Welcome

Green Manufacturing Industrial Consortium
Semi-Annual Meeting
April 2, 2013

Member Companies:

Steelcase
landscapeforms®
POLYWOOD®
FK
Post

Western Michigan University
College of Engineering and Applied Sciences
Manufacturing Research Center
Welcome
Associate Director’s Report
David Meade, Ph.D.
Welcome

• Thanks for attending
  • Visitors – potential members, and allies
  • Media – help us spread the word
  • Students – potential research team members
  • Members – engine behind the “consortium”
Our Mission

The Green Manufacturing Industrial Consortium (GMIC) has a three part mission:

1. To support advancement in manufacturing practice through the creation of more energy efficient and environmentally benign processes and products while enhancing productivity and sustaining or increasing output.

2. To provide a forum for manufacturers to coordinate research and share results, while leveraging R & D funding, at the pre-competitive stage.

3. To engage engineering students in meaningful applied research activities aimed to enhance their value to future employers.

*Pursuing Environmental, Energy, and Economic opportunities in partnership with Industry*
Outline

• Membership Update
  • Current Status/Recruiting Efforts
  • Funding Update
  • Non-Member Projects

• Action Items
  • Updates from November
  • New Items
Membership Update

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

• Recruiting/Marketing:
  – DENSO (Project underway)
  – 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 GR based Zero Waste to Landfill User Group (ZWL)
  – Invited Speaker at the Michigan Recycling Coalition Annual Meeting, May 7-9, 2013
  – Invited Speaker at MiFood 2013-Food Processing & Agribusiness Summit May 16, 2013
  – Continue to spread the word through media
Western Michigan University initiative translates research into savings

Written by Joe Boomgaard

KALAMAZOO — Managers at busy manufacturing companies have to find a balance between the work they need to do to get product out the door every day and the work they should do to ensure their operations are running efficiently.

For many, sustainable manufacturing practices often fall into the latter category.

WMU’s Green Manufacturing Initiative

By Joe Boomgaard | TBL
jboomgaard@mibiz.com

Many companies, particularly in the office furniture and other manufacturing industries, made the shift away from solvent-based wet coating to powder coating, a way to cut emissions and waste. Powder coatings stick to the workpiece instead of going down the waste stream. The coating process also poses less of a safety hazard than the solvents used to apply wet coatings.

Rapid-Line focuses on energy overhead

WYOMING — Rather than worry about business factors he cannot control, Mark Upham, president of Rapid-Line Inc., has set his sights squarely on a common target — energy usage.

Please login or register to read the full article. It’s FREE and it only takes a minute!
• Continue to joint market with the Manufacturing Technology Center (MMTC) EPA’s E3 Program (Economy, Energy, and Environment)

• NEW - partnership with the Michigan Department of Environmental Quality (MDEQ) – Office of Environmental Assistance
  – Intern funding and technical resources from the Retired Technical Assistance Program (RETAP)

$30,061.00
MDEQ Opportunity

- $30,061 to support “interns”
- 50/50 match
- Energy and/or solid waste reduction focus
- Fosters engagement with the Retired Technical Professional Program (RETAP)
- Criteria:
  - Available to small-mid sized companies with a Michigan operation
  - IAC (Industrial Assessment Center) or GSN (Green Supplier Network) identified or similar WMU identified P2/E2 (Pollution Prevention/Energy Efficiency) projects at three or more West Michigan manufacturers that are participants in the E3, GSN or are a C3 (Clean Corporate Citizen) or MBP3 (Michigan Business Pollution Prevention Partnership) program participant or supplier to such a company.
Action items from last update

• Continue to recruit members – need 1 additional to achieve critical mass financially but prefer 3+
• Complete Polywood Assessment Process and select first project
• Identify new projects for Fabri-Kal and Post
• Continue progress on Steelcase and Landscape Forms projects
• GMIC Operational Planning in absence of DOE Funding
• Continue to recruit team members and assemble research teams to support new research projects
Questions?

Thank You
Today’s Agenda
About Polywood, Inc.

- Newest GMIC Member
- 120 Full-Time and 20 Seasonal Employees
- Privately Held
- Located in Syracuse, IN
- Founded in 1990

“Poly-Wood, Inc. is an organization led by entrepreneurs guided by a passion to create and deliver intelligently designed outdoor performance furnishings that fundamentally improve the lives of consumers and encourage stewardship, favorably impacting future generations.”

What Does Polywood Do?

