Action Plan for Restructuring the Technology of a Medium-Sized Shipyard

Plan de Acción para la Reestructuración de la tecnología de un Astillero Mediano

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Abstract

Last years, a medium-sized shipyard has specialized in building tankers for chemicals. This is planned to increase the production of shipyard in medium or long terms for 4-6 boats. To achieve these objectives, the changes have to be made in all kinds of services shipyard. These changes have to take place in the organization, as well as in technological areas. In the first phase of analysis, there has been a single sequence analysis of part 1, where they perform six different methods that resulted in a large number of solutions that will help restructure of shipyard.

Key words: shipyard, restructuring, productivity.

Resumen

En los últimos años, un astillero de tamaño medio se ha especializado en la construcción de buques cisterna para productos químicos. Se prevé aumentar la producción del astillero a mediano y largo plazo a 4 - 6 barcos. Para alcanzar este objetivo, los cambios tienen que hacerse en todo tipo de servicios del astillero. Estos cambios deben tener lugar en la organización, así como en las áreas tecnológicas. En la primera fase de análisis, se ha producido una secuencia de análisis individual sobre la parte 1, donde llevan a cabo seis métodos diferentes que dieron como resultado un gran número de soluciones que ayudarán a la reestructuración del astillero.

Palabras claves: astillero, reestructuración, productividad.

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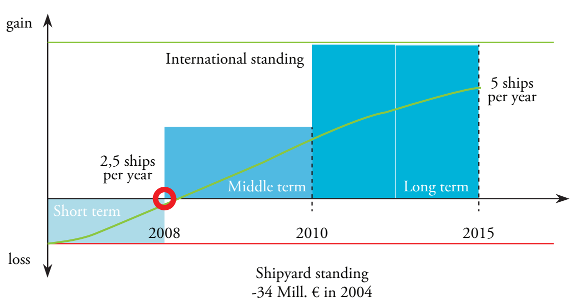
Initial Situation

Within the last few years, a medium-sized shipyard has specialized in the building of product and chemical tankers. A product arose that secured a good position in the world market. However, continuous economic development opposes a deficit of €34-million per year. To address this deficit, the shipyard has to build more ships per year. To achieve this aim, the shipyard started a multi-project in 2006. In this multi-project, the project of the development of an "Action plan for restructuring the technology and organization of the shipyard" was conducted.

As seen in Fig. 1, the requirements of the project were:

- The economic loss is compensated when 2.5 ships are built per year and this should be reached by 2008.
- Additionally, it is planed to increase the output of the shipyard in middle or long terms to 4 – 6 ships.

Fig. 1. Definition of achievable project results



To achieve these aims, changes have to be made in all types of services of the shipyard. These changes have to take place in organizational, as well as in technological areas. Basis and guideline for other service areas are the technological changes.

There has been a program including two milestones, to analyze the shipyard in detail and develop suitable actions to be undertaken.

- An analysis phase to analyze the shipyard; to show bottlenecks and their negative results towards ship production.
- A phase for development of solutions, which as a whole result in reaching the aims defined by the shipyard itself.

In the first analysis phase, there has been a sequence of individual analysis concerning the following topics:

1. Application of lean principles
2. Definition of bottlenecks
3. Crane capacities and technological workflow
4. Communication and information flow
5. Core competencies
6. Micropanel line
7. New outfitting place
8. Organizational workflow
9. Performance of outfitting
10. Payment methods
11. Process orientation
12. Second berth
13. Spatial structures and material flow
14. Welding speed and quality

The whole project was executed successfully and on schedule from the end of February to the end of August 2006 in Trogir, Coratia.

Analysis phase

The 14 analyses from part 1 where accomplished by these six different methods:

- Simulation
- Input-Output relation
- Benchmark
- Planning table
- Value stream analysis and
- Questionnaire.

How these methods were applied in the individual analysis is described in this final report.

Productivity analysis per CGT

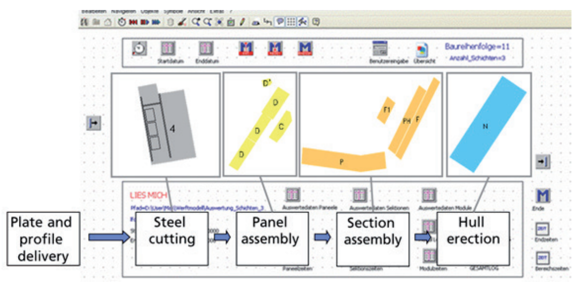
An essential conclusion of the analysis is a deficiency in all areas of production in the whole shipyard. This problem was examined closely in the main processes of steel manufacture. With a steel throughput of 10,464 tons per ship comes a 41.3 man-hours manufacturing input per ton of steel. That is 21.3 man-hours per ton of steel based on CGT. Including an outfitting expenditure of 40%, the manufacturing expenses are 35.5

man-hours per CGT and, therefore, 2.5 times the international standard (best practise 14 man-hours/ton CGT).

Simulation

Workflow simulation is an introduced and applied method to analyse lead times in complex manufacturing systems. In this project, the simulation led a distinct model (Fig. 2) of the manufacturing of the ship's hull. With the help of this model, the manufacturing workflow can be clearly described. Therefore, it was possible to show and analyse bottlenecks in manufacturing.

Fig. 2. Introduction into shipyard´s simulation model



Based on this model, future alternative manufacturing concepts can be verified and integrated into the ERP landscape to be developed.

In this simulation, we concentrated our attention on a defined number of representative types, which give a good mapping onto the real manufacturing.

