

Analyze of multipurpose ship main dimensions designed by technical criterion

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Abstract: The paper deal with impact of technical criterion of ships main dimension. In conceptual design stage for group of multipurpose ships is applied factor of deadweight utilization criterion. Generally this criterion explain the function of the ship in early stages of conceptual design project. Developed conceptual projects of multipurpose ships are with restricted main dimension and deadweight range from 5000 to 8000 tDWT. The purpose of this study is to compare main dimensions of ships developed with technical criterion with this designed with economical criterion.

Key words: ship design, deadweight, multipurpose ship, economical criterion, technical criterion

I. Introduction

In the world fleet multipurpose ships with GT up to 25 000 take 25.9% and this to GT up to 500 take 7.5% form world fleet. According[2] number of multipurpose vessel take 13.4% form world fleet. Multipurpose ship age up to 4 years old is 14.3% while ships more than 25 years old are about 32%. Moreover about 22.0% of ships are registered in non- targeted flag. This statistical data give us arguments that multipurpose ship fleet is ageing fleet and it is necessarily to do analyses for designing new ships taking into account modern goods prices, exploitation costs and freight rates. For last two COVID- 19 years gross tonnage of multipurpose vessel is reduced by 0.18% , fig.1. while for other ship types observe decrease with about 2-5%.

Principal types	2020		2021		Percentage change 2021 over 2020
	Count	Percentage	Count	Percentage	
Bulk carriers	879 725	42.47%	931 032	42.77%	3.79%
Oil tankers	601 342	29.03%	619 148	29.00%	2.96%
Container ships	274 973	13.27%	281 784	13.20%	2.48%
Other types of ships	238 705	11.52%	243 992	11.43%	2.19%
Offshore supply	84 049	4.00%	84 094	3.94%	0.06%
Gas carriers	73 695	3.50%	77 455	3.63%	5.12%
Chemical tankers	47 480	2.29%	48 858	2.29%	2.90%
Other	25 500	1.23%	25 407	1.19%	-0.36%
Ferries and passenger ships	7 992	0.39%	8 109	0.38%	1.48%
General cargo ships	76 893	3.71%	76 754	3.60%	-0.18%
World total	2 071 638		2 134 640		3.04%

Fig.1. Number of general cargo ships for one year period[3]

There are a couple of publications which analyzed ships main dimension designed by economical criterion. Used economical criterion is required freight rate. In some of them are analyzed ships characteristics.

In last two years is notice increased values of cargo freight rate in the world, fig.2. From fig.2. seems that the freight rates in fourth quarter of 2021 has maximum value form more than 10 000\$. In first quarter of 2022 this trend stay same. This is impact by different world crises.

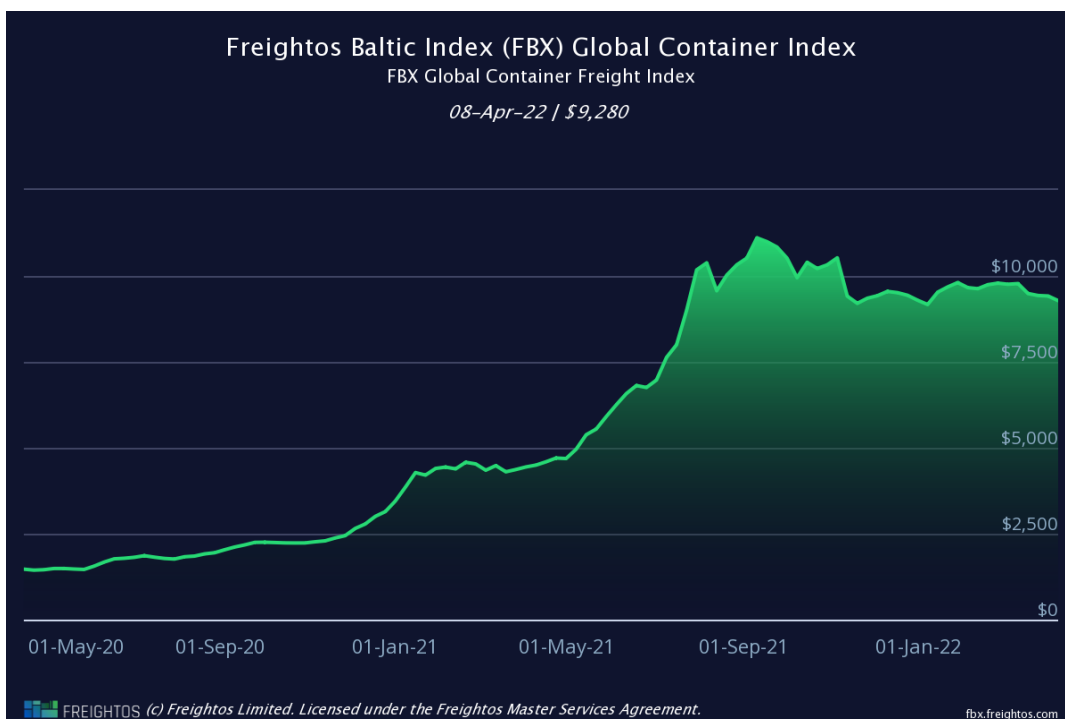


Fig.2. Cargo freight rates for two years period(2020-2022)[5]

