THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 3 - 2016, ISSN 1453 – 083X

METHODS TO REDUCE GAS EMISSIONS ONBOARD SHIPS

Ioan BOSOANCĂ
"Dunarea de Jos" University of Galati, Romania, Faculty of Naval Architecture, Galati,
47 Domneasca Street, 800008, Romania
e-mail: ioan.bosoanca@ugal.ro

ABSTRACT

Regarding the latest IMO requirements, the EEDI (Energy Efficiency Design Index) is mandatory to be limited as levels under IMO MEPC requirements.

The paper presents some paths to reduce EEDI as are applied onboard a 5550 TEU C/V and their effects upon ship's performances.

KEYWORDS: IMO MEPC, Energy Efficiency Design Index, innovative propeller, slow steaming, energy saving

1. Introduction

Greenhouse gas emissions lead not only to well-known global warming, but also to ocean acidification affecting aquatic biota [1]. Marine Environmental Protection Committee (IMO MEPC) introduced *Energy Efficiency Design Index (EEDI)* as an instrument to quantify these COx emissions, especially for new ships, even if this industry is responsible for only 3% of planetary gas emissions. Together with *Ship Energy Efficiency Management Plan (SEEMP)* they became mandatory under MARPOL Annex VI beginning with 1st January 2013.

This EEDI limitation addresses container ships, tankers, bulk carriers etc. but not passenger and RO-RO ships, even the EEDI must be calculated also for them, acc. to [2].

Having in mind the above considerations, the owners, charterers and ship's operators need to adopt measures to limit the gas emissions using different methods and technologies. This means that limiting environment pollution should be a part of the SEEMP, as by example, speed optimization.

2. Container carrier ships

Because container ships are the most important ships form the global warming standpoint, this paper presents the benefits of retrofitting the propeller onboard an existing vessel and lowering the revolution speed of Main Engine coupled directly with the propeller, so-called *slow steaming*. The ship's service speed with original arrangements is 25.0 kts. It was used a new innovative ESCAP propeller (MMG-Germany), see Fig. 1, acc. to [3]. The old FPP propeller (6 blades, 8.0 m diameter) was replaced with a new propeller (5 blades, but a greater diameter, 8.2 m) having fins for energy saving, mounted in aft side of propeller disk, similar the well-known type PBCF (*Propeller Boss Cap Fins*):

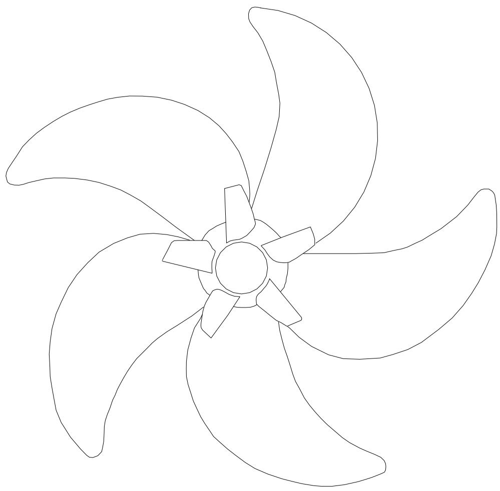

Fig. 1. *Re-design ESCAP propeller (MMG-Germany)*

Applying slow steaming concept, the MCR (Maximum Continuous Rating) power was reduced from 42140 kW @ 104 rpm to 27391 kW @ 91.3 rpm.

According to [4], the power-speed performances have been tested in progressive speed trials on Adriatic Sea, Rijeka area, in ballast condition, conducted by author.

There have been performed three double runs on north to south direction and vice versa, with the followings propeller rpm: 50, 65.0 and 91.3 rpm, applying the procedure of [5].