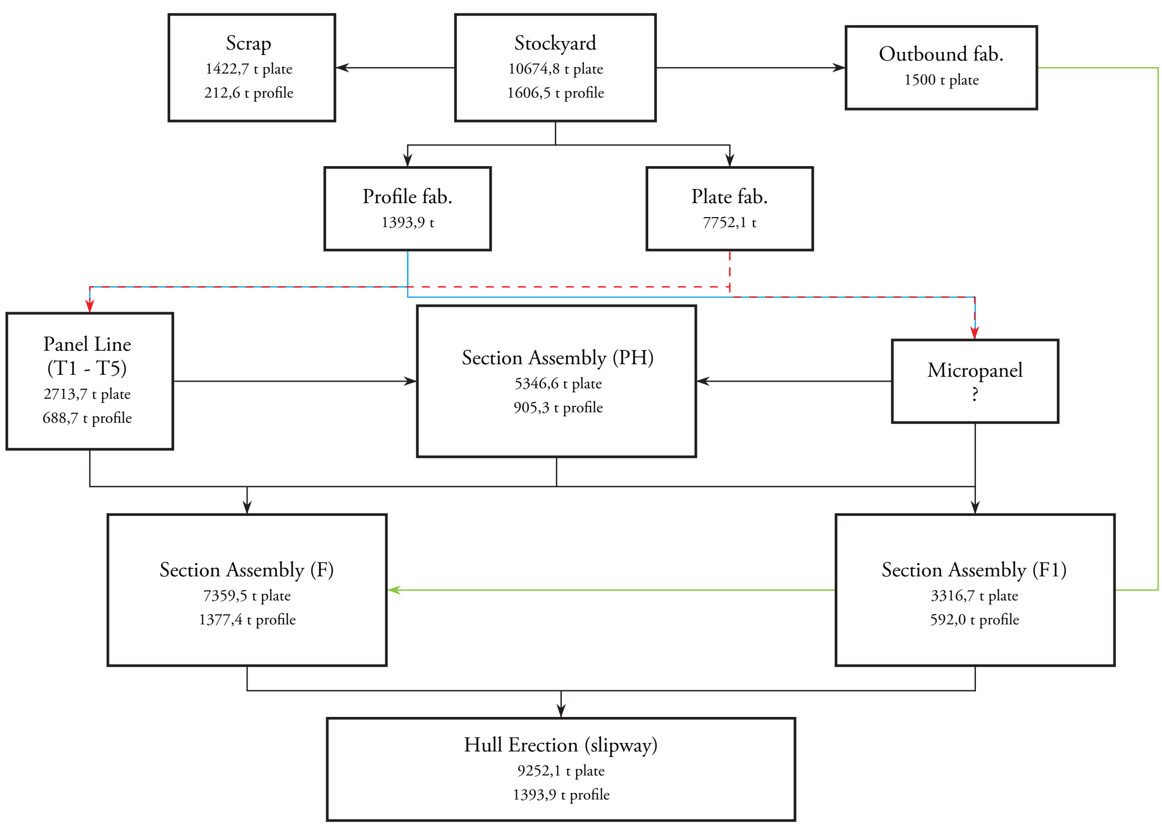
Input-Output relation

With the help of actual input-output relations of the different workshops and the expected steel throughput, at the aimed increased production rate, it can be analysed if the capacity of all workshops meets the increasing requirements.

Benchmark

With the help of the benchmark we could find if the existing welding technology and quality control

Fig. 3. Steel input and output



matches the increasing requirements. In comparison to the international ship building industry, it is clear that the welding and quality control areas are far below the international standard.

Also, with one benchmark the situation of outfitting was researched. The rates of pre-outfitting and pre-assembling in the outfitting section are less than equal to the international state-of-the-art either.

Planning table

With the Fraunhofer developed analysis tool "planning table", the spatial structure of the shipyard was analysed and checked if it could meet the requirements caused by future layout changes. The, hereby developed, spatial model can be used either as basis for alternative manufacturing concepts or as basis for the arrangement of the manufacturing workflow in workflow simulations and in ERP systems.

Value stream analysis

The question for this analysis method is, if the organizational structure of the shipyard was open to integrate lean principles. The structure was determined as not sufficiently clear to allow the integration of lean principles. This becomes apparent when looking at the material flow, which is organized by push principle.

Additionally, more deficiencies were found that interfere with a structured workflow, while applying the value stream analysis. The shipyard's internal project "Propellar" was founded to eliminate those deficiencies and first prosperities were made.

