Ship Production

Lecture 12 – Shipbuilding in Japan
Historical Factors:

1950s & 60s rapid growth in Japanese commercial shipbuilding industry.

Rapid technological advances in both ship design & construction – demand for increasingly large tankers.

Increased international competition.

Formation of Seven Major shipbuilding companies through mergers.

Shipbuilding markets collapsed in 1973 due to oil crisis (Yon Kippur War).
Historical Factors:

Large tanker market evaporated. Bulk carrier deliveries dropped by 74% by 1979.

Late 1970s & early 80s restructuring of industry leaving medium sized shipbuilders with half of Japanese output.

Technological development slowed by early 1990s.

Product innovation superceded by production cost control, so industry movement to maturity favoured cost competitiveness.
Japanese Shipyards:
Japanese Shipyards:

- Covered shops for steel fabrication.
- Outdoor platens for grand block assembly.
- A large, open building block.
- Very heavy cranes for lifting grand blocks into the erection dock.

Optimised for construction of large merchant ships from heavy, preoutfitted hull blocks.

Large open drydock allows lower-level products to be efficiently assembled into a wide variety of ship types.
Shipbuilding Deliveries, percent of world market by gross tonnes, 2002

Percentage of World Market

Japan  South Korea  China

Shipbuilding Deliveries, percent of world market by gross tonnes, 2002
Vessels:

Most of the world’s fleet are oil tankers, bulk carriers & container ships. These vessels form backbone of Japanese shipbuilding industry’s business base.

Can Japanese industry maintain competitiveness considering heavy exposure to volume product markets (compared with niche technological markets – cruise ships, FPSOs)?
Japanese Shipbuilding Industry:

“As to whether or not the Japanese shipbuilding industry will follow the English shipbuilding industry to decline and ruin, that may well depend on how well high value added fields can be pioneered and highly efficient production systems can be implemented through technological development in the future”

Okuyama, N. Japanese Industry Ups and Downs, and Causes, SNAMEJ, March 2001
Baseline = Japan (1.0)
Japanese Shipbuilding Process:

Material delivery → Plate cutting → Automatic stiffener welding

Outfitting of modules ← Curved module development ← Straight module development
Japanese Shipbuilding Process:

- Module transport
- Building block construction
- Machinery installation
- Ship handover to client
- Further outfitting
Productivity Improvements:

• Reduction in the number of workers.
• Schedule compliance & schedule-driven process improvement, i.e. ensuring milestones are met. Simple tools used such as Gantt Charts.
• Faster design-build time – benefits of series production used and throughput is maximised.
• Improved accuracy control. Critical concern – reduces rework, reduces skill content, increases use of robots.
Productivity Improvements:

• More use of automation – welding robots, painting robots, automatic line-heating, automatic welding.

• Computer-integrated manufacturing – integrate design, planning, procurement etc.

• Operations management – continuous improvement, worker involvement.

• Other factors: design for production, minimisation of staging, reduction of number of parts, laser steel processing, intercompany alliances.

Therefore management imperative is cost reduction.
### Typical cost structure: Large double hull tanker

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Percentage of Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel (35,00 tonnes)</td>
<td>14</td>
</tr>
<tr>
<td>Main engine</td>
<td>13</td>
</tr>
<tr>
<td>Hull outfitting</td>
<td>13</td>
</tr>
<tr>
<td>Machinery outfitting</td>
<td>19</td>
</tr>
<tr>
<td>Labour – design &amp; preproduction</td>
<td>4</td>
</tr>
<tr>
<td>Labour – hull production</td>
<td>13</td>
</tr>
<tr>
<td>Labour – outfitting production</td>
<td>13</td>
</tr>
<tr>
<td>Outsourced work</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Drivers for automation?

1. Increasing labour costs.

2. Expansion of South Korea industry.

3. Projected market demand for large merchant ships. Replacement VLCCs & post Panamax containerships. Average large merchant ship 60% to 70% of hull blocks are flat panel blocks.

Although drivers 1 & 2 may have persuaded Japanese yards to exit market (compare with English & European yards) – third industry development indicated there was still potential, hence investment.

Also possibility of using automated technology on high value commercial products e.g. LNG carriers.
Opportunities for cost reduction through mechanisation?

- **Outfitting** – little automation opportunities except pipe fabrication. Cost reduction comes from effective flow of materials & instructions.

- **Hull steel production work** – high level of automation possibilities since resembles classic mass production. Reduce labour hours and build in higher accuracy & repeatability in initial fabrication.
Historical automation developments:

1960s:
- Numerically controlled flame cutting machines;
- Conveyors to mechanise material handling;
- Automatic welding equipment at the assembly and erection stages;
- Electroslag & electrogas welding at the erection stage.

