Welcome
GMI/GMIC Meeting
November 2012
Agenda

• Director’s Report
• Associate Director’s Report
• Project Presentations
• Break
• Project Presentations Continued
  – ISO 50001, John Ihling presented first
• Lunch
• GMIC Closed Business Meeting
Green Manufacturing Initiative

Western Michigan University
Manufacturing Research Center
Dr. John Patten, Director
Welcome

• Introductions (round robin)
• Update-Status since last meeting (May 2012)
  – Budgets
  – Projects
  – Companies
  – Faculty and Students
• Going Forward - Future
Budgets
January 2010 to October 2012

• DOE Grant $972,000 (awarded 2010) ($668,512)
  – Spent: $634,643
  – Remainder $33,869

• Categories - Spent
  – Personnel: $565,615
  – Tuition: $29,696
  – Contracted Services: $8,075
  – Consulting: $2,452
  – Supplies: $7,138
  – Travel: $18,662
  – Other: $3,005
Projects

Ongoing

– Oven/Dryer utilization/efficiency (Energy):
  • Oven Seal
– Reuse and Recycle (Material):
  • Powder Paint – Industry/MMTC/WMU Faculty and Students
– System Optimization
  • Compressed Air, Steam, Water, etc.
– Papers, presentations: Conferences, seminars, etc.
– Green Designs and Certifications
Projects - continued

Completed 2012

– Reuse and Recycle:
  • Batteries – multi institutional effort w/industry collaboration

– Papers, presentations:
  • Autopheretics, Web Scholar, etc.

– Waste to Fuel/Energy (wood, paint and food);
– Compressed Air and Steam System Optimization
– Green Certifications
– Renewable and Alternative Energy
Projects - continued

– Grants and Contracts:
  • Consumers Energy and Franklin Energy
  • Proposal development for further Powder Paint research
    1. Enhancing wet and dry-cast concrete properties
    2. Application methods for increasing transfer efficiency
  • NSF – GOALI, I/UCRC
  • Re-Tap

– Continue evaluations of green products/services
Other Project Activities

• Green Manufacturing Certification (SME and Purdue Univ.)
• Green Product Certifications and Standards
  – Building Green, LEED (US GBC), Energy Management Standard (ISO 14000, 50001), Green Seal, etc.
• Software tools (analysis, DOE)
• Financial incentives (energy)
• Recycling (dumpster diving)
Companies

- Armstrong International
- Bells Brewery
- Borroughs
- Cascade
- Denso
- Erdman
- Fabri Kal
- Haworth
- Herman Miller
- Kellogg
- Landscape Forms
- Ottawa Gage
- Poly-Wood Inc.
- Post
- Rapid Line
- SP Industries
- VanderWall Brothers
- Steelcase
Faculty, Staff and Students

- Faculty: John Patten and Dave Meade, Claudia Fajardo, Murali Ghantasala, Margaret Joyce, Dave Middleton, Pete Parker, Johnson Asumadu, Mike Barcelona, Andre Venter, John Miller

- Staff: Carey Schoolmaster, Brian Wummel

- Students: Gary Nola, Nate Christensen, Trevor Williams, John Ihling, Michael Brio, Ana Perez, Andrew Gabriel, Marylin Glass, Tyler McMillin, Bill DeKam, Jim Martlew, Zachary Miller, Ryan Schwartz, Nathan Bowen, Joe Imesch, Erich Stuedemann, Lorena Jimenez and Alexey Gavrunov
Partners

• Michigan State University (chemistry & packaging)
• University of Michigan (Ann Arbor)
  – Michigan Industrial Energy Center (MIEC)
• Grand Valley State University
  – Michigan Alternative and Renewable Energy Center (MAREC)
• US Department of Energy: Save Energy Now, ALLY
• MMTC (Bill Small)
• Sustainable Research Group (Bill Stough)
• Consumers Energy/Franklyn (Beth Carney)
Activities

• Conferences
• Publications
• Presentations
• Posters
• News articles
• Brochures and information
Web site

- Online Journal: Green Manufacturing Research Journal
- Blog
Future

• DOE Funding: Ends December 31, 2012
• NSF I/UCRC
• Other funding opportunities:
  – NSF GOALI
Companies being Recruited

- Borg Warner
- Cascade Engineering
- Consumers Energy
- Eaton
- Heinz
- IAC
- Johnson Controls
- Kalsec
- L3 Communications
- Perrigo
- Whirlpool
Thank you

Questions?
Green Manufacturing Industrial Consortium Semi-Annual Member Update Meeting
WMU Parkview Campus
November 6, 2012

Associate Director’s Report
David Meade, Ph.D.
Outline

• Membership Update
  • Current Status/Recruiting Efforts
  • Research Activities with Members

• Action Items
  • Updates from Spring
  • New
Membership Update

Welcome!

- Steelcase, Grand Rapids, MI
- Poly-Wood, Syracuse, IN
Our Perspective on Sustainability

Overview  Aspiration / Progress  Culture  Partners

Here for good.

Commitment to Sustainability

Sustainability is one of today’s fundamental business challenges – and our goal is to create maximum value from our available assets and be catalysts for change.

We know we are on a journey. Along the way, it is our responsibility to educate ourselves, continue to study, learn and share insights, our commitments and actions in meaningful ways.

All of this leads us to deliver innovative products and increased value.

WESTERN MICHIGAN UNIVERSITY
College of Engineering and Applied Sciences
Manufacturing Research Center
Recycled Plastic POLYWOOD® Outdoor Furniture by Poly-Wood, Inc.

Poly-Wood, Inc. designs and manufactures timeless, classic, outdoor furniture. Relax in our durable and comfortable, all-weather plastic furniture — whether it's rain, snow, salt water, sun, or ice. POLYWOOD® performance furnishings are built to last — no hassles and no worries. And POLYWOOD® is green — made from a high percentage of post-consumer materials, our furniture transforms landfill waste into usable products. What are you waiting for?
Membership Update

• Current Members: Fabri-Kal, Landscape Forms, Post, Steelcase and Poly-Wood

• Recruiting/Marketing:
  – Steelcase
  – Poly-Wood (referral from WPUG)
  – DENSO
  – Continued correspondence with Haworth, Herman Miller, Cascade Engineering, Kellogg’s
  – Continued Joint Marketing with the West Michigan E3 (MMTC)
  – Participation in the Grand Rapids Manufacturers Council
  – Participation in the Waste Powder User Group (WPUG)
  – Invited Speaker at the Michigan Recycling Coalition Annual Meeting, May 8-10
  – Invited Speaker at Zero Waste to Landfill Workshop held @ Haworth, Oct 24
Powder keg: Consortium studying ways to recycle scrap powder paint

