Digital Transformation of Refinery Operations to achieve Top Quartile Performance

Sanjay Thakker
Industry Benchmarks Reveal Significant Business Improvement Opportunities from Average to Top Quartile Performers

Safety

3X fewer recordables and process incidents

Production

20% lower operating costs

10% higher Utilization Rate

Reliability

4% higher availability

Half the maintenance costs

Emissions

30% lower emissions

30% less energy use

Sources: Refining and Petrochemical Benchmarks, API, Solomon, OSHA, IHS Markit and Company Reports
The Next Era of Value Creation Will Be Enabled by Digital Technologies

- Emerson Innovations Will Power Customer’s Strategies Across Essential Competencies

## 5 ESSENTIAL COMPETENCIES OF DIGITAL TRANSFORMATION

- Automated Workflow
- Decision Support
- Workforce Upskilling
- Mobility
- Change Management

- Incremental Continuous Improvement
- Adoption of Best-In-Class Behaviors

- Workforce
- Productivity

- Time
Digital Technologies supporting Operational Excellence Performance

- **Safety**
  - Cybersecurity
  - Location Awareness
  - Procedural Automation
  - Safety Shower
- **Energy & Emissions**
  - Heat Exchanger
  - Cooling Tower
  - EMIS
- **Asset Health**
  - Corrosion Monitoring
  - Leak Detection
  - Procedural Automation
  - Flare Monitoring
  - Steam Traps
- **Reliability**
  - Collaboration Platform
  - Pumps
  - Mobile Worker
  - Electronic Logs
  - Intelligent Calibration
  - Tank Monitoring
  - Advanced Control
  - Digital Twin
- **Production**
  - Machine Learning
  - Blending

Emerson Confidential
Emerson’s Analytics Portfolio

- **Software**
  - AMS Device Manager
  - Insight
  - AMS Machinery Manager
  - Obsidian
  - Energy
  - Performance
  - Application-Specific
  - KnowledgeNet
  - KNet

- **Hardware**
  - Obsidian
  - Deep Domain & Application Expertise
  - Data Science

- **Diagnostics**
  - Smart Devices
  - Embedded Diagnostics
  - Device Alerts

- **Rule-Base Analytics**
  - Logics
  - Algorithms
  - Scenarios

- **First Principle Analytics**
  - Formulaic
  - Thermodynamics
  - Historical Data
  - Known FMEAs

- **Advanced Analytics**
  - Root Cause Analysis
  - Anomaly Detection
  - Machine Learning
  - Unknown FMEAs
  - Cross Correlations

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- **Deep Domain & Application Expertise**
- **Data Science**
Scalable Analytics Portfolio Solves Real-World Problems

Easy-to-use analytics and dashboards with pre-configured algorithms

- Relevant Time **Asset Monitoring**
- **Abnormal Situation** Identification
- Pre-Packaged **Analytics**
- **Seamless** Integration
- **Minimal Configuration**
- Simple, **Actionable Interface**

Customizable multi-asset models for health and efficiency

- **Plant, Unit, and Equipment Health**
- Equipment **Performance & Efficiency**
- Management of **Energy** Consumption, Costs, and Emissions

Easy-to-use analytics and dashboards with pre-configured algorithms

- **Asset Health & Efficiency**
- **Device & Machinery Diagnostics**
- Digital **Twins**
- Connectivity
- **Services**

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Machine Learning Analytics Portfolio Solves Problems offline and online

KnowledgetNet (Knet)

Is most comprehensive suite of Machine Learning & FMEA based analytics powered by Prescriptive and Predictive maintenance providing automated Root Cause analysis with corrective actions and Dynamic targeting.

Input
- Real-time Data & Alarms
- Performance Curves
- Historical Data
- Process Flow Diagrams
- FMEA

Offline Machine Learning
- Cleaning
- PCA
- Clustering
- Decision Tree
- Regression
- Event Clustering
- Optimization
- Sequential Rules

Dashboarding / UI
- Smart KPIs
- Workflows
- Complex Events
- Expert Rules
- Root Cause Analysis

Online Machine Learning
- Recursive Density Estimation
- Online Clustering
- Model Retraining

Output
- Asset Health Management
- Performance Gaps Detection
- Predicted Failures
- Predicted Asset Remaining Life
- Root Cause Identification
- Corrective Actions
- Process Insights
- Operating Envelope
- Predictive Models
- Historical Playback
- Soft Sensors
Pump App: Challenges For Industrial Users & Solution

There are approximately 200 process pumps in the average refinery, chemical or petrochemical plant.

Typically, only 10% of the most critical pumps have on-line health monitoring. As many as 90% of process pumps are manually or not monitored at all.

40% of total process pumps are considered “essential” pumps that are manually monitored.

Manual monitoring is not always enough to identify degrading performance and take action. Pump failures can cause process upsets and downtime, taking hours or days to recover normal operations.

Statistically, pumps will fail or suffer degraded operation every 12 months. Reactive maintenance results in 50% higher costs than preventative.

