Factory Physics: The Key to Green Industries

College of Engineering and Architecture - College Days 2012 EXHIBIT: Greening Industries

Student Chapter – Philippine Institute of Industrial Engineers (PIIE)
Holy Angel University
Angeles City, Pampanga, Philippines

In association with:

proplanner
Process & Industrial Engineering Software
Factory Physics – Green Industries
Presentation Overview

• Introduction
• Inventory Analysis
• Factory Layout Analysis
• Work Methods Analysis
• Energy Observations
Factory Physics – Green Industries
Presentation Overview

• Introduction

• Inventory Analysis

• Factory Layout Analysis

• Work Methods Analysis

• Energy Observations
• **Industrial Engineers (IEs)** - We analyze and improve work systems, which are simply collections of resources (human, equipment, material, and energy) that combine to make products or services.

• By showing how a small furniture factory in Lubao can more efficiently use their human, equipment, material, and energy resources, we demonstrate how IEs make factories more green.
Factory Physics: Introduction
Client Company Overview

- Mallari’s Nursery Furniture – manufacturer of baby furniture and other household furniture.

- Major product is a Baby Crib (kuna).

- The wood used for the product comes from old pallets from nearby industrial parks (low cost, green raw material).
Mallari’s Nursery Furniture – manufacturer of baby furniture and other household furniture.

Major product is a Baby Crib (kuna).

The wood used for the product comes from old pallets from nearby industrial parks (low cost, green raw material).

Located in Lubao, Pampanga. Hometown of 2 former PHL Presidents (Diosado Macapagal and Gloria Macapagal-Arroyo).

15 employees. All perform manufacturing operations, and serve as material handlers.
The major product of importance to Mallari is the Baby Crib, and is therefore the primary focus of this project.
Factory Physics – Green Industries
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Factory Physics: Inventory Analysis

Factory Overloaded with WIP Inventory

Large piles of Work In Process (WIP) inventory shown throughout the factory.
Factory Physics: Inventory Analysis
Factory Space Analysis
Factory Physics: Inventory Analysis
Factory Space Analysis

- Inventory - Raw Materials
- Production Equipment
- Trash
- Miscellaneous Support
- Aisles
- Scrap
- Inventory - Work in Process
- Inventory - Finished Goods
Factory Physics: Inventory Analysis

Factory Space Analysis
Factory Physics: Inventory Analysis

Factory Space Analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>SQM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work In Process</td>
<td>64%</td>
</tr>
<tr>
<td>Raw Materials</td>
<td>13%</td>
</tr>
<tr>
<td>Scrap</td>
<td>7%</td>
</tr>
<tr>
<td>Trash</td>
<td>7%</td>
</tr>
<tr>
<td>Finished Goods</td>
<td>6%</td>
</tr>
<tr>
<td>Production Equipment</td>
<td>3%</td>
</tr>
</tbody>
</table>
Little’s Law

\[ CT_{\text{System}} = \frac{\text{WIP}_{\text{System}}}{\text{TH}_{\text{System}}} \]
Factory Physics: Inventory Analysis

Laws of Factory Physics

The higher the level of Work-In Process inventory, the longer it takes products to go through the system.

\[ CT_{System} = \frac{WIP_{System}}{TH_{System}} \]
Therefore, to utilize factory resources more efficiently (and increase output), we need to decrease the amount of WIP inventory in the factory.
Factory Physics: Inventory Analysis
Increased WIP = Increased Waiting Times

• Currently, each work station produces parts for 30 finished products. This is called a Lot, or Batch.

• When a Lot arrives at a station, the worker processes the 1\textsuperscript{st} part of the Lot, while the 29 other parts ‘Wait to Process.’
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When a Lot arrives at a station, the worker processes the 1\textsuperscript{st} part of the Lot, while the 29 other parts ‘Wait to Process.’

When the 1\textsuperscript{st} part completes processing, it experiences ‘Wait to Batch’ time, as it cannot move to the next station until all 30 parts are complete.

Large Lot / Batch sizes increase the waiting times in the factory, and only serve to increase WIP, and the time for products to move through the factory (CT).
Factory Physics: Inventory Analysis
Recommendations

• Reduce Lot Sizes from 30 cribs to 15 cribs.

