Chuck Ray
The Pennsylvania State University

OPTIMIZING OPERATIONAL EFFICIENCY IN DRY KILN MANAGEMENT
What is the greatest challenge to making your company Lean?

- Time involved; cost of doing business
- Managing yield issues
- Employee development and active engagement
- Managing inventory levels
- Yield vs. getting the parts required to complete orders
- Cost of possibly changing the manufacturing process
- Managing raw material quality and lead time
- Assigning cost of carrying inventory
- Controlling inventory vs. customer demand vs. lean manufacturing principles to improve yield

(from PSU Lean Research Planning Meeting, 9-11-03)
What factors determine Lean production for your operation(s)?

- Increase inventory turns
- Yields
- Manpower/employee efficiencies
- Overall material cost
- Overhead costs
- Lead time vs. order size
- Effectiveness in managing the supply chain
- Customer willingness to pay for lean benefits (fast delivery, better yield, meet small quantity specifications)

(from PSU Lean Research Planning Meeting, 9-11-03)
What does JIT mean in your business?

- Reduce inventory
- Managing material deliveries to match production schedule
- Not hearing the customer complain
- Reduced lead times
- Raw material JIT is virtually non-existent in our industry
- Having inventory on the ground for next day delivery to customers
- Our customer base is two fold. 1. Lumber shipments (1-3 days for 70% of customer base. The balance want material within a few weeks.) This is for KD lumber with maybe some value added millwork. 2. Moulding/components (4 – 10 days for 90% of the customer base.)

(from PSU Lean Research Planning Meeting, 9-11-03)
How much have you been able to reduce lead times over the past ten years?

- 8-10 weeks to < 2 weeks on some stock items
- Very little discounting existing inventory
- Only marginally, but we have always been strong in this area
- 6-8 weeks down to 2-3 weeks on average
- Only through inventory increases which has been primarily from market conditions and raw material availability
- Approximately 33%
- Very little, product has become more customized
- For the dimension mill, 10-15 days down to 3 days
- Not much, mostly by accident

(from PSU Lean Research Planning Meeting, 9-11-03)
What processes in your operations cause the most problems?

- Controlling waste
- Communication from each level of business
- Inventory control
- Varying cost of material
- Raw material acquisition
- PROCEDURES
- Unexpected downtimes
- Shipping
- Material size and quality variations, plywood thickness variations, laminate defects
- Sanding – solid wood and veneer

(from PSU Lean Research Planning Meeting, 9-11-03)
What’s unique about wood production?

• Yield!
• Seasonality of raw material
  – e.g., log supply in winter
• Non-integrated, fiercely competitive supply chain
Traditional Lean Requirement:

• “All portions of the Lean Enterprise must be Lean”

• *Wood Products Industry Challenge:*
  – Is this feasible with wood as a raw material?
  – Does one link in the chain have to be “Fat”?
Traditional Lean Requirement:

- “All WIP must be reduced to near zero”

Wood Products Industry Challenge:

- Producing components from lumber to a precise order file, and discarding the rest, definitely decreases yield from the raw material. Are these yield losses offset by the gains from running lean?
“I guarantee I can reduce in-process inventory. But every time we’ve reduced inventory in the Rough Mill, costs go up.” – a plant manager
Traditional Lean Requirement

• “Lean companies organize a flexible & responsive supply chain”

• Wood Products Industry Challenge:
  • Are sawmills flexible & responsive?
  • Do your purchasing strategies encourage supplier flexibility or volume discounts?
Traditional Lean Requirement

• “All employees must be empowered”

• Wood Products Industry Challenge:
  – Can our hourly employees adapt to Lean?
  – Can leadership systems change?
Traditional Lean Requirement

• **Must have “Self-discipline for employees”**
  - Have everyone accept 5S as a personal goal.
    - sort, straighten, scrub, standardize, self-discipline
  - Set an example and model behavior.
  - Get everyone involved.
  - Integrate into daily work routine.

• Is this Easy for most wood products industry employees?
  - (research says it is Not; but practice says “It is!”)
Traditional Lean Requirement

• “Lean companies standardize modules with common interfaces.”

• Wood Products Industry Challenge
  – Do your machine centers “talk” to each other?
  – Do they talk to your employees or management?
  – Can a decision to purchase a new machine be made with respect to its interface capabilities, or does production capability drive decision?
In order to quantify and customize Lean for Wood Products, we need standard measures for each specific type of operation.
The macro lean indexes from our general industry model.
Average “Lean Indices” across the hardwood supply chain.
Lean indices of a furniture company.
Lean indices of a saw mill.
The single largest difference between similar companies, when measuring the input/output ratios, is energy consumption.
What would a Lean kiln drying operation look like?
1. Optimize energy usage

- Kiln checks for hot spots and air leaks
- Upgrades to controls, boilers, and venting systems
  - “Computer is best friend or worse enemy”
- Implementation of advanced control algorithms
- Monitor energy usage/bd ft/species/size
- Utilize air drying for slow moving products, and as pre-dry for all products
2. Optimize kiln scheduling

- Think of “kiln-days” as limiting constraint
- Maximize profitability subject to kiln-day constraints
- Think in terms of $ per kiln-day
- Don’t dry unprofitable products, convert to boiler fuel or open-market biomass
  - Brown maple?
- Consider out-sourcing of drying operations, or offering custom-drying capacity to local cabinet/furniture/log home companies
### Sample results

