Better Plants
U.S. DEPARTMENT OF ENERGY

IN-PLANT TRAINING PREPARATION WEBINAR

FAN SYSTEMS

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FLOWCARE ENGINEERING INC.

MARCH 29, 2018
Thank You!

Sponsor: Better Plants

Host: Charter Manufacturing Company, Inc.

One Family. One Team.
INPLT Model - The Five Major Objectives

- Identifying Energy Saving Opportunities
- Networking (Trainees/Utilities/State/Vendors)
- Project Implementation and Replication
- Leveraging Resources (State/Utilities/Peer Plants)
- Training in a Real World Environment
What is INPLT?

- Train the Trainer Program for Industry Practitioners from Multiple Entities
- Events Range from 3 to 4 days at a **HOST PLANT Site**
- Each INPLT has Series of Class Room and Field Work Sessions
- Led by DOE Energy Experts and DOE Technical Account Manager (TAM)
- INPLT Spreads the benefits beyond the walls of the host facility

**INPLTs** give U.S. Manufacturing Industry the tools and motivation to accelerate and scale the implementation and replication of their energy efficiency projects
Field and Classroom Training
## Timeline for In-Plant Training

<table>
<thead>
<tr>
<th>INPLT Component</th>
<th>Duration/Schedule</th>
<th>Description</th>
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<tr>
<td><strong>Preparation</strong></td>
<td>2-3 months prior (Phone calls and emails)</td>
<td>- Scope Development</td>
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<td><strong>Pre-Training</strong></td>
<td>2-3 weeks prior (Webinar)</td>
<td>- Orientation on safety rules and other logistics - Webinar on target system energy efficiency improvement, and related DOE software tool - Technical discussions</td>
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<td><strong>Field Training</strong></td>
<td>2-4 Days (At the host plant site)</td>
<td>- Energy Assessment and Technical Sessions - Energy Management and Replication Session - Evaluation - Close out session</td>
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<td><strong>Follow up</strong></td>
<td>12 months after (Phone calls and emails)</td>
<td>- Correspondence with Host and Participating Plants on the status of implemented energy saving projects identified due to the INPLT event</td>
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Workshop attendees should have some of the following qualifications:

- Operating fans without knowing what is effecting what?
- Chronic bad actor fans causing you nightmares?
- Designing a new process for which fans will be selected?
- Process limited because of fan capacity or poor control?
- Need better fume capture but want to keep costs down?
- Want to be more competitive by reducing costs?

There are many simple things with fan systems that can send energy requirements sky-high.
Rewards for Participation!
Meet Your Trainer

Vern Martin, P.Eng.
Sr. Mechanical Engineer
Our Mission

“To provide independent and comprehensive expertise in fan and blower systems such that users, designers, vendors and others can achieve optimal performance, energy, reliability and economic success with their applications.”

Services FLOWCARE supplies:

- Troubleshooting
- Mechanical Design
- Computational Fluid Dynamics (CFD)
- Project Management
- Major Industrial Applications
Energy Studies

- Preliminary assessments
- Energy audits
- Detailed feasibility studies
- Implementation
- Measurement and verification
### Overall Agenda

<table>
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<tr>
<th>Date</th>
<th>Events</th>
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| **Monday, April 16** | - FLOWCARE arrives on site in the morning:  
|                    |   - Fan model is moved to and set up in training room.  
|                    |   - Performance test is conducted on one of the Baghouse Fans.  
|                    |   - Test results are calculated and added to course material.  
|                    |   - [Assistance required from designated Charter Steel personnel] |
| **Tuesday, April 17**  | - Day 1 of training                                                   |
| **Wednesday, April 18** | - Day 2 of training                                                 |
| **Day 1 and 2**          | - Training room will be open at 7:30 am  
|                                |   - [See note below for Day 2]                                    |
| **7:30 - 8:00 am**          | - Coffee, continental breakfast and networking                        |
| **8:00 – 8:30 am**             | - Opening remarks, introduction and In-Plant Training overview by Tari Emerson (Charter Steel) and Sachin Nimbalkar (ORNL TAM) [Day 1 only] |
| **8:30 am – 5 pm**             | - Fan System In-Plant Training  
|                                |   - 20 minute coffee breaks approximately mid-morning and mid-afternoon; one hour lunch from 12 – 1 pm |

**Note:** It is anticipated that Day 2 will follow a very similar schedule to Day 1. However, exact time for start and stop times for Day 2 to be discussed in case there are those who have travel schedules to maintain. There may also need to be some flexibility in the event of rain or plant activities which could affect a plant tour or ‘site data collection’.
The following concepts will be covered during the two days using a variety of methods i.e. traditional slide presentations, demonstrations of fan concepts using a one horsepower instrumented fan model complete with a variety of attachments, exercises that cover material in specific modules and potentially the inclusion of actual site data taken as part of a field exercise.