[Image of bottles being recycled]

[Image of a table made from recycled materials]

Polywood, Inc.
Energy Assessment – Oven Heat Study

John Ihling, Under
Erich Stuedemann
Ana Perez
Outline

• Current Operation
• Energy Losses
• Drying Oven
• IR Oven
• Curing Oven
• Recommendations
• Future Research
Current Process Operation

- 8.5 Hrs/day
- 250 Days/yr
- Line moves at 6 ft/min
- HVAC System
  - Rely on ovens to heat facility
Energy Losses

- Load Factor
- Heating Air
- Radiation Losses due to Opening
- Radiation Losses through Walls
- Convection/Conduction Losses
- Future Calculations
Drying Oven 3D
Drying Oven Operation

<table>
<thead>
<tr>
<th>Section</th>
<th>Side (°F)</th>
<th>Top (°F)</th>
<th>Internal Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>82</td>
<td>84</td>
<td>220</td>
</tr>
<tr>
<td>2</td>
<td>91</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>133</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>92</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>79</td>
<td></td>
</tr>
</tbody>
</table>

Approx. Volume (ft³) | Air Flow Rate (lb/hr)
1550                | 350
# Drying Oven Heat Losses

<table>
<thead>
<tr>
<th>Heat Loss</th>
<th>Btu/hr</th>
<th>CF/hr</th>
<th>Cost ($/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Load</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Heating Air</td>
<td>15,480</td>
<td>15.0</td>
<td>$0.16</td>
</tr>
<tr>
<td>Opening Radiation Losses</td>
<td>4,030</td>
<td>3.9</td>
<td>$0.04</td>
</tr>
<tr>
<td>Wall Radiation Losses</td>
<td>7,030</td>
<td>6.8</td>
<td>$0.07</td>
</tr>
<tr>
<td>Convection/Conduction</td>
<td>3,240</td>
<td>3.2</td>
<td>$0.03</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>29,780</td>
<td>28.9</td>
<td>$0.30</td>
</tr>
<tr>
<td><strong>Annual</strong></td>
<td></td>
<td></td>
<td><strong>$637.50</strong></td>
</tr>
</tbody>
</table>
IR Oven 3D
## IR Oven

<table>
<thead>
<tr>
<th>Section</th>
<th>Side (°F)</th>
<th>Top (°F)</th>
<th>Internal Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>108</td>
<td>800</td>
</tr>
<tr>
<td>2</td>
<td>98</td>
<td>108</td>
<td>777</td>
</tr>
<tr>
<td>3</td>
<td>98</td>
<td>108</td>
<td>748</td>
</tr>
</tbody>
</table>

### Dimensions
- 7 (ft) x 7 (ft) x 7 (ft)

### Approximate Volume and Air Flow Rate
<table>
<thead>
<tr>
<th>Approx. Volume (ft³)</th>
<th>Air Flow Rate (lb/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1094</td>
<td>245</td>
</tr>
</tbody>
</table>
## IR Oven Heat Losses

<table>
<thead>
<tr>
<th>Heat Loss</th>
<th>Btu/hr</th>
<th>kWh</th>
<th>Cost ($/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Load</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Heating Air</td>
<td>41,640</td>
<td>12.20</td>
<td>$1.45</td>
</tr>
<tr>
<td>Opening Radiation Losses</td>
<td>179,750</td>
<td>52.68</td>
<td>$6.26</td>
</tr>
<tr>
<td>Wall Radiation Losses</td>
<td>4,450</td>
<td>1.30</td>
<td>$0.15</td>
</tr>
<tr>
<td>Convection/Conduction</td>
<td>2,550</td>
<td>0.66</td>
<td>$0.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>228,390</td>
<td>66.84</td>
<td>$7.94</td>
</tr>
<tr>
<td><strong>Annual</strong></td>
<td></td>
<td></td>
<td><strong>$16,900</strong></td>
</tr>
</tbody>
</table>
Curing Oven 3D
Curing Oven Operation

<table>
<thead>
<tr>
<th>Section</th>
<th>Side (°F)</th>
<th>Top (°F)</th>
<th>Internal Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>87</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>93</td>
<td>97</td>
<td>399</td>
</tr>
</tbody>
</table>

Approx. Volume (ft³) | Air Flow Rate (lb/hr)
---------------------|-----------------------
6740                 | 1520
# Curing Oven Energy Losses