1980s:
- Huge leap in welding automation
Recent automation developments in hull steel production:

- Unit panel & slit flat panel.
- Automatic line heating.
- Multi-robot subassembly.
Unit panel & slit technique:
Unit panel & slit technique:

1. Cutting of plate using numerically controlled flame planer;
2. Automatic fitting & welding of longitudinals to within +/-0.2mm;
3. Automatic fairing to remove weld distortion;
4. Automatic cleaning & painting;
5. Plate setup & tack welding;
6. Single-sided welding to join plates;
7. Transverse subassemblies with slits are slid over using hydraulic ram system;
Orientation of Longitudinals:
Automatic Welding of Longitudinals:
Placement of Transverses:
Automatic Line Heating:

Steel plates may be formed into complex curved forms using any combination of cold forming machinery (rollers, presses) and/or some type of thermal forming.

Manual line heating is an effective & productive process.

But it is a skilled craft practiced by experienced technicians working individually using hand tools.
Automatic Line Heating Computational Procedure:
Automatic Line Heating:

- Given required plate offsets;
- Calculates appropriate heating procedure;
- Heat applied to plate at numerically controlled workstation in fabrication shop.

**Advantages:**

- Reduction in production man-hours: 5-6 hours shop time plus 2-3 hours design time compared with 2-3 days of manual forming;
- Faster plate forming;
- Elimination of skilled shop-floor workers.
Multi Robot Assembly:

Use of robots for welding is widespread in Japanese yards. Though usually only one per work station & proportion of welding done by robots is low: 10% to 15%.

Sub assembly welding more difficult to automate than flat panel line welding, since stiffeners arranged at various angles.

Universal Shipbuilding Corporation Multirobot system - 10 closely spaced robots on subassembly line.

Kawasaki Multirobot system - 4 robots suspended from its own gantry-type crane on subassembly line.
Multi Robot Assembly:

Robots operate simultaneously under group control using CAM data:

- welding position;
- fillet length;
- welding procedure;
- robot job sharing;
- robot control;

Plus CAD data – mainly geometric.
Robot Welding & Assembly:
Robot Welding & Assembly:
Lean Production:

Term used to describe automobile manufacturing system developed by Toyota.

“All company-wide improvement activities must directly contribute to the goal of cost reduction”.

System focused on need to eliminate inefficiency, waste, throughout the manufacturing system.
Lean Production:
Lean Production:

5 general mechanisms:
1. Defining value for each product;
2. Eliminating unnecessary all steps in every value stream;
3. Making value flow;
4. Knowing that the customer pulls all activity;
5. Pursuing perfection continuously.
Lean Production – Product Value:

Final product value defined by market place.

Need to understand nature & degree of value that market demands in order to avoid incurring costs not justified by corresponding increases in market value.

Owner’s requirements should be communicated clearly to the shipbuilder.
Lean Production – Inessential Operations:

- Increasing the speed of essential process steps;
- Eliminating unnecessary process steps and waiting time;

For example introduction of line heating in 1960s increased the speed of plate forming and also reduced downstream fitting time.
Lean Production – Inessential Operations:
Lean Production – Flow:

Ideal = continuous one piece flow of intermediate products rather than batch production.

In Japanese shipyards flow is based on blocks with production processes (cutting, subassembly & assembly) carried out block by block, i.e. not built in batches.

On fixed platens welders move from A to B after fitters have moved from B to C. Shipbuilding version of conveyor system.
Lean Production – Pull:

Production management based on strict schedule adherence.

No allowance for upstream so-down nor line stoppages.

Product is delivered under a contractual obligation & there is no sales or buffer inventory at the end of the line.
Eliminate Waste

Sort
Sort through items & only keep what is necessary & dispose the rest

Sustain
Stabilized workplace entails continuous improvement

Straighten
A place for everything & everything in its place

Shine
Inspection - exposes abnormal & pre-failure conditions

Standardise
Maintain & monitor first 3 Ss
Lean Production – Pursuit of Perfection:

• Managers commitment
• Proper training
• Correct procedures become a habit
• Participation from all workers
Lean Production – Discussion:

The goal of lean production is cost reduction. Japanese shipbuilding is master of cost control and cost reduction.

Among the world’s three leading shipbuilding countries Japan has by far the highest per unit labour costs.

However the unmatched productivity of the Japanese industry approximately makes up for this disadvantage.

Net result is that Japanese shipbuilding has been able to maintain global competitiveness.
Further reading:


Recap/Reflect