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OPTIMIZATION OF THE REPAIR PROGRAM FOR SHIPPING COMPANY'S VESSELS

There are several issues to be considered in this research: the problem of optimization of the process of vessel repair by using economic and mathematical models that would provide a shipping company within a free market and full liberalization of the tramp shipping a sustainable position at the relevant local freight market and would contribute to obtaining the greatest possible profits by holding a particular cargo base and regular customers.

Keywords: *optimization; fleet repair program; local freight market; shipping company.*

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ОПТИМІЗАЦІЯ ПРОГРАМИ РЕМОНТУ СУДЕН СУДНОПЛАВНОЇ КОМПАНІЇ

У статті розглянуто питання оптимізації організації ремонту суден, вирішення яких дозволило б судноплавній компанії забезпечити стійкі позиції на відповідному локальному фрахтовому ринку та отримати максимально можливі прибутки шляхом закріплення за собою певної вантажної бази і постійної клієнтури.

Ключові слова: *оптимізація; програма ремонту флоту; локальний фрахтовий ринок; судноплавна компанія.*

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ОПТИМИЗАЦИЯ ПРОГРАММЫ РЕМОНТА СУДОВ СУДОХОДНОЙ КОМПАНИИ

В статье рассмотрены вопросы оптимизации организации ремонта судов, решение которых позволило бы судоходной компании обеспечить устойчивое положение на соответствующем локальном фрахтовом рынке и получить максимально возможную прибыль путем закрепления за собой определенной грузовой базы и постоянной клиентуры.

Ключевые слова: *оптимизация; программа ремонта флота; локальный фрахтовый рынок; судоходная компания.*

Introduction. With the growing competition at local freight markets, organization and management of freight transportation and fleet operation are aimed at ensuring the competitiveness of shipping companies at relevant local freight markets and getting sufficient profit from the current market situation. As a rule, coming to a perspective local freight market, a tramp shipping operator begins to look for the ways to retain a particular cargo base, regular clients or tries to change the work to the consecutive voyages etc. At the same time the company begins to search for possible solutions to save on different types of charges.

In addition, scientific evidence-based methods about the conditions of chartering vessels, the optimal values of operating parameters of vessels, output circuits from service for planned repair etc. become much more important.

The major tasks of optimizing operations of the shipping company in operational, current and medium-term planning are forecasting traffic, planning of fleet activity and plan repair.

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The current planning of a fleet shipping company is based on the following: the predicted values of a cargo base of the local freight market calculated for the corresponding year; analysis of the materials of fleet operations for the previous year; schemes of the fleet that take into account the features of the bunker market, the possibility of back load etc.; agreements and contracts for the carriage of cargo and other conditions.

The main optimization criteria are: net income and the percentage of presence (market share) of the company at the local market, which can be generally expressed in terms of the quantity of cargo in tons.

Background. There have been studied the issues of fleet organization and optimal fleet planning (Primachev et al., 2004) and the strategic management of a shipping company (Lugovets et al., 2010), the problem of improving the competitiveness of shipping companies mainly due to optimal choice of the markets, where the fleet will be used (Kotlubay, 2004; UK P&I Club, 2008), optimization of chartering conditions (Kotlubay, 2009; Kulchikovskaya, 2005; UNCTAD, 2004), as well as business planning of shipping companies based on economic and mathematical models (Shumlyanskaya, 2005).

Unresolved issues. However, these issues do not display an integrated approach to solving this problem. Also, the effect of the forced withdrawal of vessels out of service for repairs on the competitiveness of the shipping company is not sufficiently studied yet, due to the fact that these vessels are temporarily leaving the market which can be possibly occupied by other shipping companies. In order to keep the share at the market a shipping company may hire vessels of other shipping companies while their own fleet is being repaired. In such situation there exist many options for putting the ships out of service for repair (the choice of a shipyard), as well as options to lease other vessels (Clarkson Research Studies, 2011).

The feature of this task is that we want to go from planning of transportation (Primachev et al., 2004) to planning of fleet's operations in relatively uncertain conditions but based not on the cargo, as it was done by previous researchers (Charpentier, 2008) and which we believe is adequately predicted, but on the competition and the number of other competitors present at the market. The latter is especially important for perspective markets, where positions have to be kept under strong competition. In this situation any weakening of the market position will inevitably lead to the loss of some of its shares and the weakening can be expected during the periods of forced withdrawal of its fleet from operations, primarily for dry-docking and scheduled maintenance.

These circumstances suggest the desirability of developing a science-based methodology that allows a shipping company make optimal decisions concerning the choice of a particular scheme of taking ships for repair and the other one represents temporary replacement on the tonnage market used by other ships.

The target problem for the analysis. The purpose of this article is to develop such a fleet optimization model that would provide the shipping company a sustainable position at the relevant local freight market and obtain maximum profits by ensuring a particular cargo base and constant clients in the free market conditions and the full liberalization of tramp shipping.