<table>
<thead>
<tr>
<th>Heat Loss</th>
<th>Btu/hr</th>
<th>CF/hr</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Load</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Heating Air</td>
<td>119,800</td>
<td>116.7</td>
<td>$ 1.24</td>
</tr>
<tr>
<td>Opening Radiation Losses</td>
<td>3,080</td>
<td>3.0</td>
<td>$ 0.03</td>
</tr>
<tr>
<td>Wall Radiation Losses</td>
<td>11,440</td>
<td>11.1</td>
<td>$ 0.19</td>
</tr>
<tr>
<td>Convection/Conduction</td>
<td>4,790</td>
<td>4.7</td>
<td>$ 0.05</td>
</tr>
<tr>
<td>Total</td>
<td>139,110</td>
<td>135.5</td>
<td>$ 1.45</td>
</tr>
<tr>
<td>Annual</td>
<td></td>
<td></td>
<td>$ 3,100</td>
</tr>
</tbody>
</table>
Recommendations

• Add silhouette to IR Oven
  – Reduces Radiation Losses through openings
• Install Gas flow meters
  – Will allow more accurate gas consumption readings
• Install Oven Temperature Controls
  – Provide accurate control of internal oven temps
## Adding Silhouettes - IR

<table>
<thead>
<tr>
<th>Radiation Loss (Openings)</th>
<th>W/O Silhouette</th>
<th>With Silhouette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening Surface Area :</td>
<td>51.87 (ft²)</td>
<td>12.71 (ft²)</td>
</tr>
<tr>
<td>Btu/h :</td>
<td>179,750</td>
<td>44,030</td>
</tr>
<tr>
<td>kWh :</td>
<td>52.7</td>
<td>12.9</td>
</tr>
<tr>
<td>Cost ($/h) :</td>
<td>$ 6.25</td>
<td>$ 1.50</td>
</tr>
<tr>
<td>TOTAL :</td>
<td>$ 7.94</td>
<td>$ 3.20</td>
</tr>
<tr>
<td>ANNUAL :</td>
<td>$ 16,900</td>
<td>$ 6,820</td>
</tr>
</tbody>
</table>

**Total Annual Savings:** $ 10,080
## Gas Usage Comparison

<table>
<thead>
<tr>
<th>Time Cycle</th>
<th>Actual MCF</th>
<th>Calculated MCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-Dec</td>
<td>517</td>
<td>117</td>
</tr>
<tr>
<td>Jan</td>
<td>235</td>
<td>29</td>
</tr>
<tr>
<td>Feb</td>
<td>201</td>
<td>29</td>
</tr>
<tr>
<td>Mar</td>
<td>47</td>
<td>29</td>
</tr>
<tr>
<td>Apr</td>
<td>297</td>
<td>58</td>
</tr>
<tr>
<td>Jun</td>
<td>182</td>
<td>29</td>
</tr>
<tr>
<td>Jul</td>
<td>112</td>
<td>29</td>
</tr>
<tr>
<td>Aug</td>
<td>171</td>
<td>29</td>
</tr>
<tr>
<td>Sep</td>
<td>163</td>
<td>29</td>
</tr>
<tr>
<td>Oct</td>
<td>213</td>
<td>29</td>
</tr>
<tr>
<td>Nov</td>
<td>234</td>
<td>29</td>
</tr>
<tr>
<td>Dec</td>
<td>298</td>
<td>29</td>
</tr>
</tbody>
</table>
Future Projects

• Insulation
  – Reduces Radiation, Conduction, and Convection through the walls
• Cost-Benefit Analysis of IR vs Gas Ovens
• Cost-Benefit Analysis of Catalytic IR vs Electric IR Ovens
• Energy Losses Due to Load Factor and Oven Seams
• Thorough investigation of the Gas Ovens
THANK YOU!

COMMENTS AND QUESTIONS?
POLYWOOD, Inc.
Waste Disposal and Regrind Assessment

Nathan Christensen, Graduate Assistant, Mfg.E.
Nathan Bowen, Undergraduate Assistant, M.E.
Overview

- Waste Disposal and Regrind
  - current state
  - recommendations and considerations
  - investment and return overview
  - Q & A
Minimizing disposal fees by investing in waste collection equipment

WASTE DISPOSAL
• Annual Expense
  – $20,528
• Distribution areas
  – service charges
  – transportation
  – disposal
  – fuel
  – other
Current State

- **Transportation**
  - $8,500
  - cost originates from large containers
  - sizes range from 30 yd to 50 yd

- **Service Charges**
  - $9,700
  - cost originates from 8 yd container
Recommendations and Considerations

**Recommendations**

1. Purchase own hoppers
   a) reduces service and rental charges
   b) better control over waste disposal
2. Explore additional material reclaim options
   a) recycling
   b) elimination of waste items