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</table>

### Reduced Cost

| S. Maple     | 4/4   | high  | 313.2    | 1,300 | 407,160| 1,000| 313,200    | 300           | 93,960      | 40000   | 12    | 94    |
|              | 1 com |       | 27.6     | 850   | 23,460 | 500  | 13,800     | 350           | 9,660       | 40000   | 12    | 8     |
|              | 2 com |       | 0        | 0     | 0      | 0    | 0          | 0             | 0           | 40000   | 12    | 0     |
| PSU          | 5/4   | high  | 14.4     | 1,500 | 21,600 | 1,050| 15,120     | 450           | 6,480       | 40000   | 12    | 4     |
|              | 1 com |       | 9.6      | 900   | 8,640  | 550  | 5,280      | 350           | 3,360       | 40000   | 12    | 3     |
|              | 6/4   | high  | 72       | 1,500 | 108,000| 1,075| 77,400     | 425           | 30,600      | 45000   | 18    | 29    |
|              | 1 com |       | 18       | 1,050 | 18,900 | 675  | 12,190     | 375           | 6,750       | 45000   | 18    | 7     |
|              | 8/4   | high  | 158.4    | 1,575 | 249,480| 1,150| 182,160    | 425           | 67,320      | 47500   | 18    | 60    |
|              | 1 com |       | 42       | 1,200 | 50,400 | 775  | 32,550     | 425           | 17,850      | 47500   | 18    | 16    |
|              | 10/4  | high  | 10.8     | 1,700 | 18,360 | 1,300| 14,040     | 400           | 4,320       | 50000   | 26    | 6     |
|              | 1 com |       | 7.2      | 1,000 | 10,080 | 1,000| 7,200      | 400           | 2,880       | 50000   | 26    | 4     |
|              | 12/4  | high  | 12       | 1,900 | 22,800 | 1,400| 16,800     | 500           | 6,000       | 50000   | 26    | 6     |
|              | 1 com |       | 0        | 0     | 0      | 0    | 0          | 0             | 0           | 50000   | 26    | 0     |

|       |       |       | 685      | 1,370 | 938,880| 1,007| 689,700    | 364            | 249,180     | 237     |       |

#### Penn State Extension

Total Sales: 11323
Total mbft: 1702.05
Total $/mbf: 19272310
Total 12/4: 1261.46
Total 10/4: 440.5897
Total 8/4: 4.988,796.88
Total 6/4: 3451.5
Total 4/4: 8497

By LumberDry Model
Total Sales: 11323
Total mbft: 1702.05
Total $/mbf: 19272310
Total 12/4: 1261.46
Total 10/4: 440.5897
Total 8/4: 4.988,796.88
Total 6/4: 3451.5
Total 4/4: 8497

By PSU Model
Total Sales: 12381
Total mbft: 1685.1
Total $/mbf: 22148420
Total 12/4: 1960.4
Total 10/4: 1750.0
Total 8/4: 1200.0
Total 6/4: 900.0
Total 4/4: 600.0
3. Minimize lumber movement

- Random inventory storage (inefficient)
- Designated inventory layout (good)
- Dynamic inventory assignment (better)
- Strive for moving “front” of green and dry lumber loading
- Track raw material flows by BTU value
What is NOT Lean Kiln Drying?

• “Using kiln to simulate air drying or pre-dryer”
  – The cost of doing this should be captured and used to justify investment in pre-dryer

• “Using kiln to dry brown maple with high defect rate”
  – Makes the true cost of brown maple much higher than being charged, even if defect is accounted for... opportunity cost
What is NOT Lean Kiln Drying?

• “Taking too long to get soft maple into kiln?”
  – Synchronize harvest, sawing schedule, and kiln loading

• “The computer can be your best friend, or your worst enemy”
  – The computer is not your enemy...insufficient data is your enemy. Trying to guess conditions inside the kiln is your enemy. Invest in more sensor technology, and use the control software capability to dry to the load, not to a schedule.
Can we illustrate non-lean impact on drying operations?
Advanced process control algorithm

Actual Vs Simulated Controlled Process

- Moisture Content (%)
- Time Interval

Plot Area

- Actual Process
- Simulated Controlled Process
Estimation of fuel consumption per treatment schedule

<table>
<thead>
<tr>
<th>HT treatment (°C/min)</th>
<th>Required Minimum Temperature (°F)</th>
<th>Measured Minimum Temperature (°F)</th>
<th>Preheating Time (min)</th>
<th>Treatment Duration (min)</th>
<th>Kiln Operation time (min)</th>
<th>Fuel Consumption (BTU/pallet)</th>
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Loads Treated per Day

Timeline for Heat Treating Pallets

Heat Treatment
- 71/75
- 60/60
- 56/30

Time
- 8:00 AM
- 12:00 PM
- 4:00 PM
- 8:00 PM

Legend:
- 1st load
- 2nd load
- 3rd load
Longer treatment time incurs opportunity cost for the industry.

Cost of heat treating pallet with different treatment types and loads:

- **3 loads/day**: $0.245
- **2.4 loads/day**: $0.464
- **2 loads/day**: $0.679

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Cost ($/pallet)</th>
</tr>
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<tbody>
<tr>
<td>56/30</td>
<td>0.245</td>
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<tr>
<td>60/60</td>
<td>0.464</td>
</tr>
<tr>
<td>71/75</td>
<td>0.679</td>
</tr>
</tbody>
</table>

- 450,000 Pallets/yr
- 600 Pallets/load
- 1 kiln for one plant
- Opportunity Cost included

450,000 Pallets/yr with 600 Pallets/load and 1 kiln for one plant, Opportunity Cost included.
Summary

• Lean is here, now, and forever
• Measurements of success may be tricky, but are essential
• For lean kiln drying, focus on energy consumption and kiln utilization