• Reduce space available for WIP inventory, and better organize its locations (addressed in factory layout analysis).

• Remove trash permanently (12% of total space).

• Remove scrap from production area frequently.
Factory Physics – Green Industries
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• Factory Layout Analysis

• Work Methods Analysis

• Energy Observations
Factory Physics: Factory Layout
Current Layout
Factory Physics: Factory Layout
Current Layout – Material Flow
Factory Physics: Factory Layout
Current Layout – Material Flow (Parts)
Factory Physics: Factory Layout

Layout Issues – Lengthy Flow for Raw Materials
Factory Physics: Factory Layout

Layout Issues – Lengthy, Backtracking Flow
Factory Physics: Factory Layout

Current Layout – Actual Path Flow
Current Layout Metrics
Distance Traveled = 192 km
Material Handling Time = 69 hrs
Material Handling Cost = P3,030
Material Handling Labor = 1.53 people
Factory Physics: Factory Layout
Future Layout
Factory Physics: Factory Layout
Future Layout – Material Flow
Future Layout Metrics
- Distance Traveled = 88 km
- Material Handling Time = 45 hrs
- Material Handling Cost = P1,968
- Material Handling Labor = 0.94 people
Factory Physics: Factory Layout
Future Layout – Weekly Resource Savings

Resource Efficiency Improvements
Distance Traveled = 104 km (↓ 54%)
Material Handling Time = 24 hrs (↓ 35%)
Material Handling Cost = P1,062 (↓ 35%)
Material Handling Labor = 0.59 people (↓ 39%)
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Factory Physics: Work Methods
Bottleneck Explanation
Factory Physics: Work Methods
Bottleneck Explanation
Factory Physics: Work Methods
Bottleneck Explanation

- TH rate at each point in the Bottle
- WIP level inside Bottle
- CT to pass through Bottle
Factory Physics: Work Methods

Laws of Factory Physics

1. $\mathbf{TH}_{\text{System}} = \mathbf{TH}_{\text{Bottleneck Station}}$
Factory Physics: Work Methods

Laws of Factory Physics

1. \( \text{TH}_{\text{System}} = \text{TH}_{\text{Bottleneck Station}} \)

2. \( \text{CT}_{\text{System}} = \frac{\text{WIP}_{\text{System}}}{\text{TH}_{\text{System}}} \)
Factory Physics: Work Methods
Laws of Factory Physics

1. \( TH_{System} = TH_{Bottleneck \ Station} \)

2. \( CT_{System} = \frac{WIP_{System}}{TH_{Bottleneck \ Station}} \)
Factory Physics: Work Methods
Laws of Factory Physics

1. \( \text{TH}_{\text{System}} = \text{TH}_{\text{Bottleneck Station}} \)

2. \( \text{CT}_{\text{System}} = \frac{\text{WIP}_{\text{System}}}{\text{TH}_{\text{Bottleneck Station}}} \)

3. **Find Bottleneck Station & Increase Its Output (TH)**

\[ \uparrow \text{TH}_{\text{Bottleneck Station}} \quad \downarrow \text{CT}_{\text{System}} \]
Factory Physics: Work Methods
Laws of Factory Physics

1. TH System = Bottleneck Station

2. CT System = WIP System / TH Bottleneck Station

3. Find Bottleneck Station & Increase Its Output (TH)

Factory Management identified the Drilling Operation as the Bottleneck of the process.

The expected time (standard time) for this operation was unknown.
Find Bottleneck Station & Increase Its Output (TH)

1. \( \text{TH}_{\text{System}} = \) We could purchase another Drilling Station to increase output (add more resources).

2. \( \text{CT}_{\text{System}} \) Better yet, we could eliminate wasted time (Non-Value Added) at the Drilling Station.

