RELATION BETWEEN THE NUMBER OF REEFER CONTAINERS AND THE LOAD OF THE MARINE ELECTRIC POWER SYSTEMS

Grzegorz Nicewicz

Maritime Academy of Szczecin
ul. Wały Chrobrego 1-2, 70-500 Szczecin, Poland
tel.: +48 91 4809442
e-mail: nicze1@wp.pl

Abstract

Rapid development of unit cargo transport caused the contemporary container vessels to be adjusted to carrying a considerable number of reefer containers. They need to be plugged in to the marine electric power system right after being loaded providing they contain any cargo. They are assumed to be unplugged for no longer than twelve hours without any damage to the cargo. At present container vessels are equipped with even a few hundred of sockets for plugging in reefer containers. In case of loading the maximum number of reefer containers, they become the most powerful energy receiver on board the ship. The regulations of the classification institutions [4] define the marine electric power to be consumed by the reefer containers. The paper has been an attempt of estimation of a real value of power consumed by reefer containers illustrated by a container vessel 2200 TEU adjusted to carrying 350 reefer containers and a comparison of the achieved results with the directives of the selected classification institutions [4]. Moreover, a critical approach to the shipyard offices' methods of establishing the number of reefer containers to be plugged in for the needs of ship owning companies ordering new vessels has been presented.

Keywords: marine electric power system, marine generating set, reefer containers

1. Introduction

Within the identification tests concerning real loads of transport vessels' electric power systems in operating conditions, that have been carried out by the author of the paper for years, observations were led on various types of vessels including container ships. The adequate operational data related to the highest demand for the electric power at fixed time intervals were collected by an observer, the engine crew member making use of the measuring instruments, the standard power plant equipment. The tests' methodology and, partially, their results have been broadly discussed in the following works [5, 6, 7, 8, 10, 11, 12, 18]. The paper has been focused on the results concerning the relation between the number of the carried reefer containers and the load of the marine electric power system of the container vessels.

Six various types of container vessels owned by foreign ship owning companies were the subject of the tests. What seems interesting, the number of their carried reefer containers appeared considerably smaller than the possible maximum number assumed by the ship manufacturers. The analysis of documents [13, 14, 15, 16, 17] of one of the companies showed that such a situation has been maintained for several years. At the same time, when viewing the regulations of the international classification institutions [4], or the container ships energy balance [1], reefer containers with their maximum number assumed by the shipyard designing office appear the most

powerful receiver of electric power on board the ship. Thus, the aim was to estimate the relationship between the number of the carried reefer containers and the load of the marine electric power systems.

Because of the paper space limits there have been presented results achieved on a 2200 TEU container vessel built in Taiwan in 2003. The observations were carried out during a typical operational voyage from Europe to West Africa lasting for approximately a little more than thirty days. The number of the carried reefer containers usually appears considerably smaller than the possible maximum number of reefer containers to be loaded on board a ship (350 FEU). Power supply is provided by the marine power station consisting of four identical generating sets of rated active power 1200 KW each. The peak load recorded at the consecutive hours of the voyage was considered the measure of the active power of the marine electric power system (MEPS). The automatic measuring instruments of the power plant enabled the reading of the active power produced by the generating sets with the accuracy of 0,01 kW. When carrying the analyses the achieved values got rounded to 1 kW.