Poor equipment reliability impacts HSSE in the form of safety incidents, regulatory fines and process shut downs.

Cavitation, Premature Wear Detection

CALCULATED INSIGHTS

- Vibration monitoring
- Cavitation
- Pump pressure differential
- Process variable thresholds based on baseline capture
- Pump health index
- Abnormal situation awareness in the form of alerts
## Flare Systems – Efficient and Reliable Compliance to the New Regulations

### Challenges

**Sector Rule Emissions Complexity:**

- §63.648 Equipment leak standards- Operators would install electronic monitors on PRDs that vent to atmosphere to identify and record the time and duration of each pressure release.

- §63.670, paragraphs (o)(3) Identify the source of release on the flare systems for root cause analyses.

### Acoustic Monitoring of PRV’s

Comprehensive PRV monitoring for closed recovery and flare systems enables immediate identification and response to source control.

### Impact on Operations

Non-intrusive wireless solution utilizing acoustic / temperature transmitters to detect the PRV release in real-time.

- Detected at least 200 incidents.

- Identified 20 “bad actors” and the problems were resolved within an hour.

- Increased throughput and revenue of the units:
  - **ROI: 270%**

Client said, “The increased throughput and revenue was an unexpected bonus.”
Emerson Committed to Environmental Solutions: Emerson Presentations and Seminar 4C Conference Feb 2019

Top Quartile Environmental and Plantweb Overview
What's New under Refining Sector Rule (EPA 40CFR63)?
Challenges in Flare Measurements and Monitoring
• Wireless Measurements
• Flow Monitoring Solutions
• Gas Composition Monitoring and EPA Reporting Systems
Safety/Hazardous Monitoring Technologies
Improving Emissions and Safety Combustion Solutions for Fired Heaters
Leak Detection and Repair (LDAR)
• Pressure Relief Valves: Best Practices in Reducing Emissions
• Reducing Pump Risks with Real Time Monitoring
Workshop Collaboration and Next Steps
### Real-Time Monitoring with Plantweb Insight Creates Substantial Opportunities for High Value Savings

<table>
<thead>
<tr>
<th>Application</th>
<th>Real-time Insight</th>
<th>Annual Savings ($M)</th>
<th>ROI (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Trap Monitoring</td>
<td>Energy waste and emissions</td>
<td>$0.4 - $0.6</td>
<td>7 months</td>
</tr>
<tr>
<td>Pump Monitoring</td>
<td>Cavitation, pump health</td>
<td>$0.5 - $0.6</td>
<td>11 months</td>
</tr>
<tr>
<td>Pressure Gauge Monitoring</td>
<td>Process pressure, gauge health indication</td>
<td>$0.4 - $0.6</td>
<td>12 months</td>
</tr>
<tr>
<td>Heat Exchanger Monitoring</td>
<td>Fouling and efficiency</td>
<td>$2.7 - $3.6</td>
<td>3 months</td>
</tr>
<tr>
<td>Cooling Tower Monitoring</td>
<td>Efficiency and health</td>
<td>$0.3 - $0.5</td>
<td>4 months</td>
</tr>
<tr>
<td>Mobile Workforce</td>
<td>Startup and turnaround efficiency</td>
<td>1.6-2.1</td>
<td>3 Months</td>
</tr>
<tr>
<td>Air Cooled Heat Exchanger Monitoring</td>
<td>Fan health and fouling</td>
<td>0.9-1.1</td>
<td>13 Months</td>
</tr>
<tr>
<td>Safety Shower and Eye Wash Monitoring</td>
<td>Instant trigger indication</td>
<td>Per incident</td>
<td>Safety</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$8.8M - $11.7M</strong></td>
<td><strong>Savings Per Year</strong></td>
<td><strong>6 months</strong></td>
</tr>
</tbody>
</table>

* This chart is based on a 250,000 bpd refinery analysis by Emerson
Why is Energy Management and Control Important?

Typical Financial Flows in Utilities for Large Refinery

1.2 MM/BPD Refinery – 5% Utility Costs Savings – $30 million/Yr; 300,000 T/Yr Reduced CO2

Assumed pricing: Fuel - $5/ BTU; Steam - $8/ BTU; Power - $60/ MWH; 1,200,000 BPD Refinery
What Energy “Information” Often Looks Like Today

Only looks in the past and doesn’t detail why consumption changed

Reporting is based upon allocation using various custom calculations and spreadsheets

Difficult to understand root-cause of problems when much measurement is missing
Energy Management Solution

- Expert rules monitor energy performance and compares to targets
- **Dynamic targeting** considers process scenarios and uses regression models to identify energy performance baseline.
- Automated root cause analysis to pinpoint source of detected energy inefficiencies
- Interactive workflow provides operations with corrective actions in line with best practices
- Online visualization through web dashboards and reports
Example: Saudi Aramco Abqaiq Plants

