UDC 656.6:517

DETERMINATION OF THE OPTIMAL SPEED OF THE VESSEL

Arsen Kudzinovskyi
National Aviation University, Kyiv

Research Supervisor - Viktoriia Trofymenko, PhD.

Keywords: maritime logistics, economic speed of a vessel, function extremum.

Maritime transport is considered to be the most versatile mode of transport specialising in international trade and is characterised by high transport efficiency compared to other modes of transport. According to a study by the International Maritime Organisation, sea and river freight traffic accounts for about 90% of global freight flows [1].

The main task of maritime logistics is to carry out maritime transport with minimal costs, fuel consumption and environmental emissions. The significant and dynamic increase in global oil prices has led to significant changes in the pricing policy for marine fuel. For the cargo fleet, the share of fuel costs in the total operating costs per voyage is around 50%, depending on the vessel's range, speed and the market price of a tonne of fuel for the main engine and auxiliary machinery while underway and at berth. The rise in fuel prices leads to a significant increase in operating costs and a decrease in the profitability of transportation and payback of vessels [2]. The extreme dependence of fuel consumption on vessel speed is one of the most important parameters of planning and operation. The study of the dependence of fuel consumption on ship speed and the development of methods for selecting the optimal operating speed are discussed in [3, 4].

As the vessel's speed increases, water resistance increases dramatically, resulting in high fuel consumption. Reducing the vessel's speed results in longer cargo delivery times and uneconomical operation of the main engines. However, this results in fuel savings per voyage. The operation of vessels at reduced speeds is widely used in global practice, with the reduction of vessel speeds being set by operators intuitively, without serious economic justification. Such an approach to setting the mode of operation of ships in the maritime fleet inevitably leads to a reduction in the economic effect of ship operation. Therefore, research aimed at choosing an economically justified ship speed, on which fuel consumption directly depends, is currently relevant.

The most economical vessel speed is the speed at which costs are minimal. Thus, by finding the analytical expression of the cost function as a function of ship speed and examining the resulting function for the minimum, the most economical ship speed can be found.

It is known that the cost of fuel required for a voyage by a transport fleet vessel is proportional to the cube of its speed. Let the cost of fuel required for a certain ship is 58800 UAH at a speed of 10 knots. All other types of costs are 353,000 UAH. Let's find the most economical speed of the ship and calculate the additional profit due to fuel savings for the voyage Odesa - Istanbul (distance 2163 km).

Vessel operating costs per 1 mile are determined by the following formula:

$R = kV^3 + b$,

where k is the proportionality coefficient;

V is the vessel's speed in knots;

b – other types of expenses in hryvnia.

In practice, costs are calculated for 1 hour, so the cost function is determined by the formula: $f(V) = \frac{R}{V} = kV^2 + \frac{b}{V}$, which for a given voyage will have the form: $f(V) = 58,8V^2 + \frac{353000}{V}$.

Let's investigate the function $f(V)$ for the minimum: $f'(V) = 117,6 \cdot V - \frac{353000}{V^2} = 0,\ V > 0,$

$117,6\,V^3 - 353000 = 0,\quad V \approx 14,4.$

Thus, the most economical speed of the ship is 14.4 knots. Having calculated the costs of the Odesa-Istanbul voyage at 10 knots and 14.4 knots, we obtained the difference in the cost of the voyages, which is UAH 1,832,544, which is additional profit.

Conclusion

To increase their competitiveness in the chartering market, ship owners and operators need to reduce their fuel and lubricant costs. One of the ways to reduce such costs is to choose the optimal operating speed of the vessel. This paper considers the problem of optimising the speed of vessel operation by studying the function for an extremum that guarantees the maximum possible level of profit from a voyage.

List of references:

1. Попель С.А. Міжнародні морські вантажні перевезення: сучасний стан та перспективи участі в них України / С. А. Попель, О. В. Неліпович, К. Д. Мотюк // Науковий вісник Ужгородського університету. Сер : Економіка. – 2013. – Вип. 4. – С. 200-204.

2. Степкова В.В. Аналіз впливу зростання цін на паливо на ефективність експлуатації вантажних суден // Збірник матеріалів міжвузівської конференції "Проблеми та перспективи розвитку обліку та економічного аналізу". – Миколаїв, 2008. – 162 с.

3. Halvorsen-Weare E.E. Optimal fleet composition and periodic routing of offshore supply vessels [Text] / E.E. Halvorsen-Weare, K. Fagerholt, L.M. Nones, B.E. Asbjornslett // European Journal of Operational Research, 2012. - Vol. 223. - P. 508-517.

4. Kim Jae-Gon Optimising ship speed to minimise fuel consumption [Text] / Jae-Gon Kim, Hwa-Joong Kim, Paul Tae-Woo Lee // Transportation Letters, 2014. - Vol. 6(3). - P. 109-117.