2. Results of the field tests

Due to the record of the peak loads of the 2200 TEU container vessel's electric power system, performed at the consecutive hours of the voyage, the scatter plot of peak loads of the marine electric power system depending upon the number of reefer containers was created by means of STATISTICA 8.0 with the correlation between the variables determined. The scatter plot [19, 20] with the correlation line (full line) and the limits of 95% of confidence interval have been presented in fig. 1.
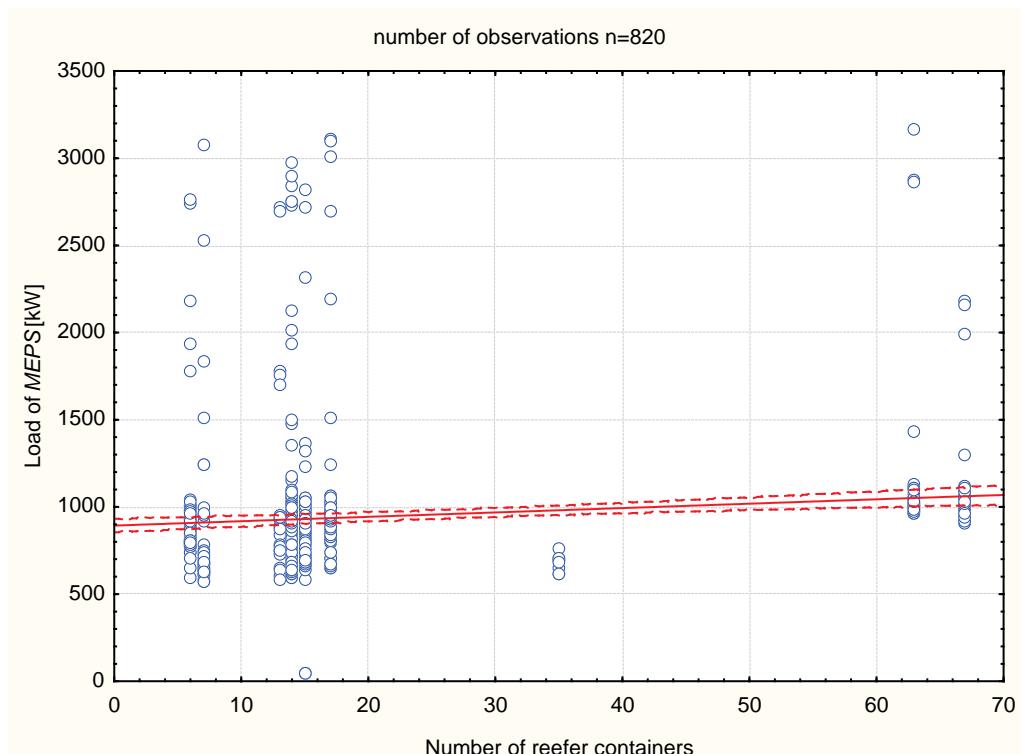

Fig. 1. The scatter plot between load of the container ship's electric power system (MEPS) and the number of carried reefer containers

Correlation between the active power load of the marine electric power system (N_{MEPS} [kW]) and the number of carried reefer containers ($k \leq 350$) has been presented by means of the formula:

$$N_{MEPS} = 893,004 + 2,5111k \text{ [kW]} \quad (1)$$

with the 95% confidence interval assumed.

In the process of testing there occurred a controlled black-out (break in the continuity of electric power supply) caused by the damage of the vessel sea water system and for a few hours power was provided by the emergency generating set. Thus, the data on peak load during the emergency generating set supply was rejected. In this way modified plot has been shown in fig. 2.
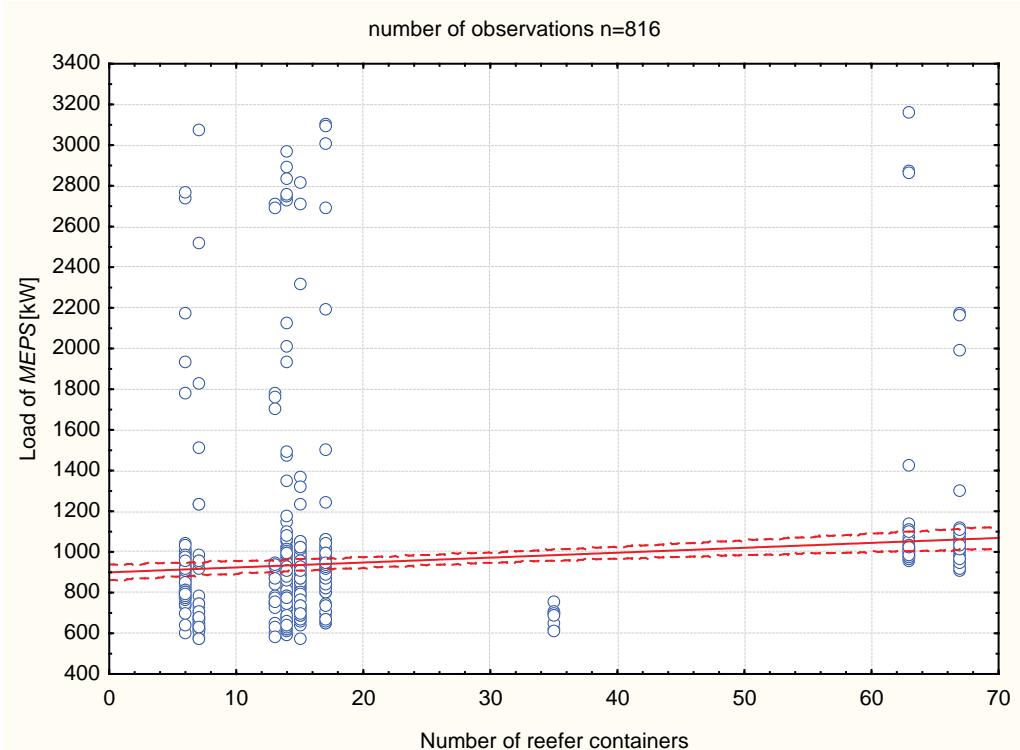

