Model of material supply control in shipyards

B. Metschkow, B. Malinowska – Siemińska
Ocean & Ship Technology Institute, Technical University Szczecin, Aleja Piastów 41, 71 – 065 Szczecin, Poland
Email: boshidar@shiptech.tuniv.szczecin.pl

Abstract

Shipbuilding is an activity aimed at assembling many thousands of elements in one very complicated object. The many different components and materials are kept in shipyard depots. Supply, storage and delivery of materials from those depots at the workshop level are the material procurement activity area. The related material costs influence strongly the general cost of ship production. This paper presents the industry’s material procurement control model. The material flow in the production depends on the transfer of information. The efforts have been made to diminish the reserves in depots. That means ordering of the material in the „Just-In-Time” mode of operation. It is the organisation system which exactly controls the deliveries of necessary materials and parts according to an immediate order from a factory to the workshop area in the shipyard. The discussed material procurement control system relates to:
1. Diminution of depots reserves in shipyard,
2. Diminution of depots area,
3. Reduction of ship production cost.

1 Introduction

In recent years the international competition between the shipyards has been to a growing disadvantage of Europe. An influential factor in that fierce rivalry are costs. In assessing the current market situation an opinion may be ventured that the West European shipbuilders are to increase their efficiency by 30 to 40 percent to achieve a pricing equilibrium with the Far East, and particularly South Korean, competitors.
The following three basic costs have an impact upon the whole cost of a ship: material, labour and financial services. The costs of both materials and finance are comparable throughout the world. The material constitutes 50-50% of the above figure on average, dependent upon the ship’s type, its size and some other factors. The financial services, and first of all those related to credits, amount to ca. 10% of the ship’s value. These two factors make up a comparable initial price at all shipyards, irrespective of the fact that the state protectionism may be substantial and alter largely the financial conditions in the shipbuilding sector and thus the relevant production costs at a shipyard. Cost differentiation emerges in case of labour where hourly rates are influenced by the labour productivity, wages, social welfare and other overheads at a given shipyard.

The material management in the shipbuilding sector has an effect, too, on both the costs of financial services and hourly rates. In developed countries the stocks have long been kept at a necessary minimum ensuring material reserves for a short production period - even for a mere couple of shifts. That system is known as „Just-In-Time”. The implementation of this system is not only dependent on a shipyard, but on the whole regional and home economies as well. Both the experiences and tradition in the developed monopolistic market or central-planned economy have been still operational in the shipbuilding sector in the Central and Eastern Europe, same being a significant obstacle in minimising the costs of the material management and eroding the position of the European shipbuilders.

The situation in the Polish shipbuilding sector from the viewpoint of a relatively cheap labour is more advantageous than that in the Western Europe. The advantage is temporary, however, since measures towards the convergence have driven the process of approaching the West European price level.

Earnings in the shipbuilding are more inert that the costs of goods and services. Their level reaches an equilibrium more slowly but this tendency is objective and irreversible.

A sudden rise in the labour productivity includes significant investments which, at this stage of the development of the national economy, sound utopian. Therefore there are the only two ways to come nearer to the Far East pricing level:

- substantial improvement of processing accuracy, pre-fabrication and assembly supported by the implementation of a system of tighter tolerances and thus a distinct reduction of repair work
- optimising the production processes, inclusive of the material management and a large scale economising on the current assets.

This paper deals with a model of a dynamic management of material reserves in the shipbuilding environment as a foundation for an essential lowering of the level of frozen assets.
2 Principles of material management

Purchasing, storage, issuance and internal transport functions all make up the material management of a production enterprises. An exceptionally wide variety of the nature of materials to be processed first (e.g. steelworks products, anticorrosive paints) and of ancillary materials (e.g. electric cables, oils), semi-finished goods (thermal insulation components, pipes), equipment (pumps, fittings), modules (nav-aids, electric motors), up to whole plants (as main engine, deck & sub-deck machinery) distinguishes the shipyard from other production plants with a more specific profile. The spectrum of grades, dimensions and values of the above requires the simultaneous observance of the three principles of material delivery: keeping stocks, supplying to customers’ individual needs and immediate use upon delivery.

The material management involves quantitative, qualitative and timely control, storage and distribution within the shipyard. It does include logistics, economy and planning of the processes in question. Due to the foregoing the term of the integrated material management is often times referred to.