- Overview of fans used in steel plants
- Fan terminology
- Fluid basics (gas handling applications)
- How fan performance curves and system curves are developed
- Fan laws (the affinity laws)
- System basics
- Fan control strategies
Fan System Training Concepts …

- The cost of fan ownership
- Conceptual approach to energy optimization from identification of potential candidates to implementation
- Energy optimization techniques
- Application concerns with various energy optimization techniques such as fan retrofits and variable frequency drives.
- System effects and the importance of good ductwork design
- Fan retrofits – what is involved to make this work?
- Selecting and purchasing efficient and properly performing fans
- Fan maintenance problems and the impact that these have on energy efficiency
- Fan system assessment at Saukville Plant – Calculations and discussion of Results
Fan Model Components
Finding Energy Reduction Opportunities in Fan Systems: 

Implementing a 'Systems Methodology'
Presentation Outline

1. Fan and system basics.
2. Energy reduction concepts for fan systems.
3. Optimization methodology.
4. Specific energy optimization techniques.
   - Retrofits
   - Variable frequency drives
   - Performance guarantees
   - System effects
5. Case studies
The Basic ‘Fan’ Definition

“The Basic ‘Fan’ Definition

“Any device that produces a current of air by the movement of a broad surface can be called a fan.”

- Fan Engineering

Does this definition also include positive displacement devices?
A fan is a mechanical device consisting of one or more vanes that is capable of being powered to rotate or oscillate such that a gas is directionally conveyed with a volume flow rate that is dependent on the resistance met by the flow.
Classifications of Fans

Centrifugal

Mixed Flow

Axial
Importance of Fans in North America

Industrial electrical energy use  
Electric motors (industrial apps.)  
Motors driving fans  

40 % (of total)  
70 % (28% of total)  
20 % (6% of total)  

From overview perspective, fans are a very large and important group!
Motor Population and Energy

The bulk of motor-driven energy is used by a relatively small part of the population.

Source: U.S. Department of Energy
Fan Performance Testing
What is a Fan Curve?

Establishes the fixed basis conditions:

- Speed
- Density
- Impeller diameter

Relationship between performance variables:

$$\text{Efficiency} = \frac{\text{Flow} \times \text{Pressure}}{\text{Power}}$$

Fan Aerodynamic Capacity

- Pressure (P)
- Power (H)
- Efficiency ($\eta$)
- Flow (Q)
Power and Energy Reduction Opportunities

Fan Power = \frac{\text{Flow} \times \text{Pressure}}{\text{Fan Efficiency}}

To Reduce Power
- Reduce Flow and/or
- Reduce Pressure and/or
- Increase Efficiency

Fan Energy = \text{Power} \times \text{Time}

To Reduce Energy
- Reduce Power and/or
- Reduce Time
Potential Areas for Energy Reduction

Comprehensive Approach: Fan Systems

Focused on the Overall System
Fan 'System Approach' Methodology

Step 1: Limit flow to what is actually required.
Step 2: Optimize the flow delivery hardware to as low a resistance level as practical.
Step 3: Maximize fan-motor efficiency as practical.
Step 4: Ensure system flow and pressure controls allow requirement to be met across the full range.
The Load-Duty Cycle

<table>
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<tr>
<th>Point of Operation</th>
<th>Operating Conditions</th>
<th>Power @ Point</th>
<th>Time @ Point</th>
<th>Annual Energy</th>
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Load Trend

Load Histogram

Load vs. Time of Day

% Time vs. Load
Optimization.....the Big Picture

The ‘System Approach’ looks at the entire fluid handling equipment: design, selection, maintenance, operation.

Which is easier to achieve?

- Reduce pressure losses by 10%
- Reduce flow by 10%
- Increase efficiency by 10%
Causes of Poor Fan Efficiency

Issues to investigate:

• Was the fan efficiency overstated?
• Was there a better choice of fan type?
• Is fan operating at a poor selection point?
• Has performance degraded since installed?

Site performance testing to rigorous standards is required to establish fan efficiency.
The Issue of Performance Tolerances

- Performance verification tests are typically indicated to be in accordance with AMCA Publication 203 ‘Field Performance Measurement of Fan Systems’.
- Acceptance tolerance criteria as outlined by AMCA 203 is equated to field test uncertainty.

<table>
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<tr>
<th>AMCA Publication 203 Field Test Uncertainty</th>
<th>Flow</th>
<th>Pressure</th>
<th>Power</th>
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<tbody>
<tr>
<td>Minimum</td>
<td>±2%</td>
<td>±2.5%</td>
<td>±3.5%</td>
</tr>
<tr>
<td>Average</td>
<td>±6%</td>
<td>±5%</td>
<td>±6%</td>
</tr>
<tr>
<td>Maximum</td>
<td>±10%</td>
<td>±8%</td>
<td>±8%</td>
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AMCA 203 Acceptance Criteria

**Efficiency**
1. -8%
2. -16%
3. -23%
Ensuring Acceptable Performance

• A ‘performance guarantee’ document is essential to lay out the Policies, Procedures and Penalties of a new fan purchase.

• However, relying on AMCA 203 for acceptance tolerances is too one-sided since it allows poorly performing equipment to pass.

• A ‘zero tolerance’ (shared risk) approach addresses fan end-user concerns.

• Insist on physical model tests.
1. Optimization of fan systems is a very important component of plant energy reduction planning.
2. A 'system-based' approach examines the requirements for flow and pressure before looking at fan efficiency and control.
3. A system-based approach takes more effort but yields much greater benefits.