Questionnaire

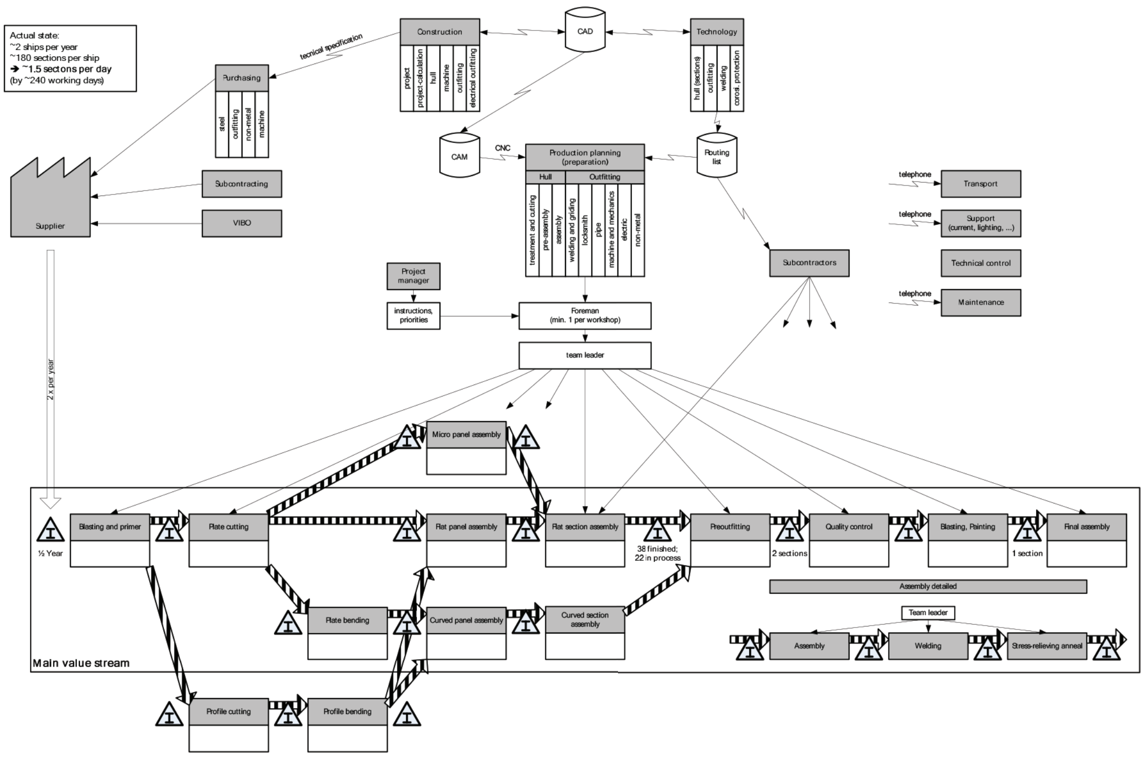
With the help of questionnaires and interview questions, which arose throughout the previously mentioned parts of our work and which could not be answered with any other analysis method were dissolved. The substantiated state of knowledge and willingness to cooperate by employees was very helpful for this project.

Solutions

Solution 1: Accuracy Control and Shrinkage Management

A basic problem at the shipyard, as well as at many other shipyards, is a lack of awareness of quality-

Fig. 4. Value Stream Model of the Shipyard



oriented manufacturing and its effect on costs in the manufacturing process. To reduce these costs, a stepwise procedure has to take place.

In the first step, awareness of the lack of quality and its effect on costs has to be created. This can only be done through consistent quality control. The tools used for this approach are described in detail ahead. To execute quality control, a team of experts has to be trained to meets international standards in quality control. The procedure is detailed ahead in this paper.

After introducing and executing the above previously measures, the shipyard can find and analyse deficiencies in the manufacturing process. These deficiencies have to be eliminated. A first step is to introduce a shrinkage manager for the shipyard. This is a software tool, which is able to deform the cutting plates so the thermal deformation due to the welding process is equalized. The tool collaborates with a CAD System and requires corresponding nesting. The introduction of such a tool requires implementation of a project-specific measuring program and external help from specialists in this topic.

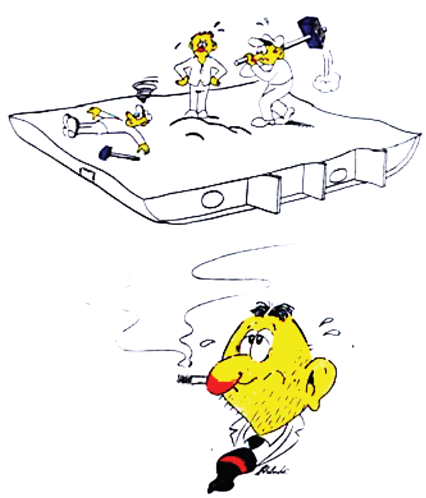
Solutions 2 and 3: Partial, panel and closed section fabrication

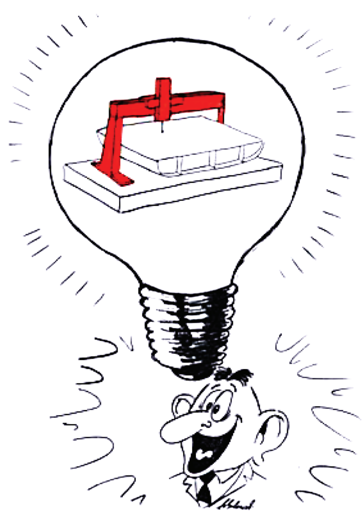
The existing buildings for the partial fabrication including plate and profile cutting and bending are in bad shape. This affects especially the foundations of the existing gantry cranes. An additional installation of new cranes with a capacity above 30 tons, which is recommended, is impossible due to the building's static. Also, the material flow is unsteady due to the existing low capacities of the cranes and transport facilities.

In panel manufacturing, similar problems are faced. This building was designed for section fabrication and the crane system installed does not reach every workplace of the panel line and assembly area. Additionally, the ways of transport are very long for plates and profiles. In general, these transport ways are too long, less developed and, hence, hard to organize. The outdoor micro-panel manufacturing depends heavily on the right light and climate conditions.

Improving the part and panel fabrication would increase steel throughput and decrease costs. Therefore, it would be necessary to relocate the panel line closer to the part fabrication.