- Biggest oil processing and crude stabilization facility in the world – 15% of global oil production
- Main oil processing center for Arabian Extra Light (AXL) and Arabian Light (AL) crude oils, with a capacity of more than 7 million bpd
- 3 main processing operations: oil, NGL and utilities.
- Average energy consumption: $\approx 30$ KBTU/Boe
- Digital Transformation Vision
- Several World Awards in Technology Innovation

Ref: EGUE 3-161972; “Combining AI and Prescriptive Analytics for reaching realistic Operation Efficiency and Optimization”; Mohammed Batouq; Ali Alwadi; Samy Achour; Mark Nixon
Deliverables

Key Performance Indicators
• 7 Plant-wide KPIs
• More than 350 sub-KPIs
• Energy Savings and Costs

Root Cause Analysis
• 7 drilldown models
• More than 100 root causes

Optimization Models
• 13 optimization models using NLP and MINLP methods

Web –based Dashboards
• 7 KPIs monitoring dashboards
• 14 Optimization dashboards
• Custom trending dashboard
• Statistical reporting
• Slow roll monitoring
• User activities tracking

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Dynamic Targeting

- Equipment Availability
- Operating Modes
- Special Events
- Process Scenarios
- Best Performance

Equipment that is not available is excluded from the key performance indicators calculation.

Energy consumption depends on the stabilization depth, e.g. slow roll equipment, extended startup boilers.

Best performance identification and baseline modeling.

Crude type changes.

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Business Results Achieved

- Energy savings were estimated to be $22M per year
- Increased visibility of the operations performance from the operator level to senior management for faster and informed decisions
- The problem-to-resolution cycle time was significantly reduced
- Best values and set points of key parameters for optimal distribution and increased profitability
- Operation knowledge was retained, enhanced and shared

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Integrated Asset Performance Platform

One Consolidated Platform for all Assets

Health Status Notifications

CMMS Integration

Empowered to Collaborate

Historical & Live Data Sources for Analytics

Asset Health & Efficiency
Integrated Multi-Asset Analytics

Asset Health
Pre-Configured Analytics

Device & Machinery Diagnostics
Condition-Based Analytics

Maintenance Work Order

CMMS Integration

Predictive push alerts to right people

Enable cross-functions Collaborations

Easy analytics deployment for SME

Health & Performance of all Assets in one Consistent Platform
Vision of Digital Refinery of Future

Pervasive Sensing

Historical Data

Control System

Predictive Analytics

PdM System

Energy & Production Optimization

Prescriptive Analytics

Perform Maintenance

Work Permit Generation

CMMS Work Order Generation

Root Cause Identification

Maintenance Team Notification

Store Room Parts Kit

PLANTWEB
The Plantweb Digital Ecosystem: Enabling Top Quartile Performance With the Industry’s Broadest Integrated Portfolio of Digital Transformation Solutions

- Consulting & Implementation
  - Industry Expertise: Projects & Operations
  - Digital Strategy & Cybersecurity
  - Shutdowns, Turnarounds, & Outages

- As-a-Service Models
  - Software Cloud-Deployed Applications
  - Asset Expertise and Actionable Insights

- Platforms & Software
  - Personnel Effectiveness
    - Digitally-Enabled Work Processes
  - Asset Performance Platform
    - Enterprise Analytics & Collaboration
  - Digital Twins
    - Plant & Asset Optimization
  - Device & Machinery Diagnostics
    - Condition-Based Analytics
  - Asset Health
    - Pre-Configured Analytics
  - Asset Health & Efficiency
    - Integrated Multi-Asset Analytics

- Secure Connectivity
  - Data Integration & Cybersecurity
    - Embedded Security at All Levels
  - Secure First Mile
    - Secure Data Pathways to External Applications and Experts

- Pervasive Sensing
  - Valve Position
  - Flow
  - Non-Intrusive Temperature
  - Radar Level
  - Pressure Gauge
  - Toxic Gas
  - Acoustic
  - Vibration
  - Non-Intrusive Corrosion
  - Location

- Intelligent Field Devices
  - Measurement Instrumentation
  - Valves
  - Pneumatics

- SCADA

- Services
  - Project, Lifecycle, and Educational Services
  - Production Optimization
  - Operator Performance
  - Control & Safety Systems

- Analytics
  - Edge, On-Premise, and Cloud

- Connectivity

- Data
Application of Digital Refinery of Future
Emerson Named ‘Industrial IoT Company of the Year’ from IoT Breakthrough

“The award recognizes Emerson’s extensive innovation and leadership in driving IIoT technologies and strategies for customers in manufacturing industries*.”

“Emerson has harnessed the power of Industrial IoT for customers through its Plantweb™ digital ecosystem to enable broader process automation and deeper data insights that can improve operations.”

Emerson was selected from more than 3000 applicants around the world.

Source: IoT Breakthrough (iotbreakthrough.com)
* - Manufacturing Industries include: Oil & Gas, Food & Beverage, Chemical, Life Sciences, Power, Water & Wastewater