INTELLIGENT PUMPING SYSTEMS:

OPTIMIZING PUMP LIFE CYCLE PERFORMANCE
PumpSmart Control Solutions

Industrial Pump Group

Pumping System Performance
Can Make or Break Your Bottom Line!

• Energy & Maintenance Savings:
  – Balancing supply with load improves efficiency and reliability
  – Increase process uptime via improved pump performance
  – Variable speed adjust energy usage according to need

• Asset Management:
  – Predictive maintenance via pump intelligence
  – Reduce parts inventory requirements

• Improved Process Control:
  – Variability reduction saves material and energy
  – Better product quality & throughput

“Motor and Valve Performance is the Weak Link in Many Control Loops”
Source: Automation Research Corporation
Strategies to Drive Manufacturing Efficiency on the Production Floor
## Typical Assessment Results

### Integrated Pulp & Paper Mill

- **Eight (8) Pumping Systems**
  - Horsepower Reduction - 950 HP
    - 3125 Installed - 2175 Required
  - Total Installed Cost - $530
  - Total Savings (3 Yr.) - $1,012
  - Mean Payback Period - 13 months
  - Mean Net Present Value - $38K
  - All Projects NPV - $358K

- The 15 pumps studies represent less than 2% of the plant pump population

- Approximately 20% of the pumps are candidates for optimization
Intelligent Pumping System

Just What Is It?
PumpSmart

Unique Capabilities

• Automatically Adjusts to Process Changes

• Automatically Adjust to Pump System Changes

• Fault Tolerance, e.g., can slow down to protect pump

• Understands When to Resume Safe Operation
PumpSmart: Major Components

- **Pump and Motor**
  - Any Manufacturer

- **Variable Speed Drive**
  - ABB ACS 600 Drive
    - PS 200
    - PS 300
  - Instrumentation
    - Any Manufacturer

- **Microprocessor**
  - Standard VFD Motherboard

- **Special Software**
  - Goulds’ Algorithms
  - Pump Domain Knowledge
Instrumentation
(ONE or More Parameters Depending on Application)

- Discharge Pressure
  - Control plus Fault Protection

- Discharge Flow
  - Control plus Fault Protection

- Other Control Parameters
  - Level, Temperature, etc.

- Suction Pressure
  - Condition Monitoring, as needed

- Suction Temperature
  - Condition Monitoring, as needed
Download Data to Microprocessor
User friendly configuration onsite or factory

- Pump Hydraulic Characteristics
- Fluid Characteristics
- Control Parameters
- Alarm Settings
- Multi-pump Sequencing
  - Up to Four Parallel Pumps
- Vibration Monitoring
  - Bearings and Casing
PumpSmart Protects Against:

- Closed Suction Valve
- Closed Discharge Valve
- Cavitation Conditions
- Minimum Flow
- Dry Running

- Other Safeguards:
  - Over-pressure, temperature, current, speed
PumpSmart Improve Reliability (MTBF)

- **Operating Range**
  - Flow or Head
  - Runs near BEP

- **Operating Speed**
  - Lower RPM

- **Impeller Diameter**
  - 25% of Trim Range
  - Reduces Vibration
Example: Lower Maintenance Cost Impeller
Cutwater Diameter Gap - 25% Wider
Pump Performance Curve

Fixed Speed: *Limits HQ Flexibility*

![Graph showing Pump Performance Curve with Total Head and Capacity, m^3/hr axes. Curves A and B indicate performance characteristics at fixed speeds.]
Pump Performance Curve
Variable Speed: Maximizes HQ Flexibility

[Graph showing Pump Performance Curve with variables and annotations]

ITT Industries
Fluid Technology
# PumpSmart vs. Control Valve

## % of BEP across Flow Range

<table>
<thead>
<tr>
<th>Flow Rate (gpm)</th>
<th>Duty Cycle % of Time</th>
<th>Control Valve Pressure Drop (psid)</th>
<th>Pump % of BEP</th>
<th>VFD Speed RPM</th>
<th>Pump % of BEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>10</td>
<td>1</td>
<td>86%</td>
<td>1750</td>
<td>87%</td>
</tr>
<tr>
<td>280</td>
<td>30</td>
<td>17</td>
<td>31%</td>
<td>1225</td>
<td>86%</td>
</tr>
<tr>
<td>120</td>
<td>50</td>
<td>30</td>
<td>26%</td>
<td>508</td>
<td>90%</td>
</tr>
<tr>
<td>80</td>
<td>10</td>
<td>31</td>
<td>17%</td>
<td>315</td>
<td>95%</td>
</tr>
</tbody>
</table>
Pumping Systems Are Energy Intensive

<table>
<thead>
<tr>
<th>Industry Type</th>
<th>Pump Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum</td>
<td>59%</td>
</tr>
<tr>
<td>Forest Products</td>
<td>31%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>26%</td>
</tr>
<tr>
<td>Food Processing</td>
<td>19%</td>
</tr>
<tr>
<td>Primary Metals</td>
<td>9%</td>
</tr>
</tbody>
</table>