MONDAY, OCTOBER 03, 2011

By Joe Boomgaard | TBL
jboomgaard@mibiz.com

http://www.wgvu.org/wgvunews/audio/fplayer1.cfm?stid=14574

Western Michigan University is halfway to its initial goal of recycling half of its waste. The university is leading a partnership that includes other local institutions. WMU's Green Manufacturing Initiative has also been growing in the past ten years. The Novi-based company Vail is one of the companies that has joined the initiative. The university is halfway to its initial goal of recycling half of its waste. The university is leading a partnership that includes other local institutions. WMU's Green Manufacturing Initiative has also been growing in the past ten years. The Novi-based company Vail is one of the companies that has joined the initiative.
MMTC

• We have partnered with the Michigan Manufacturing Technology Center (MMTC) to jointly roll-out the EPA’s E3 Program (Economy, Energy, and Environment) in West Michigan (WM-E3)

• Expanding into partnership with the Michigan Department of Environmental Quality – Office of Environmental Assistance
  – Intern funding and technical resources from the Retired Technical Assistance Program (RETAP)
Research with Members

• Landscape Forms –

New GMIC Projects Identified in May 2012:
1. Zero Waste/Zero Landfill
2. Green Parking Lot

Other Activities:
1. Facility Planning Study
2. LED Lighting process Ergonomic Study

• LF has also participated in the Waste Powder Paint User Group
Research with Members (continued)

- Post-Chose not to do Assessments, instead chose to utilize GMIC resources on existing projects:
  - Saves $3,300 in “outside contracting” costs

New Projects Identified in May 2012:
1. Changeover wash-down water reduction
   » Saves $3,300 in “outside contracting” costs

Project Continuation:
1. Project Audit – Dryer Damper Control Project
2. Zero Waste to Landfill implementation assistance
• Fabri-Kal:

New GMIC Projects Identified in May 2012:
1. Chiller energy reclaim study
2. Alternative energy system evaluation

Other Activities:
1. Ph.D. Dissertation Research – Tool Cooling Study
Research with Members (continued)

• Steelcase
  – Chose not to do Assessments, instead chose to utilize GMIC resources on existing projects
    » Saves $3,300 in “outside contracting” costs
  – Product Air Quality Testing to Support Industry Standard Testing Requirements
Research with Members (continued)

- Poly-Wood
  - Assessments Underway
    - (E3) Indiana University Purdue University Indianapolis Industrial Assessment Center (IAC)
    - WMU Student Lead Assessment
    - (E3) Still working with the Indiana MEP on the Green Supplier Network Lean/Green Assessment
Action items from last update

• Continue to recruit members – need 1 additional to achieve critical mass
• Continue progress on FabriKal, Landscape Forms and Post projects
• Complete Poly-Wood Assessment Process and select first project
• Continue development of Air Quality test processes and procedures and testing
• GMIC Operational Planning in absence of DOE Funding
• Continue to assemble research team(s) to support year two (2012) research projects
Questions?

Thank You
Project Reviews

• Landscape Forms
• Post
• Steelcase
• Poly-Wood, Inc.

• Break
Landscape Forms
Manufacturing Facility Waste to Landfill Assessment

Nathan Christensen, Mfg. E., Graduate Assistant
Objectives

- Assess the current landfill waste stream
  - Current state
- Identify materials of opportunity
  - High associated cost, volume, recyclability
- Develop systems for reducing landfill waste
  - Receptacle layout and signage
  - Employee education
  - Establish new landfill waste venues
Defining Zero Landfill

• What exactly is “zero landfill”
  – Uniform definitions do not yet exist
  – Zero Waste International Alliance definition:
    • “…90% or greater diversion.”
  – Ability of companies to reach zero-landfill can depend on products produced

• UL looking to create a third party zero-landfill certification
  – Offers three levels of certification
  – Certifications granted at 80%, 98%, and 100% landfill diversion
Planning A Landfill Assessment

• Safety equipment
  – Clothing, eye protection, gloves, footwear, containers, tarps

• Assessment types
  – Process, point-source, dumpster dive

• Develop a procedure
  – Sorting, storing material, define important metrics

• Define the end-goal, scope
  – What are you hoping to achieve
Landfill Waste Receptacles

- Do a walk through pre-assessment
  - Visually inspect waste containers
  - Familiarize yourself with the waste stream
- Waste receptacle mapping may be useful
As total waste disposal is reduced, fuel, admin., and environmental costs will also be reduced.

Recycled materials can be examined in parallel with general purpose materials as appropriate, or after zero-landfill is achieved.
The Dumpster Dive

• Established a sorting area and containers
• Compost bins set up pre-assessment
• GMI students and volunteers from Landscape Forms
• Landfill waste saved throughout two week sorting
What We Found...
**Sorted Landfill Waste**

<table>
<thead>
<tr>
<th>material</th>
<th>material weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>plastic</td>
<td>936</td>
</tr>
<tr>
<td>metal</td>
<td>116</td>
</tr>
<tr>
<td>other</td>
<td>752</td>
</tr>
<tr>
<td>returnables</td>
<td>18</td>
</tr>
<tr>
<td>grinding pads</td>
<td>272</td>
</tr>
<tr>
<td>plastic foam</td>
<td>124</td>
</tr>
<tr>
<td>food wrappers</td>
<td>14</td>
</tr>
<tr>
<td>recycled paper</td>
<td>248</td>
</tr>
<tr>
<td>glass</td>
<td>18</td>
</tr>
<tr>
<td>machine filters</td>
<td>314</td>
</tr>
<tr>
<td>wood</td>
<td>258</td>
</tr>
<tr>
<td>construction waste (not pictured)</td>
<td>97</td>
</tr>
<tr>
<td>total weight</td>
<td>3167</td>
</tr>
</tbody>
</table>

1) grinding pads   2) food wrappers   3) recycled paper   4) glass   5) other   6) metals   7) plastic   8) plastic foam   F) filters   W) wood
Landfill Distribution by Weight (lbs.) and Category (General)

- Plastic: 37%
- Metal: 4%
- Glass: 1%
- Other: 58%
Landfill Distribution by Weight (lbs.) and Category (Detailed)

- Plastic: 29%
- Metal: 4%
- Other: 24%
- Recycled paper: 8%
- Wood: 8%
- Machine filters: 10%
- Grinding pads: 9%
- Plastic foam: 4%
- Food wrappers: 4%
- Construction waste: 3%
- Returnables: 0.333%
- Glass: 0.333%
Materials of Opportunity

- Plastics
  - High volume and weight
  - Venues available
- Compost
  - High weight
  - Will require continuing education and outreach to employees
  - New disposal source already implemented
- Other
  - High volume and weight
  - May require additional research
  - Includes PPE, food packaging, some packaging
    - Additionally includes grinding pads and filters
Moving Forward

• Monitor and observe waste stream changes
  – Continuous improvement
  – Gather employee feedback
  – Mini dumpster dives in the coming months

• Implement redesigned recycling system
  – Single stream planned, multi stream a future possibility
  – Receptacle layout/placement optimization
Questions?
Jarrah’s Utilization Optimization
New Material Control & Picking Systems Design