The same is the freight rate situation in Europe, Black and Mediterranean seas. Increased values of freight rates lead to additional moments benefits for ship owners. It is public knowledge that ship is designed under rules of classification societies and ship owner requirements. She should to satisfied their requirements but and additional requirements like a enough ship strength, stability, technological effectiveness and etc. In early ship design stages is important to be proper selected ships main dimension take into account maximum utilization of her loading capacity.

II. Designed of ship main dimension by technical criterion

Analyzed ships main dimension are designed by conceptual design software EXPERT. EXPERT is software for design and optimization of ship main dimension and characteristics in early design stages. The system has two functions: system analyses and variational analyses. In this case is used system analysis. Ships main dimension are designed take into account building constraints of shipyard. Building constraints has technological character into design process. They are consist of breadth(B=16.0m), length(L=135.0m) of building facilities and lifting capacity(max lifting capacity= 1800t) of floating dock used for ship launching. Designed function is single criterion and it selected to be factor of deadweight utilization(η_{DWT}). Mathematical relation described single criterial function is:

$$F=a*f$$

where:

- a- weight coefficient, if $a>0, f=\max$; if $a<0, f=\min$;
- f- searched single criterion;

The magnitude of explain function factor of deadweight utilization(η_{DWT}) vary from 0 to 1,0. In this analysis it is intended to be 0,80. Mathematic relation of factor of deadweight utilization(η_{DWT}) is given by[1]:

$$\eta_{DWT} = \frac{DWT}{\Delta}$$

where:

- DWT- ship deadweight, t;
- Δ - ship displacement, t;

Designed ships main dimension with required freight rate target function are shown in table 1 and dimension designed by utilization of deadweight are shown in table 2.

Table 1. Main dimension by RFR criterion

RFR				
	5000	6000	7000	8000
L,m	88.63	106.68	120.6	135.06
B,m	16.00	16.00	16.00	16.00
D,m	8.81	8.93	9.03	9.17
d,m	7.08	6.88	6.67	6.57
Cb	0.689	0.721	0.721	0.772
Δ, t	7100.00	8672.71	9813.875	11407.00

Table 2. Main dimension by η_{DWT}

η_{DWT}				
	5000	6000	7000	8000
L,m	88.13	107	122.26	128.32
B,m	16.00	16.00	16.00	16.00
D,m	8.776	8.762	9.234	9.377
d,m	6.083	6.224	6.259	6.404
Cb	0.785	0.776	0.80	0.847
Δ, t	6901.01	8480.03	10046.94	11344.42

III. Analyze ship main dimension developed by technical criterion

Developed in previous paragraph main dimension are shown on fig.3. From there clear sees that ships length developed by technical criterion has lower value than this designed with economical in ships with 8000 tDWT and vice versa in ship with 7000 tDWT. In DWT range form 5000 and 6000 the value of ships length is not so different.