The corresponding speed – power diagram is shown in the bottom Fig. 2:

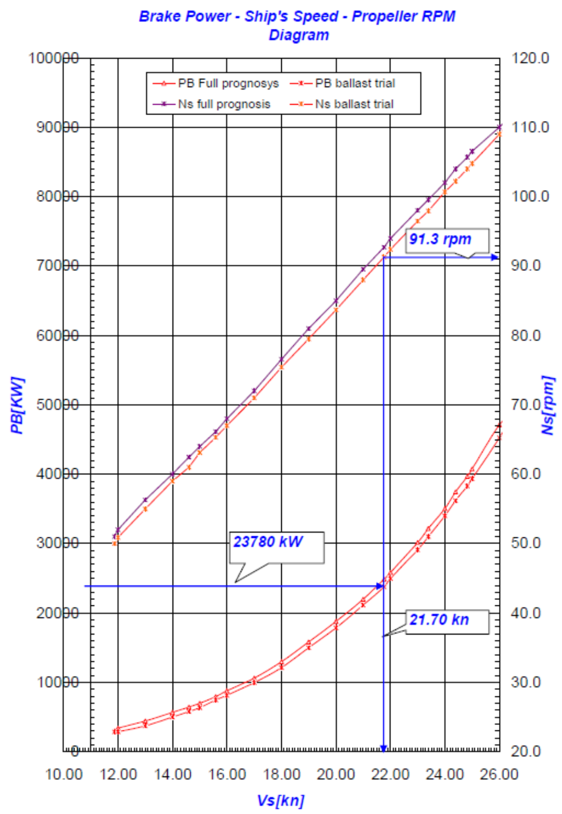

***Fig. 2.** Power-Ship's Speed Diagram*

According to [6], attained EEDI it is:

$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{MEi}\circ C_{FME(i)}\circ SFC_{ME(i)}\right)+(P_{AE}\circ C_{FAE}\circ SFC^{*}_{AE})+\left(\left(\prod_{j=1}^{n} f_j\circ\sum_{i=1}^{nPTI} P_{PTI(i)}-\sum_{i=1}^{neff} f_{eff(i)}\circ P_{AEeff(i)}\right)\circ C_{FAE}\circ SFC_{AE}\right)-\left(\sum_{i=1}^{neff} f_{eff(i)}\circ P_{eff(i)}\circ C_{FME}\circ SFC^{**}_{ME}\right)}{f_i\circ f_c\circ Capacity\circ f_w\circ V_{ref}}$$

where:

f_j: correction factor for ship specific design elements;
P_{MEi}: power of main engines;
C_F: conversion factor between fuel consumption and CO_2 emission;
SFC: specific fuel consumption;
P_{AEeff}: auxiliary power reduction;
P_{PTI}: shaft motor;
f_{eff}: availability factor of innovative energy efficiency technology;
P_{AEeff}: auxiliary power reduction;
f_i: capacity factor;
f_c: cubic capacity correction factor;
Capacity: bulk carriers, tankers, gas carriers, ro-ro cargo ships and general cargo ships;
f_w: weather factor;
V_{re}; ship's speed.

Assuming:

- Type of ship: container carrier;
- one M/E;
- P_{ME} = 42140 kW;
- C_{FME} = 3.114 acc. to [5];
- SFC_{ME} = 165g/kWh;
- P_{AE} = 2310 kW;
- C_{FAE} = 3.206 acc. to [5];
- SFC_{AE} = 220g/kWh;
- $P_{PTI} = P_{AEeff} = 0$;
- $f_j = f_{eff} = 0$;
- $f_i = 1$;
- $f_c = 1$;
- Capacity = 74447 dwt;
- $f_w = 1$;
- V_{ref} = 25 kts.

In the below Tables (no. 1 and no. 2) the EEDI, both for original ship and updated ship are calculated:

Table 1.

	Ship's original data				
	MCR	=	42140	kW	
	Deadweight	=	74447	dwt	
	Ship's speed	=	25	kts	
	No. of M/Es	=	1		
75%	P_{ME}	=	31605	kW	
	C_{FME}	=	3.114		acc.to [6]
	SFC_{ME}	=	165	kWh	
	P_{AE}	=	2310	kW	
	C_{FAE}	=	3.206		acc. to [6];
	SFC_{AE}	=	220	g/kWh	
	$P_{PTI}=P_{AEeff}$	=	0		
	$f_j=f_{eff}=0$;	=	0		
	$f_i=1$;	=	1		
	$f_c=1$;	=	1		
70%	Capacity	=	52113	dwt	
	$f_w=1$;	=	1		
75%	V_{ref}	=	19	kts	
	EEDI orig	**=**	**18.29**	g - CO_2/ton mile	

In original version, the $EEDI_{orig}$ = 18.29 gCO_2/ton mile.