Marylin N. Glass-Angeles, I.E., E.M.
Nathan J. Christensen, E.S., Mfg.E.
Special thanks to Ryan Smith!
BACKGROUND

• Previous LF’s woodshop waste assessment
  – 65% scrap rate
• Focus on *Jarrah*!
• Recommend to sort through bundles
• Recommend to properly store the lumber
OBJECTIVES

• Develop a material control system
• Define communication requirements and order preparation operations
  – Picking procedure
• Optimize material usage
• Increase labor productivity
• Decrease labor, material handling, spoilage
• Guarantee safety
WOOD SORTING

• Problem: bundles opened in small batches
• Problem: requirements not considered
• Problem: optimizing wood yield not a priority
• Decision: sort all bundles?
• Recommendation: yes!
• Why? Due to variability in lengths within bundles
### WOOD SORTING

#### Data Analysis

**ANOVA: Count versus Bundle No., Cutoff Size**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Type</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle No.</td>
<td>random</td>
<td>6</td>
<td>1, 2, 3, 4, 5, 6</td>
</tr>
<tr>
<td>Cutoff Size</td>
<td>fixed</td>
<td>5</td>
<td>&gt;=59&quot;, 102&quot;, 118&quot;, 69&quot;/72&quot;, 96&quot;</td>
</tr>
</tbody>
</table>

Analysis of Variance for Count

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle No.</td>
<td>5</td>
<td>16.40</td>
<td>3.28</td>
<td>0.18</td>
<td>0.965</td>
</tr>
<tr>
<td><strong>Cutoff Size</strong></td>
<td>4</td>
<td>1232.80</td>
<td>308.20</td>
<td>17.33</td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td>Error</td>
<td>20</td>
<td>355.60</td>
<td>17.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>1604.80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 4.21663    R-Sq = 77.84%    R-Sq(adj) = 67.87%

**Grouping Information Using Tukey Method and 95.0% Confidence**

<table>
<thead>
<tr>
<th>Cutoff Size</th>
<th>N</th>
<th>Mean</th>
<th>Grouping</th>
</tr>
</thead>
<tbody>
<tr>
<td>118&quot;</td>
<td>6</td>
<td>19.000</td>
<td>A</td>
</tr>
<tr>
<td>69&quot;/72&quot;</td>
<td>6</td>
<td>17.167</td>
<td>A B</td>
</tr>
<tr>
<td>102&quot;</td>
<td>6</td>
<td>10.167</td>
<td>B C</td>
</tr>
<tr>
<td>96&quot;</td>
<td>6</td>
<td>4.167</td>
<td>C</td>
</tr>
<tr>
<td>&gt;=59&quot;</td>
<td>6</td>
<td>3.500</td>
<td>C</td>
</tr>
</tbody>
</table>

Means that do not share a letter are significantly different.
WOOD SORTING

Standard Operating Procedure

• Designated workers
• Data collection
• PPE’s
• Materials
• Steps
• Visual aids!
• Define new system
SYSTEM DESIGN
Organization
SYSTEM DESIGN
Part Numbers

Red = 6/4 x 8"
Blue = 6/4 x 6"
Green = 8/4 x 8"
Yellow = 8/4 x 6"

A: 59" = Range: ≤ 77"
B: 72" = Range: 78" - 107"
C: 96" = Range: 108" - 113"
D: 102" = Range: 114" - 129"
E: 118" = Range: ≥ 130"
SYSTEM DESIGN
Location
SYSTEM DESIGN
Location (Cont.)
SYSTEM DESIGN
Information Flow
“BEFORE & AFTER” STATES
Main Facility

NO

YES!

NO

YES!
“BEFORE & AFTER” STATES
Midlink

NO

YES!

NO

YES!
DATA ANALYSIS

- Proportions of each length within a bundle
- New purchasing strategies
- Accurate planning and scheduling activities
- 118+ pieces may match the demand for 59- and 96 boards

<table>
<thead>
<tr>
<th>Length</th>
<th>Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>59-</td>
<td>11%</td>
</tr>
<tr>
<td>72</td>
<td>35%</td>
</tr>
<tr>
<td>96</td>
<td>10%</td>
</tr>
<tr>
<td>102</td>
<td>17%</td>
</tr>
<tr>
<td>118+</td>
<td>26%</td>
</tr>
</tbody>
</table>
INVENTORY
ECONOMICS

• Savings estimated: US$ 246,800
• Inventory expected to last 2 years
• Production hours relieved: 5 ½ per day
• Board-feet relieved per board: at least 1
• Target scrap rate reduction: 11%
• Initial investment: US$ 26,156
• Payback: 2 ½ months
ECONOMICS

• Savings reclaim example
  – NEO ROMANTICO benches
    • (7) 69” long boards
  – Estimated savings per bench: $332
  – Units sold in 2011: 907
  – Total annual savings: $33,122
  – Just ONE type of bench!
• Validate the target scrap reduction by conducting a scrap rate re-assessment
• Continue to improve
  – Study 118+ long boards
  – Use new part numbers as a purchasing negotiation tool
  – Go from a manual to an electronic picking procedure
  – Part number definition within ERP system
    • Purchase as required (kanban)
    • Aid in better planning and scheduling
  – Reduce storage space requirements
Thank you for listening!

Questions???
Facilities Planning/Design

- Planning horizon, company goals
- Business growth in various departments
- Maintain effectiveness, efficiency
- Re-layout, re-arrangement of processes, machines and personnel
- Changes may highly impact the overall system
- Re-assess system, avoid inefficiency
LED Lighting Ergonomics Study

- Identify risks for long term ergonomic injuries in current assembly process
- Opportunities to reduce such risks
- Investigate potential associated costs of these risks
- Benefits of improving the ergonomic conditions for this job
- New operation, establish a baseline
Green Parking Lots

Sustainable Alternatives to Traditional Parking Designs

Nathan Christensen, Graduate Research Associate, E.S., Mfg.E.
Natalia Matos, Undergraduate Research Associate, I.E.
Content

• What is green parking design
• Traditional parking designs
• Sustainable parking designs
• Conclusion
Green Parking Lot Design

• Green parking lots are those “designed to do environmental work”
  – Reduce materials, energy, and land
  – Safely manage stormwater runoff and harmful contaminants
  – Promote the integration of natural vegetation
  – Limit the heat island effect
Traditional Parking Lot Designs

• Non-pervious surface
  – Redirects water to specific drainage points

• Commonly asphalt or concrete
  – Energy intensive materials

• Contributes to heat island effect
  – Absorbs and then releases solar heat, increasing temperature

• Generally cheaper but requires more maintenance

Can you tell which portion is porous and which portion is not?
Sustainable Parking Lot Designs

• Basic strategies
  – Minimize parking space and lot sizes
    • Allows more room for landscaping/green space
  – Shared parking areas with other local businesses
  – Integrate vegetation as a part of the parking lot
  – Cost: Variable on design
    • Generally cheaper, as less overall area and materials are required
Sustainable Parking Lot Designs