**Considerations**

1. Cost and life of purchased hoppers
2. Placement of new receptacles
   a) small building hoppers
   b) large compactors
## Container Cost Comparison

### 8-YD Dumpster (actual data)

<table>
<thead>
<tr>
<th># of pulls</th>
<th>43</th>
<th>annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>average cost</td>
<td>$200</td>
<td>per pull</td>
</tr>
<tr>
<td>total cost</td>
<td>$8,600</td>
<td>annually</td>
</tr>
</tbody>
</table>

### 50-YD Dumpster

<table>
<thead>
<tr>
<th># pulls</th>
<th>7</th>
<th>annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>average cost</td>
<td>$600</td>
<td>per pull</td>
</tr>
<tr>
<td>total cost</td>
<td>$4,200</td>
<td>annually</td>
</tr>
</tbody>
</table>

**Difference** | $4,400 | annually
# Cash Flow Outlook

## Total Facility Bins

<table>
<thead>
<tr>
<th>Investment Bins</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bin Cost</td>
<td>$1,300</td>
</tr>
<tr>
<td>Investment Cost</td>
<td>$3,900</td>
</tr>
</tbody>
</table>

## Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$(3,900.00)</td>
</tr>
<tr>
<td>1</td>
<td>$4,300</td>
</tr>
<tr>
<td>2</td>
<td>$4,300</td>
</tr>
<tr>
<td>3</td>
<td>$4,300</td>
</tr>
</tbody>
</table>

## Current Bin Cost

| Current Bin Cost | $8,600 |

## Payback

11 (months)
Shifting toward in-house regrind of scrap process material

SCRAP MATERIAL REGRIND
Current State

- Material extruded into stock profiles
- Scrap sorted into recycle bins
- Purge material collected for regrind
Recommendations and Considerations

**Recommendation**
1. In house regrind
   a) lower cost
   b) greater control over regrind quality
   c) faster turn-around

**Considerations**
1. Initial cost
   a) machinery
   b) labor
   c) construction
2. Regrind capacity
3. Noise
## Capital Considerations

<table>
<thead>
<tr>
<th>Investments</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery</td>
<td>$ 20,000</td>
<td>per regrinder</td>
</tr>
<tr>
<td>Construction</td>
<td>$ 100</td>
<td>square foot</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Expenses</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$ 40,000</td>
<td>per worker</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Savings</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Regrind</td>
<td>$ 0.10</td>
<td>per pound</td>
</tr>
<tr>
<td>Year</td>
<td>Investment $</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>$(60,000)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>$ 105,000</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>$ 105,000</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>$ 105,000</td>
<td></td>
</tr>
</tbody>
</table>

Payback (mo.) 7

NPV $613,974

IRR 175%

<table>
<thead>
<tr>
<th>Year</th>
<th>Investment $</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$(210,000)</td>
</tr>
<tr>
<td>1</td>
<td>$ 105,000</td>
</tr>
<tr>
<td>...</td>
<td>$ 105,000</td>
</tr>
<tr>
<td>15</td>
<td>$ 105,000</td>
</tr>
</tbody>
</table>

Payback (mo.) 24

NPV $613,974

IRR 50%

<table>
<thead>
<tr>
<th>Year</th>
<th>Investment $</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$(580,000)</td>
</tr>
<tr>
<td>1</td>
<td>$ 210,000</td>
</tr>
<tr>
<td>...</td>
<td>$ 210,000</td>
</tr>
<tr>
<td>15</td>
<td>$ 210,000</td>
</tr>
</tbody>
</table>

Payback (mo.) 33

NPV $1,227,948

IRR 36%
THANK YOU!

COMMENTS AND QUESTIONS?
Lean Assessment
Polywood, Inc.

Josef Imesch, E.M., Graduate Research Assistant
Lorena Pena, I.E., Undergraduate Research Assistant
Natalia Matos, I.E., Undergraduate Research Assistant
Marylin Glass, I.E., E.M., Graduate Research Assistant
What Will Be Covered

- Inventory Management
  - Building #3: Warehouse

- Forecasting
  - Internal Forecasting
  - Forecast Sharing

- MRP Systems

- Quality Control

- Expected Benefits
Building No. 3: Warehouse

Areas for Improvement

- Dedicated system of storage
- Bar codes used to identify products
- Capacity near 100%, under current layout

Recommendations

- Replace dedicated system with a class system based on frequency of use
- Evaluate option of using RFID chips instead of bar codes
- Simulate new layouts using class based system
Expected Benefits

Inventory Management

- The Class Based System will better utilize the available space
- RFID improves the system for inventory tracking
- New layouts may better utilize the space
Internal Forecasting