A 75 hp pump uses about $20,000 in electricity annually
Pumps offer the largest potential for process energy savings

Source: DOE-OIT
PumpSmart Value Proposition

• Lower Life Cycle Cost
  • Initial Cost
  • Installation Cost
  • Operational Cost
  • Maintenance Cost

• Improved Process Control
  • Solid-State Drives vs. Pneumatic Valve Improves Performance
  • Utilizes PID algorithm in VFD or in the DCS
  • Unique Algorithm Controller (adaptive)

• Asset Management
  • Operational Data (80:1 data explosion)
  • Condition Monitoring (e.g., TDH actual, NPSH actual)
  • Links to DCS, Asset Management Software, and CMMS
PumpSmart: A Tool to Lower Life Cycle Cost

“Optimizing Pump Systems”
Pump Life Cycle Cost
(Total Potential Reduction of 30 to 70%)

- Initial Cost
  - less components
- Installation Cost
  - on new projects
- Operating Cost
  - energy, process
- Maintenance Cost
  - MTBF, repairs

Typical Total Life Cycle Cost

- 5-10% Initial
- 15-20% Installation
- 35-45% Operating
- 30-40% Maintenance
Energy to Burn
Maintenance too Frequent

• Pumps Over-sized for Actual System Demands, Lead to...
  – Throttling Valves (< 50%)
  – Increased Friction Head
  – Increased HP Requirement
  – Lower MTBF of Seals and Bearings
    • Two most common component failures

• Opening a Valve 10% can reduce HP consumption > 30%
  (at a given load)
  – Affinity Laws
PumpSmart in Process Control

“Changing the Rules of the Game”
The Control Loop -- A Fundamental Building Block
Implementing VFD’s as the Primary Control Element

Valve
Actuator
Motor
Positioner

Pump

VFD
Pumping System Elements

**Traditional Pumping System**
(Fixed speed pump, control valve, transmitter)

**Variable Speed Drive Pumping System**

Control loops are tightly associated with pumping systems.
Studies Show that as Many as 60% of Control Loops Actually Operate in Manual

Source: @ssetMAX LoopScout -- Results from audits of 300 Plants Worldwide
Studies Shows that as Many as 80% of Control Loops Actually Increase Variability

Source: Entech --- Results from audits of over 300 Paper Mills in North America
PumpSmart Application

Control Benefits

• PumpSmart Reduces Process Variability
  – Control valve backlash and stiction are eliminated. This is the single largest contributor to process variability. The tendency to oversize control valve amplifies the negative impact of backlash and stiction.
  – Overall control performance is improved. The dynamics of the VFD are faster and the process dynamics are more linear. Both of these factors will permit faster tuning with more uniform control performance
PID Loop: Response Time and Porpoising

<table>
<thead>
<tr>
<th>Process Variable</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porpoising - Fixed Speed PID Control</td>
<td>Setpoint</td>
</tr>
<tr>
<td>Variable Speed Control</td>
<td></td>
</tr>
</tbody>
</table>
Impact of Improved Measurement and Control on Process Variability

Chemical, Material and Energy Cost
Productivity and Yield
Product Quality
Operating Flexibility and Process Reliability Improved via PumpSmart Control
PumpSmart in Asset Management

“Addressing the #1 Business Driver”
Enterprise Asset Management Implementations

Automation Research Corp: “Asset Optimization Benefits Not Realized”

- EAM implementations have left Billions of Dollars of asset optimization benefits on the table.

- Less than 10% of Enterprise Asset Management (EAM) system users have done more than automate their existing work processes.

- There are many reasons for the gap between reality and expectations, including the following:
  - Most EAM implementations do not provide an integrated view of performance data.
  - Condition monitoring data and production data are missing.

Source: Asset Management (CAM)
Friday, October 06, 2000
Leif Eriksen
PUMP SMART is an ASSET SENSOR
“Turning Information into Knowledge”

- Up to 84 different parameters monitored
- Display instrument (Flow, Press, Temp) signals
- Monitor hydraulic performance (TDHa)
- Mechanical Fault logger (62 time stamped alarms, e.g., NPSHa)
- Communicates data to DCS, PLC or CMMS
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DCS Operator Interface
Pump Condition Monitoring

Operator Interface
Fieldbus
Valves & Sensors
Smart Pumping System
DCS Operator Interface
Pump Condition Monitoring (Cont’d)

<table>
<thead>
<tr>
<th>TAG</th>
<th>Description</th>
<th>Location</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>FT-101</td>
<td>Inlet Pressure</td>
<td>Chest 101</td>
<td>WARNING</td>
</tr>
<tr>
<td>TT-101</td>
<td>Inlet Temp</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>P-101</td>
<td>Feed Pump</td>
<td>Machine 1</td>
<td>CRITICAL</td>
</tr>
<tr>
<td>M-101</td>
<td>Agitator Motor</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>LS-123</td>
<td>Level Switch 123</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>CV-101</td>
<td>Inlet Valve</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>P-1342</td>
<td>Feed Pump</td>
<td>Machine 2</td>
<td>OK</td>
</tr>
<tr>
<td>FT-102</td>
<td>Inlet Pressure</td>
<td>Chest 102</td>
<td>OK</td>
</tr>
<tr>
<td>FT-104</td>
<td>Inlet Pressure</td>
<td>Chest 104</td>
<td>OK</td>
</tr>
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</table>
### Predictive Maintenance