- Porous Surfacing Material
  - Asphalt, grid surfacing
  - Allows for immediate ground absorption of stormwater
  - Eliminates need for retention ponds and traditional stormwater management systems
  - Requires less maintenance
Sustainable Parking Lot Designs

- Bioretention
  - Heavy use of vegetation in parking lot designs
  - Sloped parking areas direct runoff into swales
  - Vegetation absorbs and filters the runoff
  - Can be partially integrated with porous designs
# Sustainable Parking Design Cost

<table>
<thead>
<tr>
<th>Design Type</th>
<th>Description</th>
<th>Limitations</th>
<th>Maintenance</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porous Concrete</td>
<td>Similar to traditional concrete. Finer material such as sand removed. Lifespan longer than porous concrete but shorter than traditional concrete. ~200 inches per hour infiltration.</td>
<td>Requires large area of application to be cost effective. Requires an overflow or release design.</td>
<td>Annual vacuuming, sweeping, or hosing of porous area.</td>
<td>$3-5 per ft.²</td>
</tr>
<tr>
<td>Porous Asphalt</td>
<td>Similar to traditional asphalt with finer material removed. Good for low load bearing surfaces. Life expectancy as long as or longer than traditional asphalt. ~200 inches per hour infiltration</td>
<td>Requires large enough area of application to be cost effective. Requires an overflow or release design.</td>
<td>Annual vacuuming, sweeping, or hosing of porous area.</td>
<td>$1-2 per ft.²</td>
</tr>
<tr>
<td>Grid System</td>
<td>Rigid plastic cells filled with stone or dirt. Lower infiltration rate than porous asphalt/concrete. Life expectancy of ~20 years. ~10 inches per hour infiltration</td>
<td>Typical uses include alleys, driveways, parking lots.</td>
<td>May require additional soil, seed, or stone. May require mowing.</td>
<td>$3-4 per ft.²</td>
</tr>
<tr>
<td>Inter-locking Pavers</td>
<td>Interlocking pre-cast blocks. Comparable infiltration to grid systems. ~10 inches per hour infiltration</td>
<td>Requires an overflow or release design.</td>
<td>Easy to repair and reset tile units. Periodically requires additional sand to replace worn material.</td>
<td>$2.50-4.50 per ft.²</td>
</tr>
</tbody>
</table>
Conclusions

• Sustainable parking designs can
  – Reduce cost over the long term
  – Limit heat island effect
  – Help effectively use storm water
  – Conserve energy and materials

• Sustainable parking challenges include
  – Increased initial cost
  – Additional design work and planning
Post Foods

Cleaning Water Reduction Project

GMIC Assessment Team
Brian Wummel, Project Manager
Michael Biro, Research Assistant (UEM)
Andrew Gabriel, Research Assistant (ChE)
Ana Perez, Research Assistant (ChE)
Bill DeKam, Research Assistant (ME)
• Goal: reduce cost of cleaning production equipment, focusing on water usage
• Equipment
  – Granola cooler, granola dryer, puffs FFD, rice cooler, rice dryer, rice multi-pass
• Method
  – Two rounds of observations were conducted on each piece of equipment
Observations

- Observation sheet
- Never a “normal” clean

<table>
<thead>
<tr>
<th>Step</th>
<th>Time</th>
<th>Action</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 hr</td>
<td>Spray down cooler &amp; floor</td>
<td>2 guns</td>
</tr>
<tr>
<td>2</td>
<td>2 hr</td>
<td>Spray bars on</td>
<td>Front and back</td>
</tr>
<tr>
<td>3</td>
<td>3 hr</td>
<td>Spray cooler &amp; floor</td>
<td>2 guns</td>
</tr>
<tr>
<td>4</td>
<td>.75 hr</td>
<td>Spray bars on</td>
<td>Front and back</td>
</tr>
<tr>
<td>5</td>
<td>.67 hr</td>
<td>Final rinse, cooler and floor</td>
<td>2 guns</td>
</tr>
</tbody>
</table>

Average Total Time: 5.5 hours (22% difference)

Obs. 1: 4.9 hours
Spray Gun use: 4.7 gun hr
Obs. 2: 6.03 hours
Spray Gun use: 4.8 gun hr
• PIDs need to be updated
• Preventive maintenance/cleaning
  – Use saved cleaning time
• Adjustments to current bars and nozzles
  – Aim at appropriate angles
• Timers for ACS
• Fix leaks
  – 2 seen wasting 180 gal

• Granola Cooler - 4 spray bars not shown, 9 spray balls shown, 5 present, 1 spray nozzle capped off, pump leaked
Recommendations

- Don’t use spray guns as brooms
- Replace “auto” spray guns with spray bars

<table>
<thead>
<tr>
<th>Spray Gun Use</th>
<th>Spraying Floor</th>
<th>Potential Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gallons</td>
</tr>
<tr>
<td>31 hours</td>
<td>4.5 hours</td>
<td>4,131 / cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>107,406 / yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spray Gun Use</th>
<th>Replaced by Bar</th>
<th>Potential Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gallons</td>
</tr>
<tr>
<td>31 hours</td>
<td>15.3 hours</td>
<td>9,455 / cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>245,830 / yr</td>
</tr>
</tbody>
</table>

- Spray rate for guns = 15.3 gal/min vs. 5 gal/min for spray bars
- One clean every 2 weeks
Recommendations

• Reduce cleaning time
  – No pre-soaks
  • Puffs FFD -> 36,000 gallons ($612) each

<table>
<thead>
<tr>
<th></th>
<th>Granola Dryer</th>
<th>Granola Cooler</th>
<th>Puffs FFD</th>
<th>Rice Grit / Curing Bin</th>
<th>Rice Multi-pass</th>
<th>Rice Cooler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs. 1</td>
<td>6.5 hr</td>
<td>4.5 hr</td>
<td>5.3 hr</td>
<td>6.3 hr</td>
<td>4.9 hr</td>
<td>4.9 hr</td>
</tr>
<tr>
<td>Obs. 2</td>
<td>2.2 hr</td>
<td>4.2 hr</td>
<td>4.5 hr</td>
<td>7.0 hr</td>
<td>5.9 hr</td>
<td>6.0 hr</td>
</tr>
<tr>
<td>Difference</td>
<td>4.3 hr</td>
<td>0.3 hr</td>
<td>0.8 hr</td>
<td>0.7 hr</td>
<td>1.0 hr</td>
<td>1.1 hr</td>
</tr>
<tr>
<td>Potential Hrs.</td>
<td>8.2 hr</td>
<td>Yearly</td>
<td>213 hrs</td>
<td>$6000 misplaced labor</td>
<td>$6000 misplaced labor</td>
<td></td>
</tr>
</tbody>
</table>

- Average difference between cleans -> 23% (ranges from 6% - 66%)
- 5 of 12 cleans performed with fewer than “normal” number of workers
• **Signage**
  
