The Future of Wireless Technology and Simulation Software to Increase Pump Reliability and Efficiency

Sponsored by:
The Hydraulic Institute

Prepared by:
Jeremy Frank, KCF Technologies Inc.
Ray Hardee, Engineered Software Inc.

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Who is the Hydraulic Institute?

• Established in 1917
• Join us as we celebrate our 100th year anniversary in 2017
Here are the Hydraulic Institute Objectives and Goals for the Chemical processing Industries

- Mission and Vision: Advancing the pump manufacturing industry by becoming the world’s resource for pumping solutions
  - Addressing Pump Systems
  - Developing Standards
  - Expanding Knowledge and Resources
  - Educating the Marketplace
  - Advocating for the Industry
Take a closer look at our membership

Engineered Software, Inc.
Who is Pump Systems Matter?

• Vision: To be the leading educational & training authority on pumps and pumping systems

• Mission: Provide product-neutral training on energy efficiency, reliability, economics and effective application of pump systems

• Essential Elements:
  - Build awareness of systems optimization with pump users
  - Partner with key groups such as pump/supplier OEMs, the energy efficiency community, utilities, engineering consulting firms, and pump system users to adopt systems optimization products, services and best practices
Introduction to our two speakers...

**Wireless Technology**
Jeremy Frank  
KCF Technologies  
President/CEO

**Simulation Software**
Ray Hardee  
Engineered Software  
Chief Engineer, Emeritus

And how they relate
If You Care About Uptime, Safety, Reliability and Energy, this is Important

Your Pump System Is (Most Likely) a Poorly Designed, Unreliable, Energy Hog Ready to Sabotage Your Business.

• Average pump system efficiency: only 40%
• $2.5 Trillion Waste in U.S. Industry (Reactive)
• Predictive reliability is 3X less expensive, yet 80% of practices are Reactive
• Reliability ~ Safety ~ Uptime ~ Efficiency

What are you going to do about it?
Predictive Capability can Improve Safety & Reliability

Workforce Challenges

Reactive to Predictive

Internet of Things

2015
People Involved in the Case Studies

• Include names pictures of all collaborators:
  • KCF Team
  • ESI Team
  • IVC – Ken Starry
  • UAJA + engineering company
  • Glatfelter
  • PSU students & prof.
KCF Technologies Inc. History
Engineered Software, Inc.

- Founded in 1982, privately held
- Headquartered in Lacey, WA (1 hour south of Seattle)
- Technology spanning from Equipment Manufacturer to Distributor to Design Firm to End Pump User
- Software development and Engineering analysis competencies
- World’s first Centrifugal Pump Selection and Fluid System Simulation Technology
- System focused training for Pump and Component selection as well as System Troubleshooting and Optimization
- Increased International Representation
Seminar Presentation & Methodology
“4-I” Process for Continuous Improvement

• **INVESTIGATE** conditions that shorten machine life or increase risk of disruptions

• **IDENTIFY** opportunities for operational improvements to reduce or avoid unwanted conditions

• **IMPLEMENT** continuous monitoring coupled with in-plant reliability and operations expertise

• **IMPROVE** through actions taken, quantify and evaluate successes and savings relative to expectations
Case #1: Detection and Modeling of Cavitation in Backup Pump System

- Problem: Backup pump system exhibits high vibration & noise
Investigate – What is the Problem?

System
• 2 main pumps
  • Typically run at ~600 rpm each
• 3 backup pumps
  • Run at ~1200 rpm each when used
• Total flow rate of ~320,000 gal/hr daily

Problem
• Extreme vibrations (incl. “gravely sound”) from backup pumps
• Cavitation is suspected
Identify – Diagnose the Pump Health
Identify—IVC Technologies
Detailed Reliability Assessment

Operating Condition Levels Of Industrial Equipment

Critical
Examine, repair, replace as soon as possible

High
Begin frequent monitoring
Examine, repair, replace during next scheduled shutdown

Low
Schedule Proactive repair

Engineered Software, Inc.
KCF Technologies, Inc.
Identify—IVC Technologies
Detailed Assessment Conclusions

- **Cavitation** is present on all three backup pumps
- Pump 101 is most severe
- More system information is required

**Analysis:**

Pump 101 - Cavitation / Fluttering Check Valve. High magnitude events occur randomly throughout the time domain on all 3 pumps, with Pump 101 having the greatest values. The corresponding frequency data has elevated broad band noise, typically seen with cavitation, air entrainment and recirculation. Typically, cavitation is the most common due to NPSH degradation, but also very frequent when the suction does not have 10 times the pipe diameter of straight pipe between the suction reducer and the first obstruction in the line (such as a 90° elbow). Twenty g’s peak is excessive and will cause more rapid wear of components.

