ADDITIVE MANUFACTURING IN COMPLIANCE WITH LEAN SHIPBUILDING

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Introduction

- Problem
  - Lean manufacturing in the automobile industry
  - Lean manufacturing in shipbuilding
  - Hyundai Corporation example
- Adapted for the shipbuilding industry

http://www.dbckorea.com/lastevent.html
http://in.reuters.com/article/2011/06/12/idINIndia-57648420110612
Present shipyard configuration of interim product assembly lines

Kolich, D, Dissertation: Methodology for improving flow to achieve lean manufacturing in shipbuilding, University of Rijeka, 2011.
Lean shipyard configuration of interim product assembly lines

Shipyard panel assembly line

1) Panel assembly,
2) Panel welding,
3) Panel layout,
4) Longitudinal fitting,
5) Longitudinal welding,
6) Internal structure fitting,
7) Welding and outfitting of built-up unit,
8) Turning and fitting,
9) Welding and outfitting.
2. Principles of lean manufacturing

- A quarter of a century has passed since the publishing of the book *The Machine That Changed the World*, authors Womack, Jones i Roos.
- This book derives from Toyota known as TPS: Toyota Production System

1. Specifying the product value from the customer’s perspective,
2. Identifying the value stream,
3. Constant flow,
4. Pull,
5. Perfection or acceptable quality
2.1. Other principles of lean manufacturing

1. Just in Time and Built in quality,
2. 5S,
3. 7 wastes
4. Kaizen

Chemical tanker
Asphalt barge
Toyota production system

7 Wastes

3. Additive manufacturing

- Known as 3D printing
- 3D printer adds layers upon layer
- Plastic polymer to build a solid object
- Cheaper/faster than tool and die on metals

University of Rijeka 3D printer, Student laboratory
Norfolk Naval Yard applications

- Used for making mockups
- Simple alterations/complex hull replacement
- Engineers and workers visualize
- Decreases risk during execution
- Decreases man-hours

Direct Metal Laser Sintering

- Lasers are used to sinter powdered metal
- The laser uses 3D model data
- The material is compacted
- A solid mass is formed.
- 99% dense
Companies that use DMLS

- Stratasys - US
- Fonon Corporation - US
- EOS – Germany
- China Shipbuilding Industry Corporation
Additive manufacturing in compliance with lean

- Just in time and one piece flow
- For naval and maritime constructions,
- Manufacture one of a kind type steel part
- Without having to machine it.
- Or order it.
- Reduction in costs.
Examples in manufacturing where there are applications:

- One of a kind interim products
- Micropanel profile
- Non-standard brackets
- Outfitting equipment
  - Double bottoms
  - Side shells - single and double skin
- Decks
  - Longitudinal bulkheads

[Uljanik Shipyard, 2009.]
Increasing lean manufacturing application in shipbuilding

- Smaller and complex parts
- That is expensive to order
- Could be quickly manufactured
- Using Additive manufacturing

http://www.nwlean.net/article1103.htm
Value Stream Mapping Legend

- Supplier/Customer
- Physical pull
- Interim storage
- Withdrawal kanban
- Push arrow
- Supermarket
- Manual information
- Kanban post
- Electronic information
- Kanban pull signal
- Improvement burst
- Pull arrow

Added value process:
- Takt time
- C/T = changeover time
- # operators
- # plates/shift
- man-hrs
Value stream map – Current state

Processed steel plates and stiffeners

Production Control

Panel assembly
Duration time = 16 hours
80 man-hours

Panel assembly Workstation #1
Takt time: 4 hours
C/T = 4 hours
# operators: 5
# panels/shift: 2
20 man-hrs

Panel assembly Workstation #2
Takt time: 4 hours
C/T = 4 hours
# operators: 5
# panels/shift: 2
20 man-hrs

Panel assembly Workstation #3
Takt time: 4 hours
C/T = 4 hours
# operators: 5
# panels/shift: 2
20 man-hrs

Panel assembly Workstation #4
Takt time: 4 hours
C/T = 4 hours
# operators: 5
# panels/shift: 2
20 man-hrs

80 minutes

Interim stiffener storage

KP, S, T assembly processes

Value Stream Map - Future
Conclusions

- Additive manufacturing complements
- Lean shipbuilding well
- Entices one-piece flow
- Decreases transport, waiting and storage
- Decreases man-hours and duration time
- Significant savings
Thank you for your attention!