An objective evaluation of the situation of the shipyard material management is exceptionally difficult and requiring a careful and targeted consideration of individual components and their relationships. Achievement of the objective i.e. reduction of costs in the material management is conditional upon the skill of and preparation to the use of the so-called ‘benchmarking’. The benchmarking are continuous and systematic activities based upon indices that enable dimensioning, assessment and improvement of processes, products and services in a business entity. These indices are strategic (type A index), directive (type B index) and operational (type C index) by their nature and in the first line they relate to the cost analysis at various levels of the management (e.g. Bichler [1]).

At the current stage of the development of Poland’s shipbuilding sector the material management is largely focused on the creation of reserves and their temporary storage. The so far unstable market and distribution networks introduce the element of likelihood which also stems from the production environment in the shipyard itself.

Therefore the extent of reserves may not be calculated based only on the yard’s production programme. A better insight ensures their current level which is conditional upon the material consumption and it does not allow for the production programme directly. Some significant directive indices are listed below:

- Scope of order (Wz) or maximal material reserves (Sm);
- Ordering time (Tz) or reserves threshold level, beyond which another order is processed (Wg);
- Reserves review time-table (Tk), when the review may be performed continuously (current directive), upon each material transaction or by stages, upon expiry of a prescribed time (stage-and-step directive).
A combination of these three directive indices determines a specific policy in the material storage (Table 1), (e.g. Zapfel [2]).

Table 1 Summation of the material storage policy

<table>
<thead>
<tr>
<th>Scope of orders Wz</th>
<th>Current directive</th>
<th>Step-wise directive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>(Tz, Wz) Policy; Ordering method by point constants</td>
<td>(Tk, Tz, Wz) Policy; Method of ordering by a repeated pattern</td>
</tr>
<tr>
<td>Varying</td>
<td>(Tz, Sm) Policy; Ordering method by point variables</td>
<td>(Tk, Sm) or (Tk, Tz, Sm) Policy; Method of ordering by a repeated pattern expressed in variables</td>
</tr>
</tbody>
</table>

The above conception is known also as the stochastic method for reserves calculation against their consumption. It requires a specific statistical analysis of the material consumption and the determination of the directive indices. Only when they have been made available, a reliable judgement on the future consumption and a justification of curtailing material reserves are both possible.

3 Material management analysis

The application of the single policy displayed in Table 1 is based upon the principle that the assortment of all materials may not be regarded equally since as such it contains items differing from one another. At the outset of the cost diminution in the material management an assortment differentiation is required, the procedure being known as the type ABC analysis. The analysis is connected with the assortment analysis by quantity and value whose results are shown in Fig. 1.
Concurrently with the above or to arrive at more findings, the material management may be analysed with respect to some additional or supplementary indices (type XYZ analysis) and differently for the A, B and C classes. The incorporation of such results in a ABC/XYZ matrix enables to determine the interactions and relationships between the value-related and qualitative factors. The decision on implementing the appropriate concept, methodology or one of the material storage policies indicated in Table 1 will not be taken until the processing of analytic results and consideration of statistic relationships have been carried out.

Computerization of the organisational processes which take place in the yard’s material management enables a constant monitoring and analysis of the material reserves.

4 A dynamic model for the diminution of material reserves

The overall costs of the material management undergo dynamic changes due to the characteristics of the shipbuilding production and market situation. In the first approximation it is possible to determine the costs with the help of linear equations (e.g. Strzala [3] ) as follows (1):

\[ y_1 = \alpha_0 + \alpha_1 x_{11} + \alpha_2 x_{12} + \alpha_3 x_{13} + \ldots + \alpha_k x_{1k} + \xi 
\]  

(1)
where: 

- \((t+1, \ldots, T)\) - time variable
- \(y_t\) - clarified independent variable
- \(X_{t1}, \ldots, X_{tk}\) - clarifying variables
- \(X_{u}, \ldots, X_{tk}\) - parameters as the measure of direct impact of individual clarifying variables on a clarified variable in a relationship
- \(\xi_t\) - chance element