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<td>Agitator</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>LS-123</td>
<td>Level</td>
<td>Chest 101</td>
<td></td>
</tr>
<tr>
<td>CV-101</td>
<td>Inlet</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>P-1342</td>
<td>Feed</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>FT-102</td>
<td>Inlet</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>FT-104</td>
<td>Inlet</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
</tbody>
</table>

**Tag: P-101 Feed Pump**

The DCS Operator Interface is used for monitoring pump conditions and implementing predictive maintenance strategies. The table above lists various tags and their statuses, indicating critical issues such as a CRITICAL status for the P-101 Feed Pump.

- **Operator Interface**: Interface for monitoring and controlling the system.
- **Fieldbus**: The network that connects various devices.
- **Valves & Sensors**: Components used for fluid control and monitoring.
- **Smart Pumping System**: The integrated system for efficient and monitored pumping operations.
### Predictive Maintenance

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<td></td>
<td></td>
</tr>
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<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>LS-123</td>
<td>Level Switch</td>
<td>Chest 123</td>
<td>OK</td>
</tr>
<tr>
<td>CV-101</td>
<td>Flow Switch</td>
<td>Chest 101</td>
<td>OK</td>
</tr>
<tr>
<td>CV-134</td>
<td>Flow Switch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FT-102</td>
<td>Inlet Pressure</td>
<td>Chest 102</td>
<td>OK</td>
</tr>
<tr>
<td>FT-104</td>
<td>Inlet Pressure</td>
<td>Chest 134</td>
<td>OK</td>
</tr>
</tbody>
</table>

**Tag: P-101 Feed Pump**

**Diagnosis:** Feed pump failing...

**Total Dynamic Head (TDHa).**

**Process Impact:** Loss of this pump affects stock flow into machine chest #1 and, subsequently, stock blending.

**Schedule:** Will be repaired no later than 5/06/00.

**Repair notes**

- Replace Impeller

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**DCS Interface**

**Fieldbus**

**Valve & Instruments**

**Smart Pumping System**

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**ITT Industries Fluid Technology**
PumpSmart Control Solutions

Asset Management Software

Maintenance and Engineering Support

Alert Manager

CMMS

Email

Paging
## Maintenance Impact

<table>
<thead>
<tr>
<th>Predictive Maintenance</th>
<th>Preventative Maintenance</th>
<th>Reactive Maintenance</th>
<th>Operations Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bushings</td>
<td>Bushings</td>
<td>Bushings</td>
<td>Lost Production</td>
</tr>
<tr>
<td>Thrust Pad</td>
<td>Thrust Pad</td>
<td>Thrust Pad</td>
<td>Rework</td>
</tr>
<tr>
<td>Back Thrust Washer</td>
<td>Front Thrust Washer</td>
<td>Front Thrust Washer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front Impeller Wear Ring</td>
<td>Front Impeller Wear Ring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Back Impeller Wear Ring</td>
<td>Back Impeller Wear Ring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Back Thrust Washer</td>
<td>Back Thrust Washer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impeller Repair</td>
<td>Impeller Repair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shaft</td>
<td>Shaft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.25 Torque Ring</td>
<td>Torque Ring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.1 Casing</td>
<td>Casing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.2 Containment Shell</td>
<td>Containment Shell</td>
<td></td>
</tr>
<tr>
<td>$X</td>
<td>$X</td>
<td>$5X</td>
<td>$40X</td>
</tr>
</tbody>
</table>

Source: Olin Chemical Corp.

COST

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Fluid Technology
Condition Monitoring Improves the Cost of Maintenance in Pulp and Paper

$ / Horsepower / Year

- Condition Monitoring: $7
- Preventative: $11
- Run to Failure: $17

Source: SKF, P&P Maintenance 1994
Benefits of Condition Based Monitoring

- Maintenance Cost: down 50 - 80%
- Repair Cost: down 50 - 80%
- Spares Inventory: down over 30%
- Overall profitability: up 20 - 60%
- Revenue: up 30%

Source: Data collected from 500 operating CBM systems for over 3 years -- Fadum Enterprises, Inc.
"The question tomorrow will not be whether the machine is smart but what is the IQ of the machine,"

"Smart machinery and processes with embedded sensors and controls allow for better modeling, for faster, smoother transitions such as start-ups and production changes, tighter control during continuous operation, and faster diagnostics of potential machine problems before product quality or process operation is negatively affected."

- PIMA's North American Papermaker, March 2000
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PumpSmart
PROCESS SYSTEMS
BECAUSE FAILURE IS NOT AN OPTION

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