Areas for Improvement

- Projected forecast based on previous year’s sales
- Company-wide product forecasting
- Raw material usage forecasting

Recommendations

- Break products into categories, develop forecasts for specific categories
- Incorporate all departments in forecasting process
- Forecast raw material usage, and plan accordingly
Forecast Sharing

Areas for Improvement

- Forecasts sharing with the supply chain

Recommendations

- Encourage retailers and suppliers to exchange forecasts
- Form collaborative supplier relationships
Expected Benefits

Forecasting

- More reliable forecast = more accurate production schedule
- Improved communication throughout supply chain
- Reduced inventory, less working capital tied up
- Departments will reach a consensus

<table>
<thead>
<tr>
<th>Sales Volume</th>
<th>Gain from Improvements to under-forecasting</th>
<th>Gain resulting from Improvements to over-forecasting</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3,000</td>
<td>$5.08</td>
<td>$2.06</td>
</tr>
<tr>
<td>$2,400</td>
<td>$6.18</td>
<td>$1.21</td>
</tr>
<tr>
<td>$1,300</td>
<td>$0.59</td>
<td>$1.46</td>
</tr>
<tr>
<td>$900</td>
<td>$1.22</td>
<td>$0.92</td>
</tr>
<tr>
<td>$800</td>
<td>$1.04</td>
<td>$1.10</td>
</tr>
<tr>
<td>$800</td>
<td>$0.90</td>
<td>$0.85</td>
</tr>
<tr>
<td>$307</td>
<td>$1.01</td>
<td>$0.98</td>
</tr>
<tr>
<td>$100</td>
<td>$0.30</td>
<td>$0.90</td>
</tr>
</tbody>
</table>
MRP System

Areas for Improvement

- Sabre software utilized to track order fulfillment and shipping status

Recommendations

- Investigate company wide software implementation to track and monitor raw materials, WIP, and finished goods
- Tie in BOM and MPS to software
Expected Benefits

MRP

- Shorter lead times through better coordination among buildings
- Meet delivery dates more often
- Improved plant efficiency
- More effective purchasing plan
Quality Control

Areas for Improvement

- Quality standards vary between buildings and some are loosely defined
- Preventative quality checks
- Supplier quality records

Recommendations

- Establish quality team to make company-wide preventative quality standards
- Record defects and root cause
- Monitor and record supplier quality
Expected Benefits

Quality

- Reduced rework
- Reduced returns / warranty claims
- Reduce poor quality materials received from suppliers
Possible Future Projects

• Cost/ Benefit analysis and implementation of RFID system

• Simulate new layouts and break products into frequency categories

• Examination of forecasting methods to find the best suited approach
  – Develop product categories
  – Identify market drivers

• MRP systems research to find the best suited software

• Develop statistical process control
  – Company wide standards
Thank You For Your Attention!

Questions/Comments?
References

ASSESSMENTS:

Changeovers, Material Handling, and Visual Factory

Lorena Pena, I.E., Undergraduate Research Assistant
Josef Imesch, E.M., Undergraduate Research Assistant
Natalia Matos, I.E., Undergraduate Research Assistant
Marylin Glass, I.E., E.M., Graduate Research Assistant
Background

6 different Buildings
With 5 main functions
Changeovers

- Machine settings
- Job Instructions
- Materials and Tools

Changeover time is proportional to time and money waste.
Changeovers

Challenges

- Changeover based in a color scale
- Change of resin types
- Occasionally excessive material waste
- Production scheduling affected by seasonality

Recommendations and Possible Approaches

- Operation Research techniques for finding the optimal sequence.
- Method study and standardization of the changeover procedure.
- Develop a planning system to schedule both the order shipment and lumber production.
Material Handling

• Hidden Costs:
  – Insurance and taxes covering inventory
  – Loss and obsolescence
  – Storage space
  – Material handling equipment

Material handling cost normally represents 30% of production expenses
Material Handling

**Challenges**

- Six buildings with different processes
- Inventory levels effected by seasonality
- Several storage locations
- Long distances between and within buildings
Recommendations and Possible Approaches for MH

- Optimize building layouts
  - Facility Design Analysis
    Facilitate easy and organize material movement

- Standardization of routes
  - Work Design principles implementation
    Work instructions and safety concerns

- Process balancing
  - Lean manufacturing
    Avoids over production and extra inventory

- Inventory control systems and kanban
  - Raw and finished goods monitory control development using Lean Manufacturing techniques
    Avoids unnecessary movement and personnel utilization

- Demand forecast for Production scheduling
  - Statistical analysis of previous data and Monte Carlo simulation for forecasting future demand
Benefits

- Reduce production cycle
- Reduce downtime
- Safer environment
- Increase available floor space
- Reduce waste of motion and overproduction
- Visual pleasing shop
- Visibility of potential issues
Visual Factory

Areas for Improvement

- Inventory levels visual monitoring
- Work instructions: Standardization, and Visual features.
- Work area: Floor signalization, and workplace organization.
- Process metrics: Quality goals, system status, and equipment.