The space given for panel and section assembly is too small to produce four ships. Outputs in the micropanel and flat panel fabrication, as well as productivity in the section assembly have to be increased in coherence with a closed production. Production in three shifts maximum is highly recommended for this reason.





The relocation of the part fabrication includes the plate and profile warehouse and the working facilities cutting and bending should be conducted in a fixed procedure. In addition to the relocation of the part fabrication, the panel fabrication including the micropanel and flat panel fabrication and closed section assembly should also be relocated into the part fabrication hall. It is important to not disrupt ongoing production while constructing the new building for part and panel fabrication with a minimal investment. The new building should provide optimal material flow and the possibility to implement future technologies.

Building the new fabrication hall

The first task is to dismantle the old plate and profile warehouse and rebuild it at the new location. Relocate the old crane at the new location, as well. Thereafter, construct the new conservation hall and pull down the old one. Afterwards, part one of the new fabrication hall will be constructed where plasma and profile cutting and profile bending will take place. In the second part of the new hall the panel and micropanel line will be located. The last step is the implementation of the additional fourth and fifth workplace into the panel line.

Technological changes

In the preparation phase, two to three plasma cutting machines should be available to raise the shipyard's output to four to five ships per year. The existing bending machines have to be refurbished and modernized. To bend the profiles, an automated bending machine has to be considered.

To transport the plates from the conservation to the cutting machines, roller conveyors are to be installed. The transition from the roller conveyors to the cutting machines is done by the crane system. This roller conveyor also takes the cut and bent plates and profiles into the sorting workplace where they are sorted into comb pallets. These comb pallets are especially produced in the shipyard; about 10 of these pallets are needed. After the sorting procedure, the plates and profiles are transported directly to the micropanel line or to the outside workplaces. The route to the out-side workplaces is done by fork lifts and transport to the micropanel line is done by the installed cranes and roller conveyors. All bent plates and profiles are placed horizontally on those pallets.

The micro-panel line

The manual manufacturing process of micro-panels should be mechanized to minimize the space used by it. Therefore, for example, four work stations could be created:

- positioning of the plates on the building grid
- placement and tacking of the plates
- welding of the profiles and
- adjustment and rework

Transport of the plates and profiles is done by cranes and roller conveyors already mentioned. Next, is the transport of the finished micro-panels on pallets to the manufacture of the frame beams and intercostals. There should be as much prefabrica-tion as possible to build the frame beams to increase the productivity of the panel line.

The panel line

There should be a dry plasma cutting machine integrated able to cut plates that are 12 by 3 m big. The transport of the primered plates is again carried out by a roller conveyor reaching the cutting machines and the crane system for the route to the panel line. The plates produced should not exceed a size of 12.7 by 11.5 m. There are five working steps needed:

- The first step is to cut, bend, and mark the plates
- Followed by the placement and tacking of the plates
- The third step is to weld the profiles
- Part four and five are to place the frame beams setting, tacking, and welding

In the long term, the capacity in areas four and five has to be doubled to increase productivity and the degree of space allocation. Finally, the transport of the sections to the closed section assembly takes place.

In the closed section assembly, respectively, the panels from sectors three and five are brought together. That means the panels with attached frame beams and without them. They are placed opposite of each other, tacked and welded together.

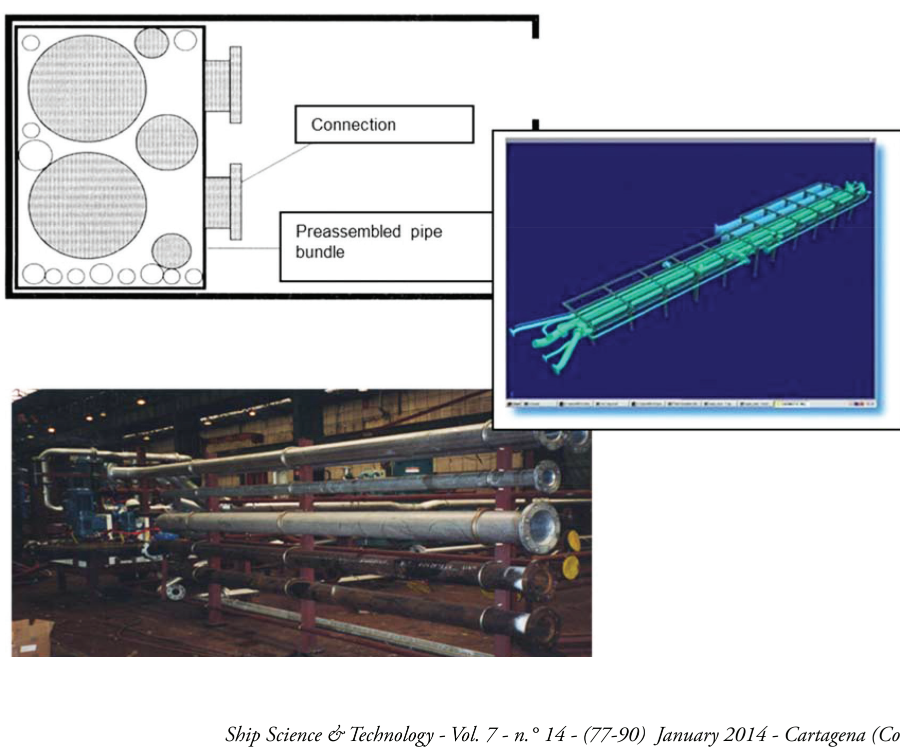
Fig. 6. Installation of a new hall over existing structures

Solution 4: Outfitting

Introduction of new designs and modern pipe connections

A lot of work force is currently used to fit and rework pipes. The introduction of new design principles would lead to decreasing rework. Therefore, it is necessary to de-velop a bidirectional interface between the CAD system for shipbuilding and the CAD system for piping. With these systems connected, the fitting points for the pipes and the ship hull structure can be easily defined to prepare the adjusting pipes between the pipe traces. The gauges of the hull

Fig. 7. Pre-assembled outfitting systems (modules)



structure define the gauges of the pipes. Along with the use of modern pipe connection systems, the cost of fitting and reworking pipes can be reduced by up to 20%.