  – Reduce cleaning times
  – Prevent leaks (180 gallons)
  – Reinforce Lock-out Tag-out procedures (2 incidents)
• Hot and cold water options
  – Hot water regularly runs out during cleans
  – Use hot water for 1\textsuperscript{st} hour of clean

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Workers</th>
<th>Time (Min)</th>
<th>Gallons of Water</th>
<th>Cost of Heating ($)</th>
<th>Water Cost ($)</th>
<th>Sewage Cost ($)</th>
<th>Labor Cost ($)</th>
<th>Total Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granola Dryer</td>
<td>2</td>
<td>275</td>
<td>4,208</td>
<td>61</td>
<td>11</td>
<td>12</td>
<td>257</td>
<td>340</td>
</tr>
<tr>
<td>Granola Cooler</td>
<td>1</td>
<td>225</td>
<td>3,443</td>
<td>50</td>
<td>9</td>
<td>10</td>
<td>105</td>
<td>173</td>
</tr>
<tr>
<td>Puffs FFD</td>
<td>3</td>
<td>210</td>
<td>3,213</td>
<td>47</td>
<td>8</td>
<td>9</td>
<td>294</td>
<td>358</td>
</tr>
<tr>
<td>Rice Multi-Pass</td>
<td>2</td>
<td>1,230</td>
<td>18,819</td>
<td>273</td>
<td>47</td>
<td>53</td>
<td>1,148</td>
<td>1,522</td>
</tr>
<tr>
<td>Rice Curing</td>
<td>2</td>
<td>190</td>
<td>2,907</td>
<td>42</td>
<td>7</td>
<td>8</td>
<td>177</td>
<td>235</td>
</tr>
<tr>
<td>Rice Cooler</td>
<td>2</td>
<td>280</td>
<td>4,284</td>
<td>62</td>
<td>11</td>
<td>12</td>
<td>261</td>
<td>346</td>
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</table>
## Savings Summary

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Implementation Cost</th>
<th>Savings (annually)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Water (gal)</td>
<td>Time</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>No spraying floor</td>
<td>$0</td>
<td>107,406</td>
<td>--</td>
<td>1,826</td>
<td></td>
</tr>
<tr>
<td>No pre-soak</td>
<td>$0</td>
<td>936,000</td>
<td>--</td>
<td>15,912*</td>
<td></td>
</tr>
<tr>
<td>Time reduction</td>
<td>$0</td>
<td>195,534</td>
<td>213</td>
<td>3,324**</td>
<td></td>
</tr>
<tr>
<td>Signage (LoTo, time)</td>
<td>$500</td>
<td>4,680</td>
<td>156</td>
<td>80</td>
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</tr>
<tr>
<td>New spray bars</td>
<td>TBD</td>
<td>245,830</td>
<td></td>
<td>4,179</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>Time from above</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>Hot/cold control</td>
<td>TBD</td>
<td>--</td>
<td>--</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>New technology</td>
<td>TBD</td>
<td>--</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycle water</td>
<td>TBD</td>
<td>--</td>
<td>--</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*assuming every Puffs FFD clean has a “pre-soak”

**labor costs not “saved” but re-directed
Next Steps

• Complete Report and Presentation
• Follow up with detailed engineering projects
  – New spray bars
  – Hot / Cold water
  – **Signage** or Lean techniques
  – New technologies
    • Dry ice blasting, high pressure water jets
• Waste water
  – Reduce sewage costs

<table>
<thead>
<tr>
<th>Number of Days In the Month:</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FLOW-MG</td>
</tr>
<tr>
<td>MONTHLY TOTAL</td>
<td>6.4670</td>
</tr>
<tr>
<td>DAILY AVG.</td>
<td>0.2086</td>
</tr>
</tbody>
</table>
• New Member, Fall 2012
• Initial Project
  – Indoor Air Quality Rapid Testing Methods
    • Starting with formaldehyde
      Team
    • Dr. Andre Venter, Chemistry WMU
      – Gregg Hasman, Graduate Student
    • Randy Carter and Kari Luth from Steelcase
    • Independent testing laboratory
Poly-Wood

• New member, Fall 2012
• Furniture and plastic lumber manufacturer
• Assessment approach
  – Established connection with IAC in Indiana (Purdue)
  – Began GMIC assessment
    • Energy usage (product cooling)
    • Material waste
    • Lean and Quality
Agenda

• Break
• Project Presentations Continued
  – GMI Sponsored Projects
    • ISO 50001
    • Waste Powder Paint
    • Oven Heat Seal
    • Green Scoreboard
• Fabri-Kal
• Lunch
Benefits of ISO 50001 Implementation

John Ihling
Undergraduate Research Assistant
Green Manufacturing Initiative
Western Michigan University
Overview

• Description
• Benefits of Implementation
• ISO 50001 vs Other Standards
• Plan-Do-Check-Act
• Implementation Checklist
• Success Stories
• Thank You
Description of the Standard

• Published by International Organization for Standardization (ISO) in June, 2011
• Designed solely for the management of energy
• Can be implemented by any company
  – Industrial Plants, Commercial Facilities, Office Buildings
Benefits of ISO 50001

• Provides a framework for the implementation of an efficient energy management system (EnMS)

• Evaluates and prioritizes building operations based on energy consumption

• A well-designed EnMS, along with a strongly engaged workforce, will yield substantial energy savings for your organization

• Certified facilities are recognized as world class leaders in energy management
ISO 50001 vs
Other ISO Standards

• *Deming’s Plan-Do-Check-Act* is the basis for ISO 50001, ISO 140001, as well as ISO 9001

• Fully Integratable with *ISO 140001* systems

• *Follows the ‘Continual Improvement’* Framework that makes Energy Management part of daily operations.
Plan: Conduct the energy review of the facility and establish the baseline, energy performance indicators (EnPIs), objectives, targets and action plans necessary to deliver the desired results.

Do: Implement the energy management action plans

Check: Monitor and measure the processes and key characteristics of operations that determine energy performance

Act: Take actions to continually improve both energy performance and the EnMS
Implementation Checklist

1. Secure Support from Top Management
2. Purchase the ISO 50001 Standard
3. Assemble an Energy Management Team
4. Conduct Training
5. Perform a Gap Assessment
6. Implement the Energy Management System
7. Continually Improve System
Success Stories

• St. Mary’s Cement
  – The first company in North America to reach certification

• Volvo Trucks
  – Achieved 25% energy performance improvement during the three year period after establishing a baseline

• Subaru Indiana
  – 2% reduction of electricity usage in 1 year

• Cook Composites and Polymers
  – Reached energy performance improvement of 14% over the first 2 years, attaining $250,000 savings per year

• Freescale Semiconductors
  – Return $2 million dollar per year in savings from 2006-2009 by implementing an Energy Management System
Thank You

Questions?
Waste Powder Paint

• Waste Powder Paint User Group
  – The Right Place, MMTC, WMU/GMI, Herman Miller, Haworth, Light Corp., American Seating

