurity Concerns Delay Digital Initiatives, Growth Potential and Market Position Suffer

Manufacturing
digital use cases

Predictive Maintenance (Analytics)
Quality and Defect Control Automation
Energy Management
Connected Products Maintenance
Assembly Line Changeover
Remote Maintenance
Visual Factory

Time to adoption

If cybersecurity concerns delay digital implementation, it could take up to five years to realize value and catch your competitors.

Adoption lag
1-2 years 2-3 years 3-5 years

Solutions to Improve Equipment Maintenance and/or Performance

CMMS/Asset Management

Bigfoot
emaint
TENNA
Fiiix
asset panda
hippo
UpKeep
Maintenance Connection
eWork Orders

Data Analysis/Modeling Tools

Excel
python
MATLAB
Tableau
Eureqa
ADVIZOR Solutions, Inc.
Trend Miner

Production Monitoring

BLACKBIRD
Fusion Production
MATLAB
SCYTEC
VIMANA
ADVIZOR

IOT Platforms

Predix
SAP HANA
Oracle Cloud
IQMS
ABB Ability
Siemens
AB Mecanica
Honeywell UOP
Bosch
enable OEM partners to communicate with legacy software and systems

use data-driven knowledge to elevate performance

connects your products, plants, systems, and machines

based on open architecture that adheres to multiple communications standards

quickly set up prototype applications

remove the guesswork from production and maintenance planning

can also be used stand-alone on premise

highly scalable cloud services
Engaging Users Across Functions & Web-Based Tool Demo Video

Diaz-Elsayed (2015) “Managing Factory Operations with the Internet of Things” Autodesk University Demo Video: https://www.youtube.com/watch?v=wrKVIMRI0Go
Diaz et al. (2011) “Energy consumption characterization and reduction strategies for milling machine tool use”
Energy Modeling for Varied MRR

\[ E_{\text{const}} = (k \cdot \frac{1}{MRR} + b) \cdot V \]

\[ E_{\text{var}} = N \cdot \Delta t \sum_{i=1}^{N} (k + b \cdot MRR_{\text{avg},i}) \]

\[ E_{\text{part}} = \sum E_{\text{const}} + \sum E_{\text{var}} \]

https://www.youtube.com/watch?v=_UOtoTBpex4
Classification of Machine Tool Modes

![Graph showing classification of machine tool modes. The x-axis represents time in seconds, and the y-axis represents power in watts. Different modes are indicated by different markers: Idle (blue circles), Spindle On (red squares), Moving Axis (green triangles), and Cutting (purple pentagons).]
### Classification of Machine Tool Modes

<table>
<thead>
<tr>
<th>True Class</th>
<th>Cutting</th>
<th>Idle</th>
<th>Moving Axis</th>
<th>Spindle On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Idle</td>
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<td></td>
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<tr>
<td>Moving Axis</td>
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<td>226</td>
<td></td>
</tr>
<tr>
<td>Spindle On</td>
<td></td>
<td></td>
<td></td>
<td>319</td>
</tr>
</tbody>
</table>

**Legend:**
- Cutting Mode
- Idle Mode
- Moving Axis Mode
- Spindle On Mode
Estimating Power Demand

- Used controller and power data (via MTConnect) for slotting operations as training data
- Leveraged supervised machine learning
- 99.2% mean accuracy achieved
Standardizing the Data Analyzed
Standardizing the Data Analyzed

Defining standard part(s) and corresponding tool path(s) to train and test solutions

- Captures varied MRR and features
- Integrates multiple types of cutting tools
- Standard tool path with all machine tool modes
- 3-axis vs. 5-axis machine tool...
Questions?

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