Increasing the documentation of preoutfitting

Installation of pipe systems is a core competence of a shipyard specialized in tankers. To bundle the installation of pipe systems it is necessary to work with a good and fast documentation system to establish simultaneous engineering. The documentation system should be "open source" to include subconstructors CAD data (e.g. Integration pipe modules, pump modules, etc.). The documentation permits meeting customer's demands throughout order fulfilment. Today, changes can only be respected until the start of manufacturing.

Installation of a new 35-ton crane

The shipyard builds a new outfitting area along the pipe fabrication building. The actual crane capacity is not able to fulfil all tasks in this area. A good solution would be a crane with a 35-ton capacity and a 50-m range. With this crane, it is possible to transport pre-assembled outfitting modules into the ship. Additional flexibility could be achieved with the existing maximum range of 50 m. It is then possible to outfit two ships parallel at the same time and this leads to independencies of delivery delays by subcontractors.

Sub constructing pipe fabrication

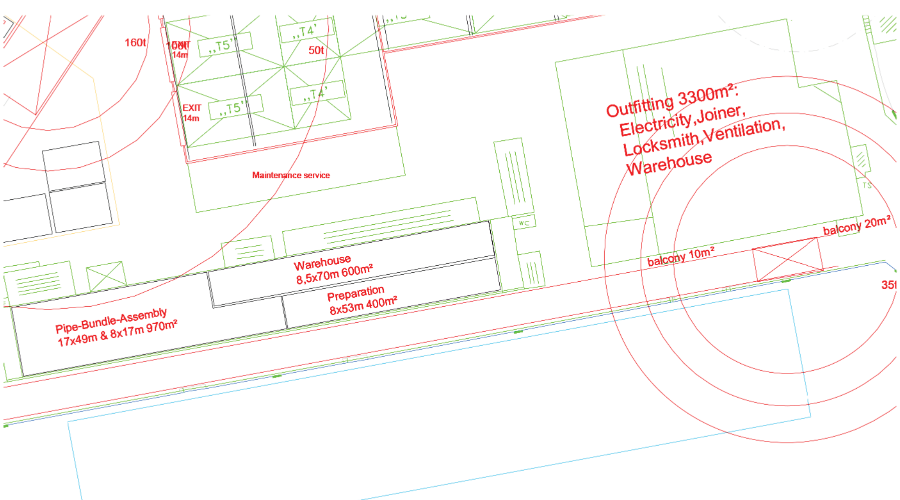
The core competence of this shipyard is the development and installation of pipe systems, as already mentioned. Preparation of these pipes can be done much more efficiently by special pipe manufacturers. Therefore, preparation of pipes should be outsourced to reduce costs as a mid-term solution. The free workers will be relocated to the pre-outfitting of sections and rings to decrease the lead time of pre-outfitting.

A 600-m² warehouse is enough to buffer the pipes on stackable pallets and deliver them "just-in-time". After these adjustments, the shipyard is responsible only for the assembly of the pipe traces and the preparation of adjusting pipes.

Relocation and elimination of outfitting processes

Along with the concentration of the core competencies the number of outfitting workshops has to be reduced and the employees relocated. The present halls and buildings are no longer necessary to full extent for the outfitting of new ships. Only the two halls closest to the outfitting quayside are needed for the new outfitting structures. Corresponding to the strategic plan of the shipyard to install a new ship repair division, the two spare buildings and the workers should be part of the new repair division. This will decrease the number of workers and areas for the shipbuilding division

Fig. 8. Relocation of outfitting processes



and increase productivity. The shipyard should look for a company that takes over parts of the outfitting and, thereby, reduces the number of outfitting procedures. A benchmark has shown that a comparable shipyard will require approx. 6000 m² for all outfitting workshops including warehouse.

Solution 5: Section assembly

With the current production, the shipyard could assemble sections for 2.5 – 3 ships maximum. The section assembly area is a bottleneck in the middle term. With a roofed-over section and module assembly area sections, more than five ships could be built. In the long term, a new hall for section fabrication has to be built.

The transport ways of pallets with profiles, plates, micro-panels, and flat panels have to be directed to the assembly area inside the new building. The area becomes assembly area for curved sections, small sections, and pre-assembled sections with a maximum weight of 60 tons. The erection of new sections takes place either on the ground or on jig pillars. The new sections will be transported either by the heavy transport vehicle or with the new transport crane.

Module assembly

The new module assembly building should be placed near the existing section assembly building and the final conservation area. The dimensions of the new building should be 56 by 32 m and it should have approximately seven assembly work-places for large sections and modules with section dimensions of approximately 12 by 12 m. There should also be a direct connection to the sections assembly building with a 60-ton crane or a roller conveyor. Inside the new hall a new 160-ton crane should be installed. Furthermore, transport of profiles, plates, micropanels, and flat panels would be secured by a predefined material flow.