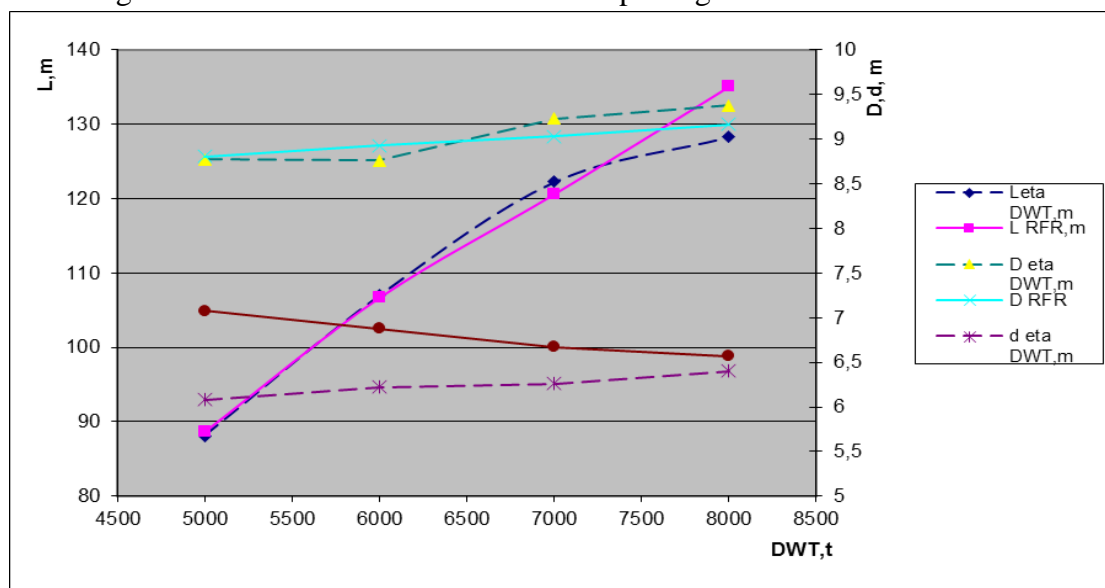


Fig.3. Ships main dimension designed by the two target functions

Breadth of all analyzed ship is constant equal of breadth of slipway in shipyard, $B=16m$. Used of factor of deadweight utilization like a target function increase value of ship draught. In this case with increasing ships DWT draught increased too. But in case with require freight rate target function draught decrease. The same is situation with ship side depth. Ship side depth in ships designed with RFR is bigger in small DWT range. Substantial difference is shown in a ship with 6000 tDWT with about 16% higher than this designed with factor of deadweight utilization. In 7000 and 8000 deadweight range side depth

designed with factor of deadweight utilization has about 31 and 35 % higher value than this with RFR factor.

Factor of deadweight utilization explain the usage degree of ship deadweight. It depends mainly from ship main dimension and its characteristics. On fig.4. are shown two curves of factor of deadweight utilization designed by two criteria.

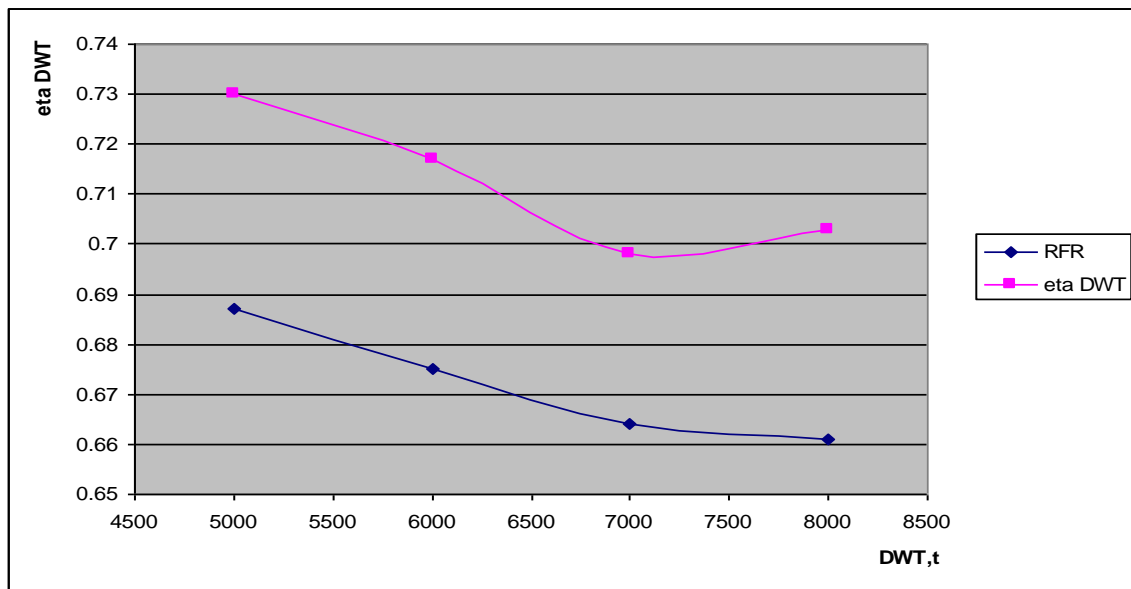


Fig.4. Factor of deadweight utilization of the two target function

The factor of deadweight utilization values developed by required freight criteria has lower values. The difference between them and this developed by factor of deadweight utilization is about 3-4 %. If this should be presented in additional loaded cargo it is about 220t for ship with 5000 tDWT and 340t for ship with 8000 tDWT. Additional loaded cargo measured in TEU number for ship with DWT it is 7 additional containers with payload capacity of 25,0t[4] and 12 TEU for ship with 8000 tDWT. For other ships in the group numbers of TEU are 9 numbers for ships with 6000 and 7000 tDWT.

IV. Conclusions

The analyze show that multipurpose fleet is ageing fleet. Take into account increased levels of freight rate designed new ships is necessary. Using factor of deadweight utilization target function ships main dimension are not so different compared with this designed by freight rate target function. Interesting in this case is the results of factor of deadweight utilization. Using this target function the number of additional containers on board on ship vary from 12 for ship with 8000 tDWT and 9 for other ships in the group. This additional possible cargo contribute for additional benefit for ship owner and exploitation of ship.

IV. References

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- [5]] <https://fbx.freightos.com/>

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