Fig. 2. The scatter plot between the load of the marine electric power system (MEPS) and the number of carried reefer containers without the data on peak load of the emergency generating set

The correlation between the active power load of the marine electric power system (N_{MEPS} [kW]) and the number of carried reefer containers ($k \leq 350$) is then presented as a formula:

$$N_{MEPS} = 899,8145 + 2,4158k \text{ [kW]} \quad (2)$$

at the 95% confidence interval assumed.

The rejection of the data on the peak load of the emergency generating set had negligible influence upon the scatter plot modification (fig. 1 and 2) as well as the function of linear correlation between the MEPS load and the number of reefer containers on board the ship – there is only few percent difference.

According to the data provided by the ship manufacturer [1] (classification supervision of the vessel during the process of her construction and operation was carried out by Bureau Veritas), it was calculated that the power demand for a single reefer container was 6,5257 kW. Thus, for the basic operational state, which is a sea voyage, the marine electric power system load (with the linear dependence upon the number of reefer containers) is defined by the formula:

$$N_{MEPS} = 767 + 6,5257k \text{ [kW]} \quad (3)$$

where $k \leq 350$.

The power demand of a single reefer container, achieved on the basis of the field data, appears 2,7 times lower than the values assumed by the manufacturer. However, it should be kept in mind that during the tests the number of reefer containers on board the ship did not exceed 70, which makes only 20% of their maximum number.

3. Regulations of classification institutions concerning the reefer containers power consumption

On the basis of the analyses presented in the previous chapter it seems to be worth referring to the regulations of selected classification institutions dealing with the ways of defining the reefer containers power demand. Classification Societies possess their own directives for estimation of the reefer containers power demand. The principles of determining the reefer containers power consumption have been presented in fig. 3 on the basis of Germanischer Lloyd regulations [4]. In case of the lack of field data it is recommended that the following principles are applied when balancing the power demand [4]:
- for a single 20' container – 8,6 kW;
- for a single 40' container – 12,6 kW.