The advantages of the construction of new assembly halls are the independence of light and climate conditions, increasing efficiency and capacity of supporting facilities like cranes and power supplies and production in three shifts is possible.

Solution 6: Ring and final assembly

Enlargement of the launching berth is basic for all further measures to improve out-put of the final assembly. The enlargement program includes the following steps:

- Enlargement of the existing launching berth to a width of 70 m and a length of 200 m
    - Launching berth 1 is located on the existing launching berth
    - Possibility to install new cranes with higher capacity in a long-term solution

- Steps to implement the facilities without interruption of the shipbuilding production:

1. Integration of the 160-t crane and relocation of the 50-t crane
2. Preparation of the new launching berth 2
    a. Preparation of the ground and sides
    b. Placement of the sliding rails
    c. Placement of the diagonal transport rails
3. Preparation of the old launching berth 1
    a. Preparation of the ground
    b. Relocation of the sliding rails
    c. Integration of the diagonal transport rails

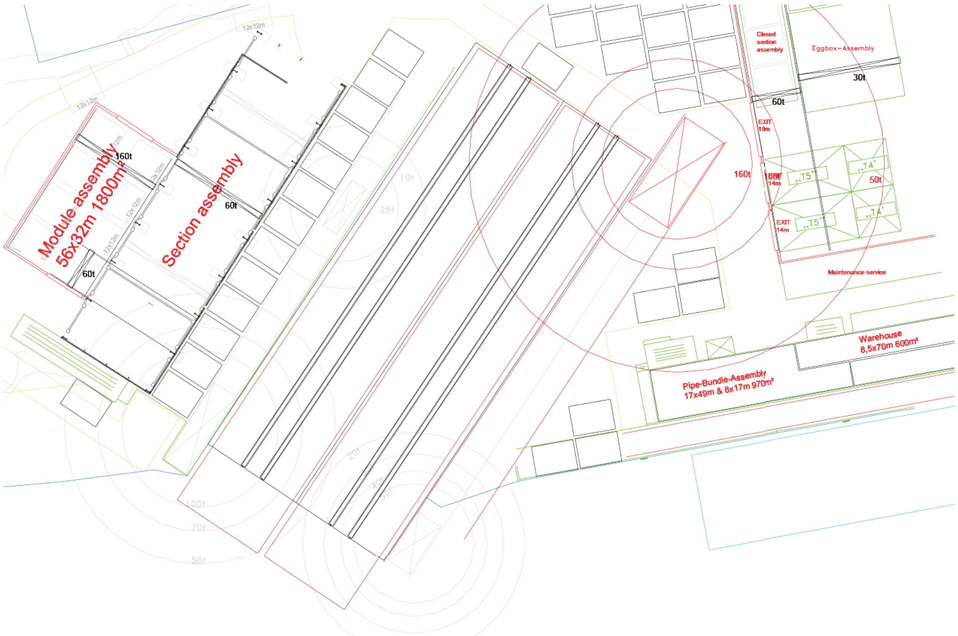
During the enlargement of the berth it is necessary to use the full capacity of both berths along the following plan to achieve the usual output rate:

1. Using the existing berth for the hull erection
2. Parallel preparation of launching berth 2
3. Using the launching berth 2 after finishing the preparation
    a. Erection of separate stern and middle/bow ship (tandem assembly)

→ Erection of the hull on three different assembly areas on the berth

- Setting the assembly starting position
- Starting with the double bottom and pyramidal erection of the ship middle
- Hull erection with the 160-t crane for ship middle and bow
- Erection of the ship stern with the 50-t crane

Fig. 9. Initial situation in final assembly



- Connecting ship middle and stern with an adjusting cut (achievable accuracy of 60 mm)
- Improve pre-outfitting of sections with pipes and ventilation systems, especially in the ship stern on the final assembly area

Preparation of infrastructure – cranes and ways of transport

Transport capacity to the launching berth is a main bottleneck in the shipyard. Therefore, a crane shall be constructed at the berth. This is followed by the necessity to build a rail system for the cranes to move on. For the 160-ton crane, two rails with an entire length of 320 m have to be placed. The existing 50-ton crane will be relocated and installed onto two rails 290-m long.

In the berth, a rail-based transport system will be installed to allow sections being transported lengthwise and crossways. At five places, there has to be a crosslink between the two berths to allow cross transport. The allowed load of the transport system has to be up to 1800 t. The length of the whole rail system lengthwise and crossways is about 1140 m. Parallel to the transportation system, a positioning system is planned to align the ring sections with the ship. This results in a decrease of crane demands. Furthermore, sliding bars have to be installed for launching; they are 640 m cumulated. Possible workflows on the launching berth after the rebuilding are shown in the following alternatives.

Ship hull erection

Different alternatives exist for hull fabrication and assembly. Fraunhofer prefers alternative 2 and alternative 1 as an interim solution until all systems are implemented into the launching berth. Alternative 1a is merely mentioned for the sake of completeness but should be avoided.

Alternative 1

Two ships are being erected in parallel with today's methods. On the first berth, mainly the 100-ton and the 25-ton cranes and on the second berth the newly installed 160-ton and 50-ton cranes are used. Using the tandem assembly method, the ship stern and middle are erected at the same time. Therefore, the ship stern is being positioned opposite of the ship middle by the new installed transportation and posi-tioning system. The assembly procedure on the launching berth could be supported with three cheap and profitable tower cranes. An additional investment for a new 160-ton crane for the launching berth 1 should be taken into account.

