The Start of a New Age for an Old Industry

Mogens Knudsen

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Abstract. The background for this history is the comprehensive renewal of concepts and solutions in connection with the rebuilding of Burmeister & Wain's shipyard at Refshaleøen in Copenhagen 1957–61. The project was started before access to digital computers was normal, but the parallel development of the first Danish computer DASK added new possibilities for planning and control of a more complex, but consistent production flow. The basis for this paper is the author's experience and personal files from participation in the project.

1 The old Shipyard

Burmeister&Wain has roots back to 1843 as engine- and shipbuilders in the port of Copenhagen. In 1872 some existing smaller shipyards were replaced by a shipyard on reclaimed land at Refshaleøen to the north of the Naval Dockyard. The production facilities included 3 building berths, a repair dock and all necessary workshops. During the first World War 1914-18 the building capacity was increased by 2 building berths and 1929 by further one.

The procedures were based on that time's facilities and handicraft, which in principal remained unchanged for a very long period. At the end of World W II in 1945 the production facilities were marked from years of stagnation and breaking-down and the maritime market demanded replacement of lost tonnage and bigger ships.

The technology during the fifties was influenced by transfer from riveting to welding, requiring new welding shops and bigger crane capacity, but also by the impact of the Marshall Help offering financial support and new ways of thinking within industrial engineering.

2 The Challenges

The period up to 1960 was characterized by progress, but also by some new challenges coming from the shipping market and the growing competition, especially from Japan. The market demanded increasing ship sizes, *e.g.* oil tankers up to 80.000 dwt. The challenge from Japan could be summarized in following issues:

Fig. 1. The Shipyard about 1939

- The government supported particularly the export industry in the effort to finance the reconstruction of the country after the war.
- The Japanese shipyards were rebuilt after the severe war damages and consequently better equipped with modern crane- and production facilities.
- Labour costs were significant lower.
- Less restrictions with regard to limitation of number of trade schools involved in a given job.
- The productivity was higher.

During the period 1957-59 B&W evaluated how to respond to these challenges and prepared thorough investigations of options for improving the capacity for competition and alternative proposals for solutions. It concluded in a plan for total reconstruction of the steel production, with new production facilities with new flow, new technology and adaption of digital solutions where appropriate. The traditional production flow in shipbuilding is characterized by few levels: the raw material (steel plates and profiles) are marked, cut and shaped in preparation shops and transported to the building berth for assembly to the final hull. The majority of the manual work takes place at the berth under difficult conditions: difficult access, bad working positions and influence of weather. With the introduction of welding, part of the hull is prefabricated in welding shops and thus reducing the said inconvenience, however limited by the crane capacity at the berth.

The plan for innovation (see figure 3 below) included replacement of the 5 active building berths by one building dock, dimensioned for bigger hulls (up to 80.000 dwt). With the same, or as foreseen, increased production volume, this required short lead times per hull (down to 1 month) and limitation of the need for working hours spent in the dock, accomplished by the limitation of the number of incoming building blocks to