**Recommendation:**

Verify no obstructions in the inlet for Pump 101. Inspect all valves for operation which could impact flow, entrain air, or generate symptoms similar to water hammer.
Delayed onset cavitation can be found on all three backup pumps whenever they are run.
Identify – How Can the Pump System be Optimized?

Options:
- Change start-up procedure (variable speed)
- Adjust control methodology (multiple pumps)
- Replace faulty equipment (pumps/valves)
- Modify pump system (inflow)
- Other Options?
Implement – What can we do to Understand the System? - Modeling

Pump Characteristics and Expected/Normal Operating Conditions are Simulated
Implement – What can we do to Understand the System? - Modeling

Warning/Fault Condition: Negative Pressure (Siphon Effect)
Improve: What is the Recommendation and Outcome?

- Modeling – Conclusions
- Siphon effect (vapor flashing / cavitation)
- Multiple pump operations
- Recirculation valve
- Different scenarios were tested this morning on this pump system
Determining a Cause for Cavitation

• Only backup pumps have cavitation
• Operators comment pump cavitation occurs after a few minutes of operation
• Negative pressure at summit causes unstable flow in “down pipe”
• Additional test are needed to determine:
  • When pump cavitation starts
  • Start backup pumps in sequence to determine when the problem occurs
What the Tests Should Show

- Pump cavitation only occurs when pressure variation occurs
- Pressure variation only occurs when down pipe is not vented properly (high flow rates)

If this is the case the problem could be resolved by eliminating the pressure variations at the summit by:

- Install tank at summit
- Increase the size of the vent line at the summit
- Increasing the head loss in the down pipe to eliminate low pressure
Case Study #1: Conclusions

- Wireless technology identified cavitation signature on backup pumps
- Hydraulic model identified unstable flow in down pipe
- Additional plant operating data confirmed cavitation cause by varying pressure at summit due to poorly vented down pipe
- Evaluated options of eliminating pressure variations at summit.
Case Study #2: Solve Pump System Reliability Issues in Pulp Manufacturing
Investigate – What is the Problem?

System

• 2-Pump Liquor Pump System
• Booster Pump – 1800 RPM
• Make-Up Pump – 3600 RPM

Problem

• Premature motor/pump failures, inability to maintain necessary pressure to Make-Up Pump
• Suspected Cause: flow obstructions / cavitation
Identify – Diagnose Pump System Health

- Primary Liquor Pump (3600 RPM)
  - No evidence of cavitation
  - Steady Vibrations

Lack of random, high frequency content
Identify – Diagnose Pump System Health

- Booster Liquor Pump (1800 rpm)
  - Drastic variability in vibrations
  - Common evidence of cavitation

High frequency, broadband vibrations
Identify – How Can the Pump System be Diagnosed and Optimized?

Options:

• Monitor system data in real-time, including for cavitation

• Integrate data into historian software – OSI PI

• Modeling – understand system-level improvements & redesign

• Operational – implement preventive acid flush to clean system based on data
Implement – What can we do to Understand

Pipe FLO model
Improve: What is the Recommendation and Outcome?

• Modeling (need to get system/model information)
• Conclusions
Overall Movement towards Improved Reliability and Efficiency

2015 DoE NOPR
Rulemaking for Commercial and Industrial Pumps Energy Conservation Standards
Embrace the Future: IoT, Industrial Wireless, Modeling and Predictive Monitoring

Customer – “I’ve got a problem and I don’t know what it is!!!”

Wireless Technology – “This is your problem, how do we fix it?”

Software modeling—“This is the most efficient way to fix the problem”

Conclusion: “We’ve solved this problem in a way that it won’t happen again”
Questions?

• Mark Sullivan – Director, Education & Marketing
  Pump Systems Matter – The Hydraulic Institute
  msullivan@pumps.org
  973-267-9700

• Jeremy Frank, PhD – President/CEO
  KCF Technologies Inc.
  jfrank@kcftech.com
  814-867-4097

• Ray Hardee– Chief Engineer, Emeritus
  Engineered Software, Inc.
  ray.hardee@eng-software.com
  360-412-0702