The scalar notation of the dynamic model is expressed by the following formula:

\[
\begin{align*}
\begin{bmatrix}
    y_1 \\
    y_2 \\
    \vdots \\
    y_i \\
\end{bmatrix} &= \begin{bmatrix}
    1 & X_{11} & X_{12} & \cdots & X_{1k} \\
    1 & X_{21} & X_{22} & \cdots & X_{2k} \\
    \vdots & \vdots & \vdots & \ddots & \vdots \\
    1 & X_{T1} & X_{T2} & \cdots & X_{Tk} \\
\end{bmatrix}
\begin{bmatrix}
    \alpha_0 \\
    \alpha_1 \\
    \vdots \\
    \alpha_k \\
\end{bmatrix} + \begin{bmatrix}
    \xi_1 \\
    \xi_2 \\
    \vdots \\
    \xi_i \\
\end{bmatrix}
\end{align*}
\]

where:

- \(Y_{Tx1}\) - observation vector on the endogenous variable
- \(X_{tk(K+1)}\) - observation matrix on the clarified \(k\)-variables of the model
- \(\beta_{(k+1)x1}\) - vector of unknown (structural) parameters

where: \(k\) - number of parameters to be evaluated
The resultant general formula of the matrix linear economic model is as follows (3):

\[ y_{txl} = X_{txl}(K+1)\beta_{(K+1)x1} + \xi_{txl} \]  

To solve the economic model, it is to determine the values of \( \beta \) and \( \xi \) relying on the statistic data \( x, y \). Then is to proceed further from the theoretic to am empirical model.

The to date applied models to characterise the stockpiling processes have been restricted to research of the relationships between reserves and production volume or material consumption. A full and thorough analysis of the impact of individual factors on reserves in the yard’s depots by means of the econometric models may be replaced exclusively with simultaneous consideration of the factors concerning both delivery and material consumption.

The further steps of the creation of an economic model are listed below:
- determining the aim of research;
- determining endogenous variables;
- selecting clarifying variables;
- collecting statistic data;
- selecting analytic formula - theoretical model;
- model assessment;
- model verification – within its framework it is to be resolved whether the assessed model outlines the development of the endogenous variables with an accuracy that ensures achieving the goal of research.

5 Example of the application of dynamic model at Polish shipyards

The model research on the material reserves (e.g. Strzala [3]) has been carried out at three Polish shipyards.

10 different econometric models have been pre-selected. Some of them are listed below:
- a model with the value of material reserves being dependent on their consumption and a time factor throughout subsequent quarters;
- a model with the incomes from storage dependent on a time variable and on stocks;
• a model with material reserves being dependent on a time variable, material consumption, material income, costs and sales.

The model for computing the storage costs versus a time variable and material reserves, and incomes is specified below. The model may be presented by the following formula:

\[ K = \alpha_0 + \alpha_1 T + \alpha_2 Q_1 + \alpha_3 Q_2 + \alpha_4 Q_3 + \alpha_5 Z + \alpha_6 P + \xi \]  

(4)

where:
- \( K \) – storage costs
- \( T \) – time variable
- \( Q \) – quarter-related variables
- \( Z \) – reserves
- \( P \) – income

This relationship illustrates virtually (in 88.3%) the reality, statistic tests \( \alpha_1, \alpha_2, \alpha_4 \) have been met with an accuracy of more than 90%.

6 Results of calculations

The calculations for this model have been made within a thesis (e.g. Majer, Bujewicz, Mazur [4]). The collected data concerned a period between 1994/1 and 1997/II. Upon completion of all the mathematical calculations the results were as shown in Fig. 2..

Rys.2 Chart on storage costs at a shipyard
7 Conclusions

The dynamic model regulates the delivery of materials, semi-finished products and equipment to the storage space and depots. The fusion of delivery timetable and manufacturing process induce the diminish of capital expenditure. Storage space, levels of assets frozen in the stocks, internal transport between both the depots and work stations are all significantly reduced. The dynamic model connect the elements of “Just-In-Time” system and classical method of lead the material distribution. This model take into consideration the specific of shipbuilding process.

The introduce of dynamic model must be preceded by following tasks:
- Elaboration of statistic analysis of the assortment and material consumption by the principles of “Benchmarking” method.
- Assembling the statistic data from the signifying terms
- Information transmit between timetables of manufacturing process and material distribution
- Creating of mathematical models on base of real situation, software development and data base
- Verification of dynamic models and corrections introducing
- Testing start in selected division of material distribution
- Checking of financial situation after testing start and risk checking during the introduction of dynamic system of leading the material distribution in all shipyard.

References