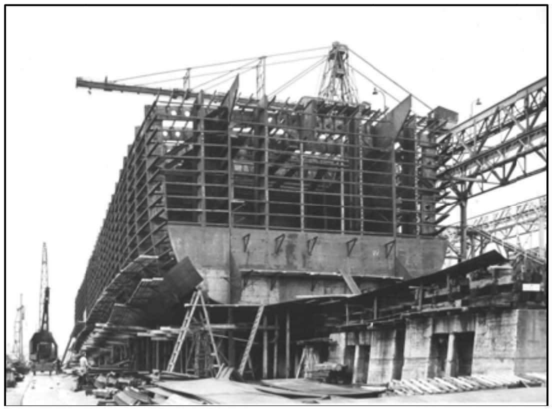

Fig. 2. Building Berth on Old Shipyard

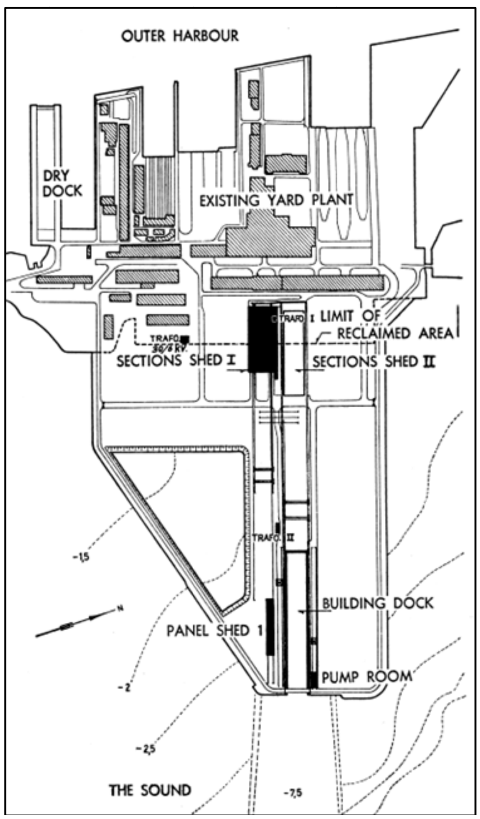

Fig. 3. Layout of new shipyard concept

relatively few, three-dimensional units. The fabrication of the building blocks would take place in two closed assembly shops, of which shop no. 1 delivered sub-assemblies (up to 240 tons) to shop no. 2, placed in line with the building dock. Shop no. 2 and the building dock were covered by two common Goliath cranes for handling of up to 600 tons blocks. Input to the assembly halls came from specialised shops, each being equipped for production of technologically similar structures e.g. plane panels, curved panels, web frames etc.

The building dock, assembly shops and adjacent buffer areas were placed on reclaimed land, which made it possible to run the production in the old shops simultaneously with the construction work. The basic lay-out, budget and project schedule were approved by the board early 1958 with an estimated date for start of operation July 1960. The construction works [1] lasted 2½ years, so actual start of operation was three months late.

Fig. 4. The new Shipyard

3 Simulation of New Production Flow

The design of the total lay-out including workstations, buffer areas and transport facilities was based upon manual simulation of complete production flows for a building program with a mix of different types of ships. For each type of ship structural design-drawings was used as basis for breakdown of the steel hull into main blocks and the main blocks into components, the components into subcomponents etc.

The block structures for each main block were visualized by assembly charts (hierarchical networks) with branches and nodes, where a node represents the start of an assembly process and a branch the processing of an ingoing component. See figure 5.

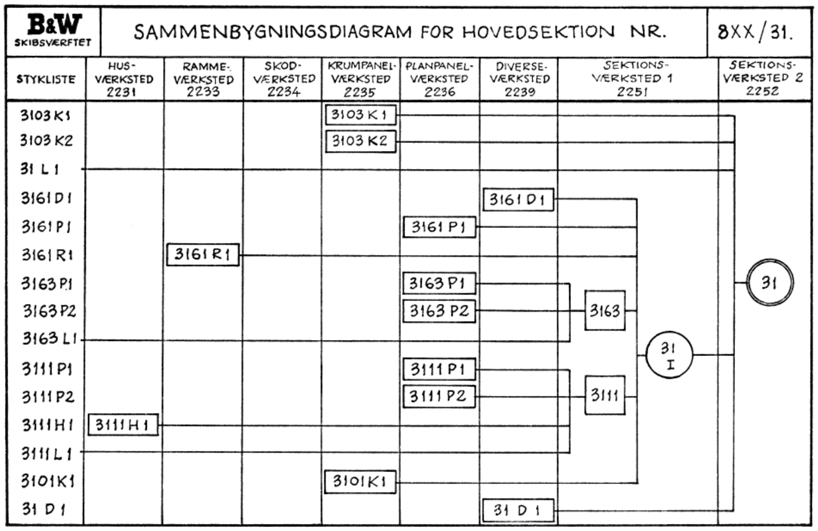

Fig.5. Assembly Chart

Each of these processes was described by identification number, reference to workstation, assembly steps in the station, estimated lead time and number of man hours as basis for manual planning and calculation of the total need for shop area, man hours and crane lifts over time and as a basis for final evaluation of the need for shop areas, buffer areas, crane capacity and manning per shop.

The starting point for establishment of a new building program was the build-up of the hulls in the building dock, with estimated dates for delivery of each block and backward planning of main blocks, components and sub components etc.

The experience from this exercise was of great importance for the coming development and design of planning by computer.

4 Introduction of Digital Technology

The production technology had to be transformed from an old, decentralized system, based upon manual traditions, to a coherent process of production flows from various supply centres through different levels of assembly to a central bottle neck. It required new demands on technical coordination, time planning, presenting of work drawings and on the timely registration of use of resources and work progress. To achieve the planning- and registration task manually seemed to be impossible according to the experience gathered from the simulation exercises.

At the same time when the new shipyard concept was formulated, the first computers were introduced in some Danish companies and The Danish Academy of Technical Science had started the historic project for development and building of the first

Danish computer ‘DASK’ [5] with inspiration from the Swedish computer ‘BESK’. The project team, established as ‘Regnecentralen’, was very active in informing about the new possibilities, creating a lot of interest and inspiration. Part of their costs was covered by contributions from companies and institutions with commitment from RC to supply program assistance and computer time for a defined task, corresponding to the contribution, This opportunity was fully utilized by B&W by agreement on the development of a set of programs which, based on B&W’s system specifications, should solve the needs for planning of the hull production for a complete building program.

This was quite a challenge at that time due to the big amount of data compared with the computer capacity, the needs for developing special techniques for sorting, for limitation of runtimes and for definition of algorithms for specific planning calculations. The programming language at that time was machine code, which later was replaced by Algol. It was an exciting learning period for pioneers, who with ingenuity set the standards for the future.