Table 2.

	Ship's new data				
	MCR	=	27391	kW	
	Deadweight	=	74447	dwt	
	Ship's speed	=	21	kts (after sea trials)	
	No. of M/Es	=	1		
75%	P_{ME}	=	20543	kW	
	C_{FME}	=	3.114		acc.to [6]
	SFC_{ME}	=	165	kWh	
	P_{AE}	=	2310	kW	
	C_{FAE}	=	3.206		acc. to [6];
	SFC_{AE}	=	220	g/kWh	
	$P_{PTI}=P_{AEeff}$	=	0		
	$f_j=f_{eff}=0$;	=	0		
	$f_i=1$;	=	1		
	$f_c=1$;	=	1		
70%	Capacity	=	52113	dwt	
	$f_w=1$;	=	1		
75%	V_{ref}	=	16	kts	
	EEDI new	**=**	**14.85**	g - CO2/ton mile	

In updated version (innovative propeller and de-ratted M/E) the $EEDI_{new}$ = 14.85 gCO_2/ton mile.

3. Conclusions

Reduction of gas emissions is an important task in maritime transport, both for designers, shipbuilders, owners, charterers etc. The legislation on sea and shore related to pollution uses different procedures, and is more and more updated in order to reduce the gas emissions.

In Fig. 3 below are shown the rules for new ships beginning with 2025 and the calculated EEDI for original and updated ship.

For the ship presented in this paper (already in operation since 2011) the calculated EEDI is greater than limit for new ship beginning with 2015, even after new propeller mounting and M/E de-ratted. This means the new values for gas emission are very low and great investment efforts should be made in the future for ships already being in operation to fulfill the new rules regarding the gas emissions.

Anyway, lowering maximum accepted level for gas emission means less pollution and a cleaner environment.

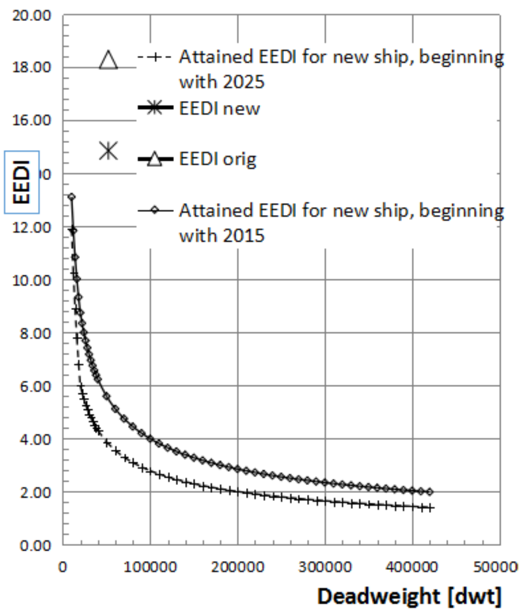

Fig. 3. *Attained EEDI for original propeller, new propeller and MEPC rules beginning with 2025*

References

[1]. Matthias Hofmanna, Hans-Joachim Schellnhubera, *Oceanic acidification affects marine carbon pump and triggers extended marine oxygen holes*, www.pnas.org_cgi _doi_10.1073_pnas.0813384106.
[2]. ***, *Implementing the Energy Efficiency Design Index (EEDI). Guidance for owners, operators, shipyards and tank test organisations* – Lloyd Register 2012.
[3]. ***, *FPP Manual, MMG Project no. 90.1427-00-8200*, 2014.
[4]. Bosoanca I., *Power – Ship's Speed onboard MSC Alicante, 5550 Teu Container Carrier*, Diagnose and Measurements Group, July 2016.
[5]. ***, ISO 15016-2015: *Ships and marine technology - Guidelines for the assessment of speed and power performance by analysis of speed trial data*.
[6]. ***, *Guidelines on the method of calculation of the attained energy efficiency design index (EEDI) for new ships, Resolution* MEPC.212(63) 2012.