Key research findings. Summing up the experience of fleet planning given in the works by of Lugovets et al. (2004) and Shumlyanskaya (2005) and taking into account

that the choice of repair facilities and terms of factory repair are the elements of the fleet's activity plan and the main criteria for its realization are the optimization of the cost-income ratio and the percentage of presence (market share) at the relevant local market the following model of optimization of fleet shipping company is proposed:

$$\frac{\sum_s \sum_r \sum_j \sum_t f_{srjt} x_{srjt}}{\sum_s \sum_r \sum_j \sum_t (M_{srjt} + B_s a V^e_{srjt} t_{srjt}) x_{srjt}} \to \max; \quad (1)$$

$$\sum_s q_{srjt} x_{srjt} \le Q_{rjt}, \forall r \in G, \forall j \in J, \forall t \in T; \quad (2)$$

$$\sum_r \sum_j \sum_t t_{srjt} x_{srjt} \le T_s, \forall s \in S; \quad (3)$$

$$\sum_r \sum_j \sum_s (q_{srjt} x_{srjt}) / \sum_r \sum_j Q_{rjt} \ge d_t, \forall t \in T; \quad (4)$$

$$\frac{\sum_s \sum_r \sum_j \sum_t f_{srjt} x_{srjt}}{\sum_s \sum_r \sum_j \sum_t t_{srjt} x_{srjt} D_s} \ge \overline{p}; \quad (5)$$

$$f_{srjt} = f^0_{srj} - c_{srj} \left(\sum_r \sum_j \sum_s (q_{srjt} x_{srjt}) / \sum_r \sum_j Q_{rjt}\right), \forall s \in S, \forall r \in G, \forall j \in J, \forall t \in T; \quad (6)$$

$$\sum_{s \in S_p} \sum_{j \in J^+_w} m_{srjt} x_{srjt} \le N_{rwt}, \forall w \in W, \forall t \in T, r \in R_p; \quad (7)$$

$$\sum_w \sum_{j \in J_w} m_{srjt} x_{srjt} = m_{srt}, \forall s \in S, r \in R_p, \forall t \in T; \quad (8)$$

$$\sum_r \sum_{j \in J^+_a} x_{srjt} + x^H_{sat} = \sum_r \sum_{j \in J^-_a} x_{srjt} + x^k_{sat}, \forall t \in T, \forall a \in A, \forall s \in S; \quad (9)$$

$$\sum_r \sum_{j \in J^-_a} x_{srjt} \ge x^H_{sat}, \forall s \in S, \forall a \in A, \forall t \in T; \quad (10)$$

$$x^k_{sat} = x^H_{sat+1}, \forall t, t+1 \in T, \forall a \in A, \forall s \in S; \quad (11)$$

$$x^H_{a_{0s}, t_{0s}} = 1; m_{srt} = const, \forall s \in S, \forall r \in G, \forall t \in T; \quad (12)$$

$$x_{srjt} \ge 0, x^H_{sat} \ge 0, x^k_{sat} \ge 0, \forall s \in S, \forall r \in G, \forall j \in J, \forall t \in T, \quad (13)$$

where x_{srjt} – the number of voyages made by ship s within the section j by option r in period t; r – the kind of ship's work (shipping r, repair r etc.); $M_{srjt} + B_s aV^e_{srit} t_{srit}$ – the variable component of the price at the local freight market, see formula (3); d_t – the market share, which must be held for a period t; f_{srjt} – the financial result (profit) for the trip from the carriage of cargo r by the ship s on the section j in the period t; q_{srjt} – loading the ship s with cargo r at the section j in period t; Q_{rjt} – the amount of cargo transportation cargo r at the section j in period t; t_{srjt} – the time of the voyage of the ship s with cargo r for the section j in period t; T_s – the time budget of the ship s; D_s – s ship's deadweight; f^0_{srj}, c_{srj} – the regression coefficients; S – set of ships, including the possible lease options to replace the ones removed from service; G – set of items of goods; J – a lot of traffic areas, including ballast; $\overline{p}$ – normative profit per ton deadweight per day of operations.

The specific feature of the task, except the above, is that the multitude of units A also includes a subset of the ship repair bases W. The index w specifies the number of the base. The set R_p defines the variety of types of ship repair (factory /dock/ unplanned and others); S_p – the multitude of vessels under repair; J_w^+ – the set of the sites included in the ship repair base w. Then m_{srjt} is the scope of work according to the type of repairs r for the vessel s at the "repair" site j in the period t; x_{srjt} is for the voyage of the vessel s with the type of repair r at the "repair" site j in the period t; N_{rwt} is for the scope of the repair work r of the ship repair base w allotted for the vessels of the shipping company in the period t; t_{srjt} is the stay of the vessel of s type, with the type of repair r at the "repair" section j in the period t; $x^н_{sat}$ =1, if the ship s is at the beginning of the period t in the unit (the base) a; x^k_{sat} =1 if the ship s is at the end of the period t in the unit a; J_a^+ is the set of sites, included in the unit a; J_a^- stands for the set of the sites coming out of the unit a; T is for the multitude of planning periods; t_{0s} is the initial planning period of operation of the vessel s; a_{0s} – the starting unit of work of the ship s.

The objective function of the model (1) is aimed at achieving the maximum of the ratio results to costs. The inequalities (2) and (3) are the limits in the volume of traffic and the calendar budget of time of the vessels.

The inequalities (4) and (5) are the limits in the market share and the intensity of foreign exchange earnings for the shipping company. (6) is the regression equation that determines the dependence of the standard of financial result f_{srjt} from the share market.

The inequalities (7) and (8) represent the dedicated power restrictions of the ship repair base's facilities and the number of types of repairs for each vessel within a given period. The expression (9) is the equation of the balance of the fleet passage through the sites. The expressions (10) and (11) are additional conditions for the equations of the fleet passage, which determine the lower limit of the departure area a and connect the final and the initial periods of fleet operation. (12) and (13) determine the conditions imposed on the variables of problem decision.

Conclusions. Considering that the choice of repair facilities and timing of plant repairs are the elements of the fleet activity plan and the main criteria for its implementation is the optimization of the profits-costs ratio and the percentage of presence (market share) of the company at the relevant local market, the optimization model of fleet shipping company is offered.

The proposed model allows planning the fleet activity in a fairly high uncertainty taking into account other competitors at the market and makes it possible to optimize decisions concerning shipping retiring at the repair, as well as the temporally replacement of such ships by other chartered vessels at the local market.

Furthermore, the specific feature of the model is that individual limitations could be considered on individual vessels of the shipping company.

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