Alternative 1a

Both launching berths 1 and 2 with their transport and positioning systems will be used for hull erection. On the free spaces of the launching berths the rings will be erected in a defined tact. The degree of completion will be less with each ring. This alternative recommends another crane on the second berth. The erection procedure on the launching berth could be supported with three cheap and profitable tower cranes.

Alternative 2

With this alternative, the ship is erected in the first berth and the ring section assembly takes place in the second berth. It starts with the erection of the ship stern sections, which are transported to the first berth directly after completion. Afterwards, the ring sections are assembled to be pushed onto the ship stern. Five additional workplaces will be available. One of them for the erection of the ship stern and four for the assembly of the ring sections of the middle ship. All together, the ship with a length of 180 m consists of six ring sections and, respectively, one ship stern and one ship bow. Transport and positioning are managed by the rail system installed.

Ring assembly workstation on the launching berth

The area at the end of the second berth is designated for ship stern ship erection. The 50-ton crane does most of the work on this berth. The erection takes place on so called keel block pillars, while the stern is put together from all the small sections. The superstructure on the ship stern should be assembled as one module. The weight of the whole ship stern structure with the superstructure on top is about 1800 t.

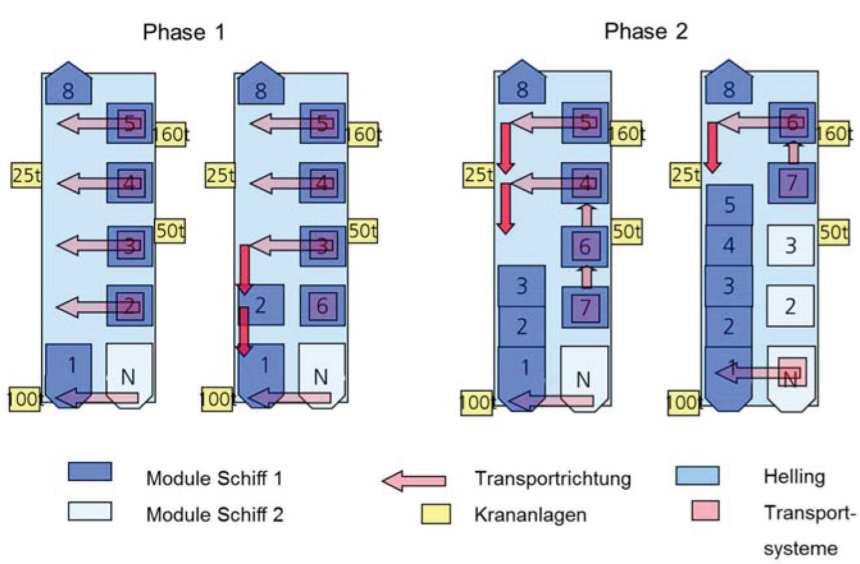
Transport to berth 1 is managed with the use of keel block pillars. Placement of the superstructure and the main engine will be done by a floating crane.

In the area above the ship stern erection, the ring sections of the ship middle are assembled. The 160-t crane supports the erection. The ring sections will be approximately 23 m long and have a weight about 1200 t. At these workplaces, pre-outfitting of the sections also takes place. The sections have to be assembled according to the defined erection sequence.

The area at the top of the launching berth 1 is allocated to the ship bow erection. The erection is supported by the 100 and 25-t cranes. The ship bow will be transported to the rest of the ship. After welding the sections, the hull is complete and the ship can be launched.

Because this shipyard did not introduce the assembly of ring sections, it was necessary to

Fig. 10. Concept of the new final assembly



analyze comparable shipyards with this erection method. Through these comparisons, a possible increase of productivity caused by the change of methods can be previously calculated. As basis, analysis from German shipyard activity sampling is taken. In general, it can be said that enclosure of the assembly area into closed buildings could increase productivity by about 20% just through light and climate conditions. Use of mechanical welding could increase this productivity by another 25%.

Another advantage of mechanization is that employees are free to work in second and third shifts.

Solution 7: Organization

Production planning and control and simulation

To introduce manufacturing simulation, the simulation model developed by Fraunhofer should be used. Here, reference sections are defined and their lead times in the main production and in bottlenecks are acquired. These sections would be the part fabrication, panel assembly, section assembly, and hull erection. Simulation can be started with this data. In a following step, this simulation can be upgraded with data from PPC systems, NC systems and CAD systems. A database reference to classify the building parts and groups is created. By implementing a specific IT structure, the simulation can be done in real time.

Multi-sampling

Multi-sampling can be used in the ship building industry, but due to the high complexity of the workflow and the assembled structures, modifications in preparation, execution, and analysis have to be undertaken. Thereby, this increases the evaluation possibilities and creates a tool to analyse and control the lead times.

The aim is to find the production expenses and develop comparable figures for effort estimation and controlling. The procedure to enforce activity sampling in the shipyard is very complex. Therefore, an expert team is needed to generate it in the shipyard, which will be trained by external specialists, *i.e.*, Fraunhofer AGP.

Solution 8: Design requirements

The main fraction of the costs is generated during the planning and constructing phase due to mistakes that delay the assembly or lead to reworks. By rationalizing in this area and introducing "FMEA", costs could be reduced significantly. It is highly recommended to change design methods to design for manufacturing and design for assembly.

Investment plan

The investment plan is based on the concept developed and current possibilities at the shipyard.