Recommendations and Possible Approaches

- Apply 5S and visual factory
- Personnel Training
- Implement safety regulations and make them visual
- Motivate employees
Thank you for listening!

Questions?
Post Foods

Cleaning Water Reduction Project

Michael Biro, Research Assistant (EM)
Nathan Bowen, Research Assistant (ME)
Marylin Glass, Graduate Research Assistant (IE)
Colin Knue, Project Manager
• **Goal**
  – Lower the cost of cleaning production equipment, focusing on reducing 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
  - Condensed Rice Cooler observation sheet
  - Average total time for both observations and percent difference between obs. 1 and 2
  - Total water hose use, if 2 hoses used at once time multiplied

<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 hoses</td>
</tr>
<tr>
<td>2</td>
<td>2 hr</td>
<td>Spray bars on</td>
<td>Front /Back</td>
</tr>
<tr>
<td>3</td>
<td>3 hr</td>
<td>Spray cooler &amp; floor</td>
<td>2 hoses</td>
</tr>
<tr>
<td>4</td>
<td>.75 hr</td>
<td>Spray bars on</td>
<td>Front/Back</td>
</tr>
<tr>
<td>5</td>
<td>.67 hr</td>
<td>Final rinse, cooler, &amp; floor</td>
<td>2 hoses</td>
</tr>
</tbody>
</table>

Average Total Time: 5.5 hours (22% difference)

Obs. 1: 4.9 hours
Obs. 2: 6.03 hours

Water hose use: 4.7 gun hr
Water hose use: 4.8 gun hr
Eliminated water hoses as brooms

Replace “auto” water hoses with spray bars

Reduce cleaning time
  – Eliminate Pre-Soaks

Signage
  – Reduce cleaning times
  – Help support changes

(Taken & Approved by Post)
Using Brooms

- Eliminate water hoses as brooms
  - Use brooms to sweep
  - Place food scrap/debris in bins

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Water Hose Use (hours)</th>
<th>Spraying Floor (hours)</th>
<th>Potential Annual Savings Gallons</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Machines</td>
<td>31</td>
<td>4.5</td>
<td>107,406</td>
<td>$1,826</td>
</tr>
<tr>
<td>Building 20/32</td>
<td>93</td>
<td>13.5</td>
<td>320,000</td>
<td>$5,478</td>
</tr>
<tr>
<td>Building 4</td>
<td>118</td>
<td>17.25</td>
<td>300,000</td>
<td>$5,126</td>
</tr>
</tbody>
</table>

(Taken & Approved by Post)
Clean Time

Water Cleaning Performance Scoreboard

<table>
<thead>
<tr>
<th>Date</th>
<th>Cleaner(s)</th>
<th>Cycle Time</th>
<th>Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
</tbody>
</table>

The TARGET cycle time should always be the minimum of the previous ACTUAL times
### Pre-Soak Study - Puffs FFD

<table>
<thead>
<tr>
<th>Wet Clean Date</th>
<th>Shift (1, 2, 3)</th>
<th>Pre-Soak Time (Please Check Column)</th>
<th>0 hours</th>
<th>2 hours</th>
<th>4 hours</th>
<th>Pre-Production Inspection (Please Circle)</th>
<th>Inspector</th>
<th>Inspection Date</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New Spray Bars

- Replace “auto” water hoses with spray bars
  - Design bar using AutoCad
  - Calculate costs

### Spray Bar Implementation

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Initial Cost</th>
<th>Water Reduction (gallons)</th>
<th>Financial Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granola Cooler</td>
<td>$2,084</td>
<td>119,808</td>
<td>$3,324</td>
</tr>
<tr>
<td>Granola Dryer</td>
<td>$4,597</td>
<td>103,428</td>
<td>$2,037</td>
</tr>
<tr>
<td>Total</td>
<td>$6,681</td>
<td>223,236</td>
<td>$5,361</td>
</tr>
</tbody>
</table>