• Initial Testing
  – Combustion
    • Energy Content (19,000 J/g), similar to coal (20,000 J/g), 30% residue
    • Emits CO₂
  – Solubility
  – Spectroscopy
  – Particle Size
Research Projects

- Transfer Efficiency
  - Dr. Venter, Chemistry WMU
  - Experiments planned for mid-November

- Concrete Products
  - Dr. Attanayake, Civil Eng. WMU
  - Experiments began in October
    - Wet-caste experiments
    - Leach testing
The use of waste powder paint (WPP) in cement-based products (wet-casting)

Upul Attanayake, PhD, PE
Assistant Professor

Team Members:
Rusthi Mohamed Ibralebbe - Graduate Assistant
Abdul Wahed Mohammed - Graduate Assistant
Payam Aminay - Graduate Assistant
Matthew Moran - Undergraduate Assistant
Introduction

- Powder paint is used in automotive and furniture industries.
- Approximately 1.5 million pounds per year of waste powder paint (WPP) is accumulated from six companies involved in the survey performed by the Green Manufacturing Initiative.
- WPP can be discarded into landfills or recycled.
- Degradation of re-processed polymer and waste exceeding the capacity of the outlets are the challenges in recycling process.
Potential Applications of WPP

- Can be used in masonry or concrete industry as a cement replacement or property modifier.
- WPP is a combination of different polymers

- Polymers in cement-based products
  - Polymeric chemical admixtures used to alter fresh concrete properties
  - Polymer modified cement or concrete with improved performance

- The use of WPP in cement-based product
  - Can be used as a polymeric admixture to improve the fresh and hardened properties
  - Can be used as an additive to improve the strength and durability properties

Source: GMI 2011
Particle size distribution

- Virgin powder paint - 54 μm (mean value)
- Waste powder paint - 37 μm (mean value)
- Cement – 95% of particles are smaller than 45 μm and the average particle size is around 15 μm

Source: GMI 2011
To investigate the influence of physical and chemical properties of material, operation procedures and methods, and exposure conditions on the reaction of the constituents used in cement based products and the properties of the final product (fresh, hardened, and durability properties).
# Detailed Breakdown

<table>
<thead>
<tr>
<th>Materials</th>
<th>Mixing and Handling and Exposure condition</th>
<th>Reaction (WPP + Cement mixture)</th>
<th>Final product</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waste powder paint</strong>&lt;br&gt;Physical properties (powder form)&lt;br&gt;- Particle size distribution&lt;br&gt;- Particle shape&lt;br&gt;- Surface properties</td>
<td>Mixture proportions / Mix design&lt;br&gt; Mixing equipment&lt;br&gt; Transportation equipment&lt;br&gt; Placement methods and equipment&lt;br&gt; Curing methods/requirements&lt;br&gt;- wet curing&lt;br&gt;- steam curing&lt;br&gt;- curing duration&lt;br&gt;- curing temperature</td>
<td>WPP particle dispersion and distribution&lt;br&gt; Influence and interaction of WPP during the cement hydration process and products&lt;br&gt; Reaction of WPP as a polymer&lt;br&gt;- Admixture polymers&lt;br&gt;- Polymer-modified concrete</td>
<td><strong>Fresh properties</strong>&lt;br&gt;- flowability/workability&lt;br&gt;- setting time&lt;br&gt;- heat of hydration&lt;br&gt;- volume change&lt;br&gt;- air content&lt;br&gt;- unit weight</td>
</tr>
<tr>
<td>Chemcial properties&lt;br&gt;- Surfactants and other additives</td>
<td><strong>Hardened properties</strong>&lt;br&gt;- rate of strength gain&lt;br&gt;- flexural strength&lt;br&gt;- tensile strength&lt;br&gt;- density&lt;br&gt;- porosity/permeability&lt;br&gt;- modulus of elasticity&lt;br&gt;- bond strength&lt;br&gt;- resistivity&lt;br&gt;- shrinkage&lt;br&gt;- creep&lt;br&gt;- soundness&lt;br&gt;- void parameters</td>
<td><strong>Durability properties</strong>&lt;br&gt;- freeze/thaw resistance&lt;br&gt;- chemical resistance&lt;br&gt;- volume stability&lt;br&gt;- thermal properties&lt;br&gt;- leaching behavior&lt;br&gt;- absorption&lt;br&gt;- permeability&lt;br&gt;- Crack bridging behavior&lt;br&gt;- Water repellency&lt;br&gt;- Abrasion resistance</td>
<td></td>
</tr>
<tr>
<td><strong>Cement</strong>&lt;br&gt;- Physical and chemical properties</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Research Plan by Task

- **State-of-the-art literature review**
  - State-of-practice of using polymer based material in cement base products
  - State-of-practice of using waste powder paint in cement-based products
  - Review cement and waste powder paint chemistry

- **Testing for fresh and hardened Properties**
  - Mix waste powder paint in dry form with 5, 10, 15, 20 % powder-cement ratio by weight and test for fresh and hardened properties of cement paste and mortar. Understand the interaction and potential effects on fresh and hardened properties.
  - Develop a solution based waste powder paint mixture to be used in cement-based products. Identify a suitable solvent. Mix in liquid form and reevaluate fresh and hardened properties to identify the optimum mix.
  - Employ microscopic and testing methods to evaluate the microstructure
  - Employ other testing methods to evaluate physical and chemical properties of mixture ingredients

- **Data analysis and results interpretation**
  - Use test data to explain material interaction

- **Summary, conclusions, and recommendations**
Current Status of Cement Mortar Testing

<table>
<thead>
<tr>
<th>Property</th>
<th>American Society for Testing and Materials (ASTM) Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive Strength</td>
<td>ASTM C192, ASTM C305, and ASTM C109</td>
</tr>
<tr>
<td>Absorption</td>
<td>ASTM C173</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>ASTM C596</td>
</tr>
<tr>
<td>Setting Time</td>
<td>ASTM C191</td>
</tr>
<tr>
<td>Temperature</td>
<td>ASTM C1074</td>
</tr>
</tbody>
</table>

**Mix proportions:**

Water-Cementitious material ratio = 0.45,
WPP = 0%, 5%, 10%, 15%, and 20% of cement replacement
Current Status of Cement Mortar Testing

Compressive Strength

**Specimen molds**

**2 in. cube specimens preparation**

**Specimen curing**

**Shrinkage**

**Specimen molds**

**Specimen preparation and testing**

**Setting Time**

**Test setup – Vicat apparatus**
Waste Powder Paint
User Group

Dr. Upul Attanayake
Brian Wummel
Tyler McMillin
Alexey Gavrunov
Problem

OBJECTIVE: Waste Powder Paint (WPP) for controlling efflorescence in masonry blocks

WASTAGE → INDUSTRY USEABLE COMMODITY

currently no use for the waste powder paint caused by many manufacturing practices

INCINERATION

WPP

HARD TO RECYCLE due to the colors becoming mixed and mixing with dirt and other impurities

WPP is being investigated as an additive or filler for concrete applications.
Tests are ongoing on the effects of WPP as a concrete additive.