The planning technique [2] was based upon interactive planning of open networks (one per main block with defined finish date), backward planning of ingoing subassemblies on multiple levels according to the assembly diagram (Fig. 4), and calculation of start- and end-time and time for delivery to the buffer store for each subassembly. With starting point in these dates and parameters, recorded with the input, load per time period and shop is calculated and presented as curves showing need for man hours and shop/store area to be compared with the upper limit of capacity. A new sequence will for each shop calculate the need per day for ‘moving’ the actual subassemblies forward or backward in time in order to balance the load with the planned capacity and create a new time schedule. The result will normally lead to a new iteration with modified input.

Processing of a feasible building program required normally three times iterative running on DASK. Development of system specifications and computer programs took place 1960-1962 and the final program was implemented as basis for daily shipyard planning from January 1963.

At that time a complete planning of the hull production with three iterations occupied DASK continuously for 32 hours. When the B&W main office in 1966/67 acquired its own computer (CDC1606) the same runtime after reprogramming could be reduced to 3 hours. With the same planning concept as developed before IT became a normal tool, the computer program currently has been re-programmed and extended and has been in use all the following years.

5 Data Collection

With the improved possibilities for detailed and quick work planning it became clear that the existing ways of data collection and feedback not were sufficient, due to missing and uncertain data and the time needed for manual preparation of input to a new work program. Introduction of digital technology could solve these problems by a better timeliness, means to exclude false references and extension of recorded data with e.g. start- and end-time per person per job. Equipment for data collection existed already, *e.g.*, Olivetti RP60.

Beyond the existing come- and go-registration at the gate, new stations for collection of person and job information were installed in all work shops.

The data collecting was done by means of punch cards, one representing the person, a second representing the actual job and a third special extra information plus automatic registration of time. The total output was printed on paper tape, in this early version of IT without online facilities, and sent to the computer centre for update of the administrative and planning systems. In this way planning and follow-up would be based on more reliable data that were just one day old.

6 Further Electronic Production Equipment

Stepwise assembly of the steel hull requires controlled accuracy on all steps to assure the quality of the final building block and its correct assembly with adjoining blocks.

It was obvious that the existing manual methods for marking-up of big plane panels, or even shell panels not would be sufficient accurate, so it was decided to look for an electronic solution. With assistance from The Danish Technical University a system was designed, based on overhead gantries running on tracks in each side of the shop carrying a carriage with a projector, which by electronic control could move to any point in the shop with high accuracy. The projector moved in a planned sequence from point to point indicated by a light cross and marked manually.

This arrangement was abandoned after some years and replaced by automatic marking-up the plates during the cutting process on new acquired electronic cutting machines.

7 The End of the Era

Production in the new facilities started in 1960 when the shipyard had the maximum workforce ever corresponding to 3600 people. The first couple of years were marked by substantial start-up problems and extra costs, but the experience from this learning period became basis for the following year’s success, especially with series building of bulk carriers.

The market conditions for shipbuilding were strongly affected by external factors like the Suez war 1956, the Oil crisis after 1972, and the competition from new shipyards in South Korea and China dominated more and more from the middle of the seventies.

The B&W shipyard had since the start together with the engine factory belonged to A/S Burmeister & Wain’s Maskin- og Skibsbyggeri. Financial problems [4] mainly caused by the shipyard and a power game between some leading Danish enterprices and individual persons, led to separation from the engine factory 1971. In 1980, after some stormy years, the engine factory (B&W Diesel A/S) was taken over by MAN

(Maschinenfabriek Augsburg Nurnberg) and the shipyard was established as an independent company Burmeister & Wain's Skibsværft A/S.

B&W's 150 years anniversary was celebrated 1993. The shipyard was then the last living part of the former glorious company, but only for a short while.1996 became a fatal year with stop of payments and subsequent liquidation. After 45 years activity in the new surroundings, delivery of 170 new-buildings and a number of other steel constructions the era finally was over, following the fate of most Danish shipyards. It should be added, that the realisation of the assets fully paid all creditors.

The ideas behind B&W's solutions and their realization have had big influence internationally as nationally.

Internationally: By the transfer of the new technology to shipyards in China, South Korea and other Asiatic countries. This contributed through their success to the decay of shipbuilding industry in our part of the world. This development was inevitable and in many cases assisted by persons with experience gained from the B&W project.

Nationally: By establishment of a comprehensive, country wide training program for the Danish industry fostered by The Danish Technical University and The Danish Association of Iron- and Metal Industry Employers (Sammenslutningen af Arbejdsgivere indenfor Jern- og Metalindustrien i Danmark). The purpose of the program was to support the growing awareness of the impact of information technology with practical examples and systematic understanding of methods and models for introduction of IT in production control, for a great deal based upon experience from the B&W project [3].

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