Ergonomic Benefits of Lean Manufacturing Cells

U-Shaped Manufacturing Cells

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Overview

• Introduction
• Lean Manufacturing versus traditional systems
• Detailed Case Study
  – General problem statement
  – Example analysis of several random stations
    • Provide classic “patchwork” alternatives/improvements
• Alternative cellular design
  – What is cellular manufacture?
  – Ergonomic benefits of U-shaped manufacturing cells
• Summary
Lean manufacturing

“Our goal is to take care of our customers. We will do this by being the safest, most ethical company with the highest quality, lowest cost, best productivity and profitability”.

Axioms in support of these goals are:

1. Center the process around target
2. Reduce Variability
Lean Manufacturing

- An American management “crutch”
- An American marketing tool

The most misunderstood and misrepresented concept in America
Historical Case Study
Case Study: Cabinet producer

- Large assembly plant with multiple lines
  - Long tradition of serial assembly line
- Worker demographics
  - Average age (40+)
  - Growing female workforce (>50%)
- Invited to look at “repetitive stress”
  - Growing number of insurance claims
  - Hoped to show growing awareness vice actual growth in problems
Typical Layout

Up to 20 lines operate throughout plant
Highly seasonal

Station 1
Base Plate & sidesAssembly

Stations

Stations under analysis
Ergonomic Assessment Tools

• Goal was to analyze each station with multiple tools to provide comprehensive evaluation
  – NIOSH Lifting Guides
    • Both 1981 and 1991
  – Psychophysical Guides
  – Rapid Upper Limb Assessment (RULA)
  – Backsoft Software

• None of these invoke “legal” requirements
Lifting, twisting and non-neutral postures are a serious problem by all modern standards.
Classic “Patch-it” Approach

Station Analysis with Improvements
Station 1: Current Arrangement
Assembly of Base and Side Plates

• Top view

• Side View

Weight of Base Plate = 19.32 lbs
Weight of side = 8.66 lbs
Frequency = 7 lifts/minute
Activities at Station 1

- Pick up the base plate from RHS
  - Glue the slots
  - Pick up LHS side plate from back trolley
  - Insert LHS plate into baseplate
  - Staple the LHS side plate
  - Twist around and pick up RHS plate
  - Insert the RH side plate into base plate
  - Staple the plate
Number of Assemblies/min = 7 **

• Lifting and Turning Activities: 3/Assembly
  - Base Plate lift-20 pounds/ 90 degree turn
  - LH side plate lift-8.66 pounds/180 degree turn
  - RH side plate lift-8.66 pounds/180 degree turn

• Joining and Stretching Activities: 4/Assembly
  - Gluing the slots along length of base plate~29 inches
  - Stapling the sides to base plate~29 inches

** 30 Second rule: If a total time to do a subtask is less than “30 seconds,” it is considered repetitive in nature
Alternative Design for Station 1

- Top View

- Side View
Other lifting options
Improvements

**Existing System**

Task 1
Origin Lifting Index=2.957
Destination lifting index=3.155

Task 2
Origin Lifting Index=1.331
Destination lifting index=2.38

Angular Movement: 90 deg and 2 x 180 deg

**Proposed system**

Task 1
Origin Lifting Index=1.9343
Destination Lift Index=2.716

Task 2
Origin Lifting Index=0.87
Destination lifting index=1.22

Angular movement: 2 x 90 deg
Observations & Suggestions

- Many tasks being done at one station
  - Supervisor frequently assists this workstation
- Workload variation from 10-20 pounds
- No gloves or ear plugs or eye protection being used
- Twist 90-180 degrees both clockwise and anti-clockwise
- Single trigger stapling gun

Suggestions:
- Alter work station design
- Split tasks
- Use touch stapling equipment or trigger lever action
- Replace glue bottles with alternatives

Even with improvements, stations remained unsatisfactory
Lifting, twisting and non-neutral postures are a serious problem by all modern standards.
Engineering Suggestions

• Eliminate the use of pistol grips
  • Switch to more versatile vertical grips
• Eliminate the use of triggers
  • Use “touch” staple guns
  • Alternatively, use 3 finger or reverse action triggers
• Avoid buying any tool with a single finger trigger action
Possible tools

The right grip for the job.