Currently, concrete containing WPP is being tested to be used to counter efflorescence development.

The two tests that are in trial are leach testing and absorption testing.

The beneficial potential of WPP as a concrete additive is being tested to divert the WPP from landfill.

Results will be used to determine what applications can potentially use the WPP mixed concrete.
Specimens

CONCRETE BLOCKS:
- 3 blocks with WPP composition 1 mix A
- 3 blocks with WPP composition 1 mix B
- 3 blocks with WPP composition 2 mix A
- 3 blocks with WPP composition 2 mix B
- 3 blocks with WPP composition 3 mix A
- 3 blocks with WPP composition 3 mix B
- 6 blocks without WPP

CONTAINERS:
- 12 plastic containers with lids
- 4 plastic buckets

OTHER:
- Epoxy and an epoxy gun
- Box fan
- Weather station
SUMMARY:

✓ Measure weights of each block, container, and amount of water
✓ Place each block in the container with de-ionized water
✓ Keep the blocks in a setup for seven days
✓ The blocks are allowed to dry and observed for efflorescence
✓ Measure the blocks weights

Test ran for two weeks
  1 week of 1” water level
  1 week of 3” water level

OBSERVATIONS:
Efflorescence development was seen on the samples of mix B
Absorption Testing

SUMMARY:
- Measure weights of each block
- Place each block in the containers with de-ionized water
- Keep the blocks in a setup for 24 hours
- Make them saturated surface dry
- Measure the blocks weights
- Place the blocks in an oven
- Measure weights after removing

EXPECTED RESULTS:
This will give us results as to how much water is able to infiltrate into the samples, furthering our results on leaching, since efflorescence development is directly correlated to the water infiltrating the samples
Thank you

Questions?
Energy Saving Improvements for Industrial Ovens
Project Update

GMI/GMIC Semi-annual Meeting
11/06/2012

James Martlew
William Dekam
Gary Nola, Graduate Student
Project Overview

• Problem description and motivation
• Project goal and objectives
• Previous work and accomplishments
  – Computational
  – Experimental
• Progress since last meeting
• Ongoing work
Problem Description

- Heat escapes through oven door openings
- Current solutions lack analytical foundation
Motivation

• Energy savings
• Cost savings
  – Production often runs 20hrs/day, 365 days/year
• Increase worker comfort
• Ease of implementation

Modeled Temperature Profile
Overall Goal and Objectives

• Goal:
  – Demonstrate a method for reducing energy consumption in industrial ovens through air seal optimization

• Objectives
  – Develop an analytical approach to predict oven performance
    • Computational tools
  – Validate the proposed model with field data
    • Experimental tools
  – Evaluate changes to oven configuration
    • Design of experiments
    • Minimize energy use and cost of implementation
Previous Work and Accomplishments – Computational

• Experimental and computational efforts have proceeded in parallel
• Developed 3D model of industrial oven using computational fluid dynamics software
• Reproduced heat loss through oven door
  – Missing boundary conditions
  – Limited by computer power
Previous Work and Accomplishments – Computational
Previous Work and Accomplishments – Experimental

• Measured spatial (2D) temperature distribution at the oven exit using in-house developed measuring tool.
Progress Since Last GMI Meeting-Computational Work

• Secured funds to purchase a high power computer
  – Capable of running complex Fluent simulations

• Optimized mesh
  – Research license of ANSYS purchased
  – Increases accuracy of model
Progress Since Last GMI Meeting-Experimental Work (1)

- Focused on measuring velocity boundary conditions
  - Velocity at nozzle exit
  - Determine the most accurate turbulence model
- Measured air velocity at jet exits

[Bar charts showing frequency of jet velocity for conical and rectangular jets]
Particle Image Velocimetry

- Experimental technique used to measure fluid flow

![Diagram of Particle Image Velocimetry setup](image)

- Scaled nozzle
- Laser and optics
- High-speed camera
Progress Since Last GMI Meeting-Experimental Work (2)

• Developed bench-top experimental setup to evaluate turbulence models
Ongoing Work

- Finalize measurements of jet velocity using bench-top setup
  - Select most effective turbulence model for practical oven
- Run CFD simulation to predict thermal transport in actual oven
- Conduct parametric study to optimize oven seal performance
Acknowledgments

We would like to thank:

• Mark Lindquist and Rapid-Line
• Dr. Cluadia Fajardo
• The Green Manufacturing Initiative
• The Office of the Vice President of Research for granting us the Undergraduate Research Excellence Award
• OVPR FRACAA
### Green Scoreboard

<table>
<thead>
<tr>
<th>Company</th>
<th>Project Description</th>
<th>Investments</th>
<th>Annual Savings</th>
<th>Simple Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armstrong International*</td>
<td>Efficiency of Overhead Doors</td>
<td>$5,100</td>
<td>$28,439</td>
<td>2 Months</td>
</tr>
<tr>
<td>Borroughs Corporation*</td>
<td>Forklift Battery Pack and Charger¹</td>
<td>$33,000</td>
<td>$29,530</td>
<td>13 Months</td>
</tr>
<tr>
<td></td>
<td>Application of Wind and Solar²</td>
<td>$56,000</td>
<td>$--------</td>
<td>N/A</td>
</tr>
<tr>
<td>Company A</td>
<td>Reusing Waste Food Stream as Biomass Fuel</td>
<td>$1,380,000</td>
<td>$442,307</td>
<td>37.5 Months</td>
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<tr>
<td>Ottawa Gage*</td>
<td>Redesign of Chemical Controls</td>
<td>$7,500</td>
<td>$5,000</td>
<td>18 Months</td>
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<tr>
<td>Rapid-Line</td>
<td>Transformer Consolidation</td>
<td>$0</td>
<td>$1,500</td>
<td>N/A</td>
</tr>
<tr>
<td>Herman Miller</td>
<td>Steam Drives</td>
<td>$97,500</td>
<td>$94,800</td>
<td>12.3 Months</td>
</tr>
<tr>
<td>Landscape Forms</td>
<td>Assessments</td>
<td>$122,678</td>
<td>$615,939</td>
<td>3 Months</td>
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<tr>
<td></td>
<td>Jarrah Optimization</td>
<td>$26,000</td>
<td>$247,000</td>
<td>2.5 Months</td>
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<tr>
<td>Fabri-Kal</td>
<td>Assessments</td>
<td>$188,055</td>
<td>$248,471</td>
<td>10 Months</td>
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<tr>
<td></td>
<td>Oven Study</td>
<td>$32,000</td>
<td>$103,000</td>
<td>3.7 Months</td>
</tr>
<tr>
<td></td>
<td>Heat Recovery</td>
<td>$500,000</td>
<td>$120,000</td>
<td>48 Months</td>
</tr>
<tr>
<td></td>
<td>Waste Exchange</td>
<td>$0</td>
<td>$12,000</td>
<td>0 Months</td>
</tr>
<tr>
<td>Post</td>
<td>Oven Study</td>
<td>$2,000</td>
<td>$110,000</td>
<td>0.2 Months</td>
</tr>
<tr>
<td></td>
<td>Water Reduction</td>
<td>$5,000</td>
<td>$25,000</td>
<td>2.4 Months</td>
</tr>
<tr>
<td></td>
<td>Landfill Audit</td>
<td>$12,000</td>
<td>$40,000</td>
<td>3.6 Months</td>
</tr>
</tbody>
</table>