**ROI** 15 months
New Signs

• Signage
  – Reduce cleaning times
  – Help reinforce changes
## Conclusion

- Reduce equipment cleaning times
- Use brooms, not water hoses
- Eliminate Puffs FFD Pre-Soaks

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Implementation Cost</th>
<th>Savings (annually)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Water (gal)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time (hours)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Money ($)</td>
</tr>
<tr>
<td>No spraying floor</td>
<td>$0</td>
<td>620,000</td>
</tr>
<tr>
<td>No pre-soak for Puffs FFD</td>
<td>$0</td>
<td>910,000</td>
</tr>
<tr>
<td>Time reduction</td>
<td>$0</td>
<td>195,534</td>
</tr>
<tr>
<td>Granola Cooler Spray Bar</td>
<td>$2,084</td>
<td>119,808</td>
</tr>
<tr>
<td>Granola Dryer Spray Bar</td>
<td>$4,597</td>
<td>103,428</td>
</tr>
</tbody>
</table>

**Total Savings:** $33,193
Next Steps

• Follow up with detailed engineering projects
  – New spray bars
  – Performance Scoreboard
  – Signage & Lean techniques
  – Hot/cold water options
    • Hot water regularly runs out during cleans
    • Use hot water for 1st hour of clean
  – Research new technologies
    • Dry ice blasting, high pressure water jets
Questions?
Veneer Sand-Throughs
Data Collection & Analysis

Nathan Bowen, ME, Undergraduate Research Assistant
Marylin Glass-Angeles, IE, EM, Graduate Research Assistant
Josef Imesch, EM, Graduate Research Assistant
Zachary Miller, CE, Undergraduate Research Assistant
Nathan Christensen, Mfg.E., Graduate Research Assistant
Quick Points

- Wood and Composite Office Furniture
- Lean Environment
  - 5S
  - Visual Factory
- Constant Improvement
  - GMIC Projects
The Problem

• Sand-throughs
  – Veneer damage from *Heesemann* sanding process
  – Particle-board under veneer face does not stain

Sandthrough Picture
End of Line

• Product ships
  – Customer dissatisfaction
  – Rarely Occurs

• Repair or Scrap
  – Steelcase dissatisfaction
  – “Hidden” costs
Data Collection

- February Observation Visits
  - Tracked defect totals
  - Took note of production interruptions and irregularities

Good parts → Stage board in front of sander → Load sander with proper board amount/pattern → Inspect parts at eye spy and touch up as necessary → Load boards for finish → Finish operations

Observer’s location
# Data Collection

## Sand-Throughs Check Sheet

- **Plant:** Steelcase, Woodplant  
- **Machine:** Heesemann Sander  
- **Operation:** Sanding Veneer on Particleboard  
- **Date:** Monday, Tuesday, Wednesday, Thursday, Friday (Circle)  
- **Recorder's Name:**

<table>
<thead>
<tr>
<th>DEFECT TYPE</th>
<th>OCCURRENCE</th>
<th>SUB-TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>One-Sided</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Two-Sided (FRONT)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Two-Sided (BACK)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Defect Report

<table>
<thead>
<tr>
<th>Daily (Location)</th>
<th>SUB-TOTALS</th>
<th>AVERAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Corner</td>
<td>80</td>
<td>4.44</td>
</tr>
<tr>
<td>1-Edge</td>
<td>48</td>
<td>3.20</td>
</tr>
<tr>
<td>1-Top</td>
<td>18</td>
<td>2.00</td>
</tr>
<tr>
<td>1-Crack</td>
<td>23</td>
<td>2.09</td>
</tr>
<tr>
<td>1-Warp</td>
<td>5</td>
<td>2.50</td>
</tr>
<tr>
<td>2F-Corner</td>
<td>305</td>
<td>15.25</td>
</tr>
<tr>
<td>2F-Edge</td>
<td>122</td>
<td>6.10</td>
</tr>
<tr>
<td>2F-Top</td>
<td>31</td>
<td>3.44</td>
</tr>
<tr>
<td>2F-Crack</td>
<td>41</td>
<td>3.15</td>
</tr>
<tr>
<td>2F-Warp</td>
<td>8</td>
<td>2.00</td>
</tr>
<tr>
<td>2B-Corner</td>
<td>109</td>
<td>6.06</td>
</tr>
<tr>
<td>2B-Edge</td>
<td>70</td>
<td>4.38</td>
</tr>
<tr>
<td>2B-Top</td>
<td>28</td>
<td>3.50</td>
</tr>
<tr>
<td>2B-Crack</td>
<td>82</td>
<td>7.45</td>
</tr>
<tr>
<td>2B-Warp</td>
<td>11</td>
<td>5.50</td>
</tr>
</tbody>
</table>
# Defect Report