The level of the assumed coincidence factor is 0,9 [4].
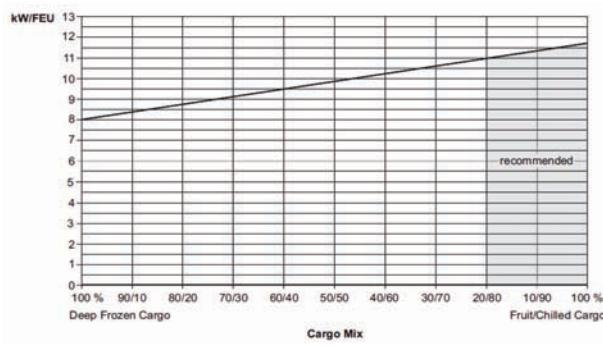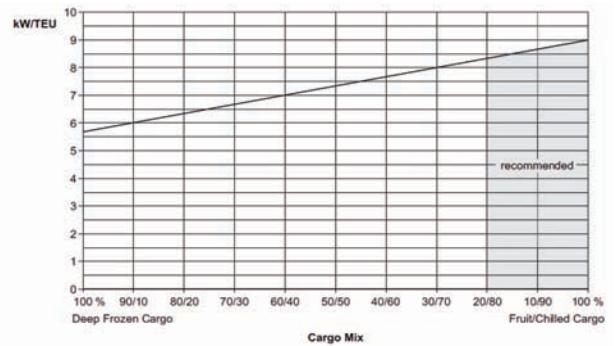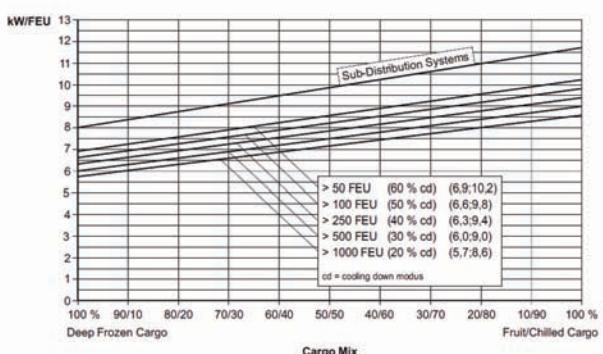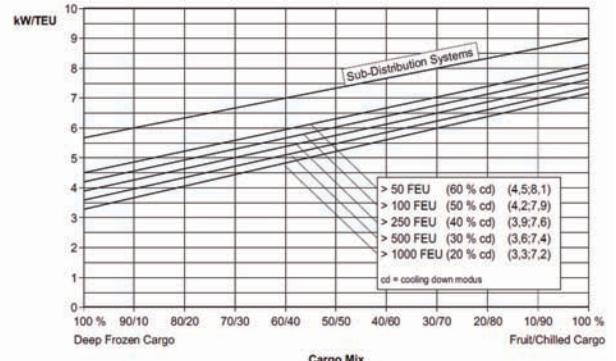
Fig. 3. GL directives for defining the power demand of the cargo hold ventilation system and reefer containers: a) and c) in case of 40' reefer containers; b) and d) in case of 20'reefer containers, according to [4]

The above presented GL regulations appear even more protective than the ones applied during the construction of the vessel, the subject of the analyses presented in the paper. Such approach of the classification institutions may cause a considerable overestimation of the reefer containers power demand and lead to long lasting operation of generating sets at low load, especially in case of a number of carried containers smaller than the one recommended by the ship manufacturer for power balancing. This may endanger the shipping company to considerable financial losses due to the deterioration of the technical condition of auxiliary engines fed mostly with residual fuels [2, 3, 9, 10].

4. Final remarks

During the process of 2200 TEU container vessel construction, when balancing the electric power demand, the shipyard designing office assumed that at the total number of 350 reefer containers to be loaded, the load per one container equaled 6,5257 kW, that is almost three times higher than the result obtained due to the calculations carried out by the author on the basis of the field data. This low value estimated by the author may result from the relatively small number of reefer containers carried at the time of tests. It should be noted that not all ship owners of container vessels transport vast numbers of reefer containers, what is proved by the data collected on the six container ships, the subject of tests. Thus, the shipyard designing departments should make use of such documents as [13, 14, 15, 16, 17] possessed by the ship owner technical services while designing the number of socket connections for reefer containers to be plugged in and estimating their power demand. This type of exaggerated equivocation of classification companies and ship manufacturers may lead to considerable overestimating concerning the assessment of electric power demand and adjustment of the number of power generating sets, which puts the shipping companies at risk of financial losses. In case of 1100 TEU container vessels, the subject of the tests, the ship owner technical services decided to have the residual fuel oil for auxiliary engines to be changed for the distilled fuel due to the low loads of generating sets. This way of long lasting (several years) operation has significantly increased its costs. Moreover, a part of power plant fuel system turned out useless (e.g. residual fuel oil heating system). At the same time the auxiliary engines operation at low loads caused accelerated deterioration of their technical condition, especially the fuel injection equipment. In order to avoid this type of mistakes, it seems necessary to make use of field data at the stage of designing vessels. The knowledge of real electric power demand, or the data on the number of carried reefer containers allows for adjusting the product – a newly constructed vessel – to the requirements of a recipient (a shipping company).

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