Wrong

Right

Wrong

Right
Engineering continued

• Purchase self-adjusting gravity carts
  – Greatly reduces Lifting Index in all cases
  – Can be the foundation modern Kanban
• Modify the stations to eliminate at least half the twisting actions
  – Gravity carts promote this!
• Purchase lightweight plastic hand trucks to help with the rework item. Greatly improves the Lifting Index in all cases.
Engineering Continued

• Build inexpensive tool holsters along the line to keep tools off the ground
• Need alarm system to alert workers to stops and starts of the assembly line
• Replace Glue bottles with caulk type guns having 3 finger trigger actions
Administrative Suggestions

• Institute the concept of a lay down area
  – Investigate having one person manage the laydown area. Also act as 2\textsuperscript{nd} person lift
• Institute 2 person lifts of rework items
• Institute a rotation policy in the line
Other Suggestions

• The assembly line needs to be set up to be flexible to people of different heights
  • Use the cell to split large/small items
  • Provide step-ups

• Use of gloves recommended at all stations

• Use rubber mallet for press fits instead of human fist

• Demarcated stacking areas with limiters

• Use of ergo mats to reduce stress on feet since jobs primarily involve standing for extended hours

• Use of lift assist devices when large assemblies must be overturned or packaged
Cellular Pull System

• All the “fixes” listed previously are patches on an operating system
• Recommended slowly having “workers” redesign the line using cellular group technology techniques
Cellular Pull System

- Modify the new assembly line with a simple arrangement—introduce cellular manufacture

- Improve QA
  – *MOCOMOO!*  

*MOCOMOO >>*

Make one, check one, move one on!
U-Shaped “Lean” Cell

KEY:
- DP - Drill press
- L - Lathe
- HM - Horizontal milling machine
- VM - Vertical milling machine

- Material movement parts within cell
- Path of worker moving within cell
- Worker positions
Some of the Manufacturing Advantages

- Flexible
- Designed by workers
- Continuously improved by the workers
- Paperless
  - No MRP system
- Simple, not complex, machinery is used
  - Designed by workers
- Double or triple capacity easily
Ergonomic Simulations

- RULA/REBA
- Ergonomic Job Analysis Software (U. Arkansas)
- Liberty Mutual Tables
- Michigan 3D Static Strength Software
- ProPlanner discrete simulation software
- Delmia’s “Human” software
- ADAMS LifeMOD 3D Finite Element Software
Simulations
Simulation Outcomes

• Properly designed cells will ALWAYS
  – Have lower kilocalorie expenditures
  – Score lower on
    • RULA
    • REBA
    • Liberty mutual software
    • All back evaluation software
    • Complex 3D biomechanical software
Advantages of Cellular Approach (1)

• Promotes Neutral Postures
  – Adjust cells to either large or small cabinets
  – Work pieces come from customized bin systems immediately in front of workers

• Eliminates twisting motions and lifting

• Task enlargement
  – Avoids the nature/risk of “30 second rule”

• Easy to double production rate
  – Simply add another worker to cell from a cell that currently has little or no demand
Advantages of Cellular Approach  (2)

• Reduces floor space requirements
  – Combining lines and workers into new lines
  – Eliminates the “laydown” area. Reduces/eliminates WIP

• Less material handling
  – Smaller pieces are produced and synchronized to the work orders
  – No rework >> less handling

• Highlights true production problems
  – Less clutter to hide nature of QA problems
Advantages of Cellular Approach (3)

- Reduces risk of back injury by avoiding awkward postures and minimizing changes in height
- Reduces venous pooling from static sitting/standing
- Promotes healing (i.e. avoids static postures and muscle atrophy)
- The workers design the cell. They improve the cell. They OWN the cell.
Economic Costs

• Initial cell cost is minimal
  – First step in cell design is to simply rearrange existing equipment (Black “The Factory with a Future”)

• Subsequent cell cost is incurred only when improving the cells production/process.
  – Properly improved cells are ergonomically better and safer for the worker WITHOUT SPENDING MONEY ON SAFETY/ERGONOMICS.
Summarizing

- Extensive simulation with numerous software products conclusively show that a U-shaped manufacturing cell is inherently friendly to ergonomics.
- Well trained design engineers can let the workers design a cell that works well and that they feel comfortable working in. This frees management to focus on protecting the inherent safety/ergonomic benefits of the cellular manufacturing process.