<table>
<thead>
<tr>
<th></th>
<th>SUB-TOTALS</th>
<th>AVERAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner</td>
<td>494</td>
<td>8.82</td>
</tr>
<tr>
<td>Edge</td>
<td>240</td>
<td>4.71</td>
</tr>
<tr>
<td>Top</td>
<td>77</td>
<td>2.96</td>
</tr>
<tr>
<td>Crack</td>
<td>146</td>
<td>4.17</td>
</tr>
<tr>
<td>Warp</td>
<td>24</td>
<td>3.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SUB-TOTALS</th>
<th>AVERAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-Side</td>
<td>174</td>
<td>3.16</td>
</tr>
<tr>
<td>Two-Side-F</td>
<td>507</td>
<td>7.68</td>
</tr>
<tr>
<td>Two-Side-B</td>
<td>300</td>
<td>5.45</td>
</tr>
</tbody>
</table>

## Sand-throughs (Count)

- **Warp**: 600
- **Crack**: 200
- **Top**: 100
- **Edge**: 50
- **Corner**: 1

## Sand-throughs (Count)

- **Two-Side-B**: 500
- **Two-Side-F**: 400
- **One-Side**: 300
### Defect Report

#### February (Week) Production (Units)

<table>
<thead>
<tr>
<th>Week</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>12,605</td>
</tr>
<tr>
<td>2nd</td>
<td>13,406</td>
</tr>
<tr>
<td>3rd</td>
<td>13,790</td>
</tr>
<tr>
<td>4th</td>
<td>12,108</td>
</tr>
</tbody>
</table>

| Total for 2 Lines | 51,909 |
| Total for 1 Line | 25,955 |
| 3/4 of Total     | 19,466 |

- **Defects Observed 1 Line**: 981
- **Defects Estimated 2 Lines**: 2,616
- **Sand-throughs Rate (%)**: 5.04%

| Average US$ / Part | $55.00 |
| Total US$         | $2,854,995.00 |
| Defects in US$    | $143,880.00 |
Possible Causes

• Operator Error
  – Incorrect adjustment to the programming

• Wood Species

• Veneer reaction to weather (i.e. Humidity, Temp.)

• Sanding Belt Condition
  – Fresh belt grit may over-sand
  – Worn belt may be irregular in sand quality

• Machine Sensor Failure

• Incorrect Programing
Next Steps

• Differentiate Apparent from Real Causes
• Site Visits
  – Examine internal operation of *Heeseman* sander
  – Evaluate surface features of pre-sanded pieces
• Experimental Research
  – Close work with Steelcase engineers
• Execution of Findings
  – Implement improvement process
Thank You!

Any Questions?
Landscape Forms
Manufacturing Facility Waste to Landfill Assessment

Nathan Christensen, Mfg. E., Graduate Research Assistant
Marylin Glass, I.E., E.M., Graduate Research Assistant
Michael Biro, U.E.M., Undergraduate Research Assistant
John Ihling, U.E.M., Undergraduate Research Assistant
Natalia Matos, I.E., Undergraduate Research Assistant
Overview

• Review material
  – goals
  – completed tasks
• Updates
  – updated material
  – implementation
• Moving forward
  – next steps
  – timeframe
Landfill Waste Assessment

• Goals
  – zero-landfill in 2-3 years
  – conduct continual assessments
  – shift toward zero-waste

• Completed tasks
  – composting system in place
  – initial landfill assessment
  – baseline established
Updates: Material Figures

NOTE: Figures distributed by weight.

NOTE: Approximately 4,000 lbs of material sorted.
Updates: Implementation

• Additional employee training
• Material sorting system
  – single and multi-bin systems
  – material specific bins
  – bin location study completed
• Zero-landfill green team
Updates: Implementation

- Receptacle layout
  - center of gravity techniques
  - placement relative to current landfill station
  - population used for the weighted figure

Center of Gravity Technique:

\[ x = \frac{\sum_{i=1}^{n} a_i W_i}{\sum_{i=1}^{n} W_i}, \quad y = \frac{\sum_{i=1}^{n} b_i W_i}{\sum_{i=1}^{n} W_i} \]

Where:

- \( a_i \) = horizontal distance from center of gravity
- \( b_i \) = vertical distance from center of gravity
- \( W_i \) = weighted value for a given area
Updates: Implementation
Moving Forward
Special Thanks To:
Ryan Smith, Landscape Forms

THANK YOU!
COMMENTS, QUESTIONS?