3. \( \uparrow \text{TH} \) Bottleneck Station

\( \downarrow \text{CT} \) System
Factory Physics: Work Methods
Video Time Study – Drilling Operation
Factory Physics: Work Methods
Gantt Chart – Drilling Operation

Gantt Chart

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>[0 - 147.10 (147.10)]</td>
</tr>
<tr>
<td>B</td>
<td>[147.09 - 150.70 (3.61)]</td>
</tr>
<tr>
<td>C</td>
<td>[150.71 - 205.26 (54.55)]</td>
</tr>
<tr>
<td>D</td>
<td>[205.26 - 206.89 (1.63)]</td>
</tr>
<tr>
<td>E</td>
<td>[205.26 - 208.87 (3.61)]</td>
</tr>
<tr>
<td>F</td>
<td>[208.80 - 263.43 (54.55)]</td>
</tr>
<tr>
<td>G</td>
<td>[263.43 - 271.07 (7.63)]</td>
</tr>
<tr>
<td>H</td>
<td>[271.07 - 300.96 (17.09)]</td>
</tr>
<tr>
<td>I</td>
<td>[300.96 - 290.46 (1.52)]</td>
</tr>
<tr>
<td>J</td>
<td>[290.46 - 290.69 (1.73)]</td>
</tr>
<tr>
<td>K</td>
<td>[290.69 - 308.5]</td>
</tr>
<tr>
<td>L</td>
<td>[308.57 - 310.1]</td>
</tr>
<tr>
<td>M</td>
<td>[308.57 - 312]</td>
</tr>
</tbody>
</table>
Standard Time for Drilling Operation = 5.21 min.

Setup time accounts for 47% of the operation. Need to reduce setup time.
Factory Physics: Work Methods
Distribution of Time - Drilling Operation

- 42.25% Transformation
- 19.04% Picking/Supply
- 17.02% Equipment Related
- 9.45% Part Related
- 4.36% Body Movement
- 4.67% Walking (materials)
- 1.03% MISC SVA

Percent

Transformation 42.25%
Picking/Supply 19.04%
Equipment Related 17.02%
Part Related 9.45%
Body Movement 4.36%
Walking (materials) 4.67%
MISC SVA 1.03%
Clearing 1.33%
Cleaning 1.33%
Sanding 1.33%
VA 1.33%
Quality 1.33%
Assembly 1.33%
Printing 1.33%
Unloading/Loading 1.33%
Waiting 1.33%
Welding 1.33%
Footing 1.33%
Factory Physics: Work Methods
Non-Value Added Time - Drilling Operation

- 37.41% NVA
- 42.25% VA
- 20.34% SVA
Factory Physics: Work Methods
Distribution of Non-Value Added Time

NVA Category

Percent

Equipment Related
Part Related
Walking/materials
Body movement
Packing/unpacking
NVA
Waiting
Walking/tools
Hoisting
Unloading/Loading
Cleaning

45.48%
25.27%
12.49%
11.70%
5.85%
Wasted Time mainly occurs during machine setup (adjusting settings), and rotating the parts during the operation.
Factory Physics: Work Methods

Recommendations to Reduce NVA Time

- Plastic bins for nails, arranged within reaching distance of the operator.
- Fixtures such as quick clamps for the table and work surface.
- Re-design the Drilling machine to eliminate manual part rotation.
Factory Physics: Work Methods
Recommendations to Reduce NVA Time

- Plastic bins for nails, arranged within reaching distance of the operator.
- Fixtures such as quick clamps for the table and work surface.
- Re-design the Drilling machine to eliminate manual part rotation.
- These recommendations would save 0.8 minutes per product at the Bottleneck station.
- This reduces Drilling time by 17%, and allows more products to flow through the factory, with the same amount of resources.
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The factory experiences frequent brownouts, and the company has no alternative energy source.

During brownouts, equipment cannot run, including the critical bottleneck operation.
Factory Physics: Energy Observation

Current Issue

• The factory experiences frequent brownouts, and the company has no alternative energy source.

• During brownouts, equipment cannot run, including the critical bottleneck operation.

• This significantly affects the company’s efficient use of its resources.

• Most would suggest purchasing a back-up generator, which is not a cost effective, clean, green source of energy.
The Philippines experiences a great amount of solar energy. Mallari should consider purchasing solar panels to capture and utilize this free, green source of energy.

A secondary benefit is to have an alternative power supply during brownouts, in order to keep operations running.
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