Fig. 11. Implementation of shop floor simulation: Future scenario

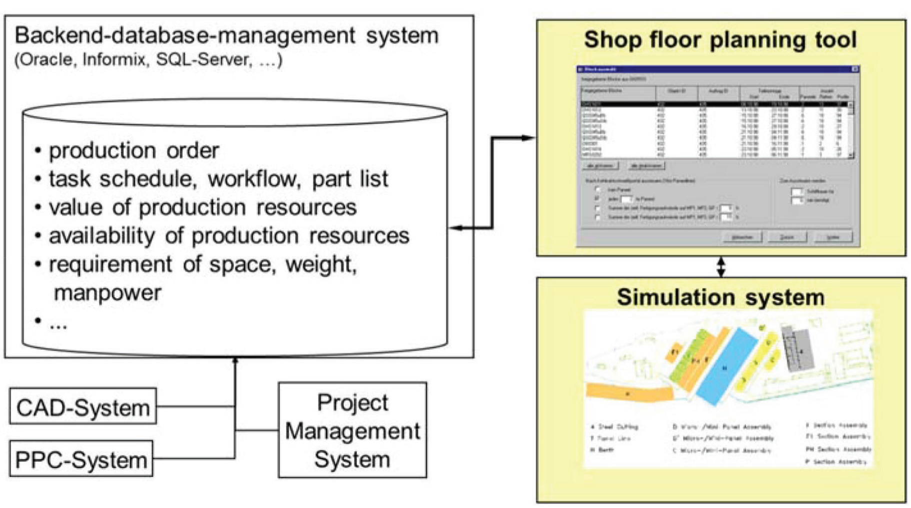
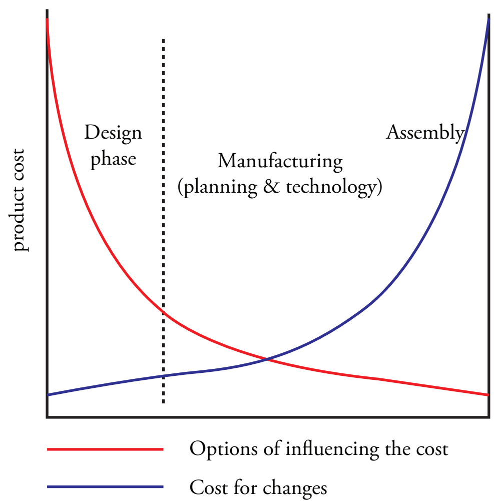


Fig. 12. Influence of design requirements



The costs for investments depend on prices estimated from Fraunhofer and the shipyard and on market prices. The investment plan is divided into three parts and should be followed consecutively.

The first package includes new section and steel conservation buildings, the new part and panel fabrication hall, as well as IT infrastructure. The investment volume is about 16.1-million Euros. The second package includes the new cranes, the berth's extension, and the rail and transport system, as well as pipe conservation, welding robots and the new positioning of the outfitting. The volume of this investment is about 15.4-million Euros. The third package includes the rail system for the ring as-sembly, the keel block pillars, the ring positioning system, and the web mounting gantry.

Additionally, the new building for the module assembly with the correspond-ing cranes and a profile bending machine complete the package. Its investment vol-ume is about 8.3-million Euros.

The complete investment volume is 39.8-million Euros. The actions combined in these packages should be carried out as a whole to equalize the output of all work-ing areas and facilities. Should any points of this investment plan not be arranged, this would have negative consequences for the shipyard.

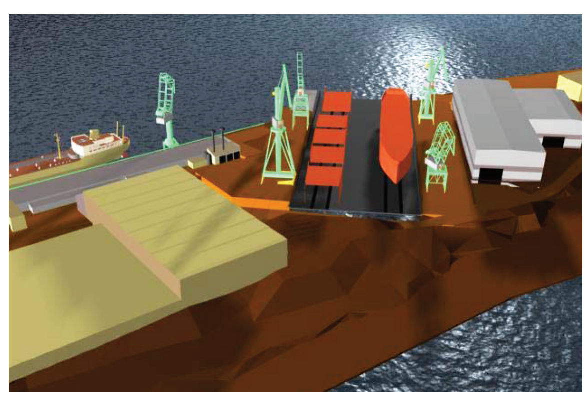
Productivity analysis

By implementing the measures introduced, the shipyard could increase the actual production from 2 ships per year up to 5 ships per year with the same number of employees. Currently, the productivity is about 18.5 tons of steel per person per year. The launching berth and the cutting station turned out to be the bottlenecks in the manufacture process. By arranging the investments mentioned in package 1, organisational changes and the use of the tandem assembly method, approximately three ships per year could be manufactured; this corresponds to 50% productivity increase.

After this phase, the berth with its cranes will be the new bottleneck. After applying the second package of investments, productivity will increase by another 26.7% and the shipyard could now build 3.8 ships per year. Again, there would be a shift of the bottleneck to the transport capacity at the manufacture section. After completing the investment plan's third package, another increase of 31.6% in production is possible. The shipyard would now be enabled to produce five ships. The capacities would be balanced. The assembly section would be bounded by the closed fabrication section and the fitting durations at the ring assembly to about five ships. The area on the launching berth is also bounded by the fitting duration of the ring sections.

With optimal process control and discarding of more measures even the manufacture of six ships per year is possible.

Fig. 13. The new shipyard concept



Conclusion

The targeted aim to produce 4 ships is achievable if the previously mentioned measures are carried out. Due to upcoming crisis in shipbuilding, the shipyard did not find a new private owner until the summer of 2012. The conversation process did not start until this time.

Bibliography

http://www.fraunhofer.de/en.html