- Can be found at the GMI website

<table>
<thead>
<tr>
<th>Total Investments</th>
<th>Total Annual Savings</th>
<th>Total Project Simple Payback</th>
<th>Temporary Jobs Created or Sustained¹</th>
<th>Average Project Investment</th>
<th>Average Annual Project Savings</th>
<th>Average Project Simple Payback</th>
<th>Permanent Jobs Created or Sustained²</th>
<th>Average Project Simple Payback</th>
<th>Permanent Jobs Created or Sustained²</th>
<th>Average Project Simple Payback</th>
<th>Permanent Jobs Created or Sustained²</th>
</tr>
</thead>
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<td>$154,177</td>
<td>$141,532</td>
<td>13.1 Months</td>
<td>61</td>
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</tbody>
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Fabri-Kal: Waste Heat Reclalm

Green Manufacturing Industrial Consortium: Engineered Solutions

Ana Perez, William DeKam
Brian Wummel
Dr. Dave Meade
8/10/2012
Project Description

• Waste heat that is normally exhausted to the atmosphere through an evaporative cooling tower is looked to be reclaimed.
• Waste heat recovery offers a chance to improve energy efficiencies and save money.
Process Flow Diagram

Chiller

C-Cold
C-Hot

T3

T2
T4

T6

T1

T5

C1

C2

C3
C4

C5
C6
Technology Review

Energy Conversion Technologies:
• Thermoelectric Generator
• Stirling Engine
• Organic Rankine Cycle
• Kalina Cycle

Other Technologies:
• Variable Frequency Drives
• SGS Green Box Fluid Cooler
Thermoelectric Generator

- **Seebeck Effect**
  - Converts Temperature Difference $\rightarrow$ Electrical Energy
- **Efficiencies <10%**
- **Temperature difference of 10-15 °F creates mV**
- **Needs large temperature differences to create a significant amount of energy**
Stirling Engine

• Stirling Cycle
• Invented in 1800
• Temperature Difference $\rightarrow$ Mechanical Work
• Highly Inefficient
• Operates best with temperatures in 600-800 °C (1112-1472 °F)
Organic Rankine Cycle

Similar to Steam Cycle but uses Organic Compounds (Refrigerants)

Best within 200-300 °F range
- Can operate at lower temperatures but depends on organic compound

HCFC 123 can be used
- B.P. = 81 °F
- Phased out by 2020

Not new so not as expensive
Kalina Cycle

Similar to steam cycle but uses ammonia/water mixture

Ammonia is highly corrosive → High Alloy Stainless Steel

Wasabi Energy owns 95% of the intellectual property and licenses out manufacturing rights → Currently an expensive technology to implement
Potential Cost Saving Projects

1. Heat reclaim for Make-Up Air Preheating
2. Organic Rankine Cycle
3. Installation of:
   a) Sterling Green Solutions fluid cooling system
   b) Variable frequency drives on current cooling towers
Waste Heat Reclalm for Make-Up Air Preheating

- Review and recalculation of IAC review
- Reduced natural gas bill during colder months
- Potential Consumers Energy Incentives
- ROI of less than 3 years
Organic Rankine Cycle
Thermal-Electrical Energy Conversion

Preliminary Calculations
- 1.46 MM kWh/yr
- $117,000/yr in Electrical savings

Implementation Cost = $500,000
- 2 Heat Exchangers
- Turbine
- Gearbox
- Generator
- Controller

Payback Period = 4.3 years

Contact Infinity Turbine for other turbine options
Sterling Green Solutions: Green Box

- Replaces Current Evaporative Cooling Towers
- Closed Loop Design Offers Savings by:
  - Eliminating all Chemical Additives ($30K/yr)
  - Utilizing VFDs to Minimize Energy Usage
  - Offers "Free Cooling" to Reduce Chiller Use
  - Reducing Water Consumption by up to 95%

A site visit by Sterling Green Solutions could provide potential savings and an accurate ROI
Installation of VFDs

Variable Frequency Drives (VFDs) allow for the precise control of cooling tower fans

- Reduces Energy Loads
- Increases System Lifespan (fans, belts, bolts)
- Eligible for Consumers Incentive Program

![Graph showing energy savings with VFDs](image-url)
Conclusions

Each of the options presented offer varying savings potential including:

- Reduced Electricity Use
- Reduced Natural Gas Use
- Eliminating Chemical Additives
- Decrease Maintenance/Downtime

Before any project is undertaken a complete review by Fabri-Kal staff or a professional engineer is recommended. The recommendations given here are based on the assessment of GMIC employees.
Agenda

• 12:00 to 12:30    Lunch
• 12:30 to 2:00    GMIC Business Meeting
GMI/GMIC Meeting
November 2012
GMIC Member Meeting

- Approval of Minutes from May
- MOU updates
- Budget Update
- Project Proposal Discussion
- Year-three Planning
- Open Discussion/Open Issues
MOU 2012 Updates

• No additional changes since last meeting
• 2013 MOU’s will be included with initial invoice
• 2013 Invoicing cycle to begin in December – thanks for your payments
Budget Review

• $62,000 remaining of first $150,000 ($125,000 received)
• Significant portion of student costs have been covered by the DOE grant
• Cycle for Year 3 memberships begins January 1
  – F-K & Landscape - January 1
  – Post – March 1
  – Steelcase & Poly-Wood - TBA
Project Proposals

• Members chose in November to continue with individual projects for 2012

• Expanded resources 2012:
  • Brian Wummel, Research Coordinator – started January
  • Marylin Glass, PhD Student, started January
  • 2-3 additional undergrads (8-10 total currently)
  • New Faculty:
    – Andre Venter – Chemistry
    – Laila Cure, Tycho Fredericks, Azim Houshyar, Bob White – Industrial Engineering
    – Upul Attanayake – Civil Engineering
    – 10-12 active now
Year Two Planning
Research Brainstorming

• Current Focus:
  • Continue to recruit members
  • Continue current projects for all members
  • Complete assessments and select project for Poly-Wood
  • Begin Round-Robin member site visits

• Select joint project(s) for 2013 ??
Open Discussion/Open Issues

Around the Room - Pros/Cons:
  What’s working?
  What’s not working?
Thanks for coming

The GMIC’s success is dependant on your support and involvement