

ship to shore cranes, reloading technology

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DEVELOPMENTAL TENDENCIES IN CONTAINER SHIPS RELOADING TECHNOLOGY

Summary. The analysis of developmental tendencies in reloading technology for container ships is presented in the paper. Innovative methods are described for typical solutions. The paper indicates factors which can have significant influence on forming modern systems of loading and unloading containers on vessels.

TENDENCJE ROZWOJOWE W TECHNOLOGII PRZEŁADUNKU KONTENEROWCÓW

Streszczenie. W artykule dokonano analizy tendencji rozwojowych w technologii przeładunku kontenerowców. Na tle typowych rozwiązań przedstawiono podejścia innowacyjne. Wskazano na czynniki, które mogą mieć istotny wpływ na kształtowanie nowoczesnych systemów rozładunku i załadunku kontenerów na jednostki pływające.

1. INTRODUCTION

The container system in the present day shape has been formed for more than a hundred years. History of common application of the container for transporting goods on the sea dates back to the half of the 20th century. Simplicity, safety, reliability and possibility to transport large parties of cargo placed in containers determine the attractiveness of the transport mode. Standardization of dimensions and shape of containers enabled organization of transportation in the form of intermodal transport. In the effect the container supplies can be faster and on time reducing the cost of transportation process. Indispensable changes of methods for transporting and servicing containers including reloading technologies accompanied dynamically growing demand for the containerized transport.

The seaway transport has been the main stream of container transport in recent years. First specialized ships for carrying these integrated cargo units were built in the fifties of the 20th century. These were the ships capable of accommodating only dozens of twenty-foot containers (TEU) onboard. Today the largest ships are capable of transporting more than ten thousand TEU, and the ships even larger are currently being designed.

Increasing the transport capabilities of ships called for introducing significant structural changes; increasing main particulars (length, breadth, depth, draught) as well as modification of cargo hold structural design. In the results of the changes two basic types of ships for carrying containers can be distinguished: containerships (also referred to as cellular containerships), ships loaded and unloaded using lift on-lift off system (lo-lo) as well as roll on-roll off (ro-ro) ships [1, 2]. There are also ships

combining these two systems. The present paper is focused on the problems related to the lo-lo system.

Operating ships carrying several or a dozen thousand containers call for the suitable port infrastructure and suprastructure. The process of dynamic evolution of ports is a consequence of appearing new generations of containerships. The ports become the main intermodal sea-land transport chains, and the specialized container terminals appear within their structures which are equipped in the suitable reloading systems and places for storing and managing containers. The effect of these actions is to be an improvement of quality of port operations. On the basis of opinions presented in [3] we can say that other parameters related to organization of reloading such as decreasing energy consumption, better using transport means, safety improvement and increasing traffic fluidity can soon become more significant.

Intensity of employing the containership transportation capability, as it is in the case of each cargo vessel, depends primarily on two following factors: her speed and duration of stay in ports. The violent increase of fuel consumption, resulting in the cost increase, is a serious limitation for the first factor while the duration of stay in ports is determined by the reloading systems [2] dealt with in the present paper.

2. MODERN RELAODING SYSTEMS

Reliable operation of the port reloading terminals depends mainly on functioning of points of loading and unloading ships. Their technical equipment depends principally on the type of the serviced ships. Decisions on application of specific solutions are taken during designing a terminal. Reduction of ship operation costs is one the main criterion of selection. Meeting the criterion leads to shortening the duration of stay in the port to the necessary minimum. Obtaining this result depends on many factors, one of them being the large reloading efficiency due to employing modern technologies where the specialized overhead cranes play key role. In the case of the containerships these are mainly container gantry cranes (also referred to as ship-to-shore STS). Their technical parameters must be correlated to the designed loading point. Increasing the efficiency of existing systems requires significant modernization of technical solutions what is not always possible due to available space, economical conditions or technical parameters of equipment already installed (e.g. capacity).

Moreover, the innovative concepts are presented and discussed in the background of typical containership reloading technologies. However, the systems employing jib cranes or onboard gear are not addressed as in the modern, large terminals are used marginally due to the low efficiency.

2.1. Typical concepts

The specialized overhead cranes play key role in loading and unloading of containerships. The gear must be capable of taking containers from each place onboard. Therefore the crane dimensions must be correlated to the main particulars of ships they are to service.

Structural designs of the cranes and the working parameters (Table 1) have been undergoing significant changes, according to appearing new containership generations. The smallest containerships (feeders) having capacity of 100÷499 TEU and breadth within 15÷20 m, operate mainly so called feeding lines, lines important for large transoceanic ships, e.g. M/S Emma Maersk, having capacity of 15000 TEU, and breadth up to 60 m.

For definition of structural concepts of the overhead cranes the names of containership types are commonly used (feeder, panamax, post-panamax, super post-panamax), depending on what containership type they service. The smallest, feeder type cranes, are equipped with girders of length not exceeding 30 m. They are characterized by simple technical solutions (one reloading trolley, single spreader). Single trolley for transporting containers is a typical solution of reloading system, applied also in the other crane types. It allows to obtain efficiency of 30÷40 TEU/h. The scheme of the crane equipped with one trolley (w1) is presented in Fig. 1.

Table 1

Working parameters of container cranes

Type of overhead crane	Number of container rows	Length of crane waterside girder [m]	Capacity [t]	Empty/full container lifting speed [m/min]
Feeder	up to 10	up to 30	up to 40	30/60
Panamax	up to 13	36÷42	40÷45	60/120
Post-Panamax	up to 18	48÷56	45÷60	60/120÷75/150
Super Post-Panamax Megamax	up to 24	60÷70	50÷65 (120)	75/150÷90/180

Other types of cranes are characterized by significantly larger dimensions. Super post-panamax cranes employed in the largest terminals are equipped with waterside girders of the length up to 60 m. The cranes can be equipped with systems composed of two trolleys (w1, w2) cooperating via the reloading platform (Fig. 2). This solution increases the reloading efficiency with respect to one-trolley systems by several tens percent, despite the fact that the total way of both trolleys can reach 90 m, and the time to cover the distance is greater than 20 s. Some of the super post-panamax cranes are constructed for capacity of 120 t, allowing simultaneous transportation of four 20' or two 40' containers. A tendency is also observed (Table 1) to increase another parameter important for efficiency, namely lifting speed. The lifting speed increase obviously requires energy demand (power for lifting one 20' container at speed of 60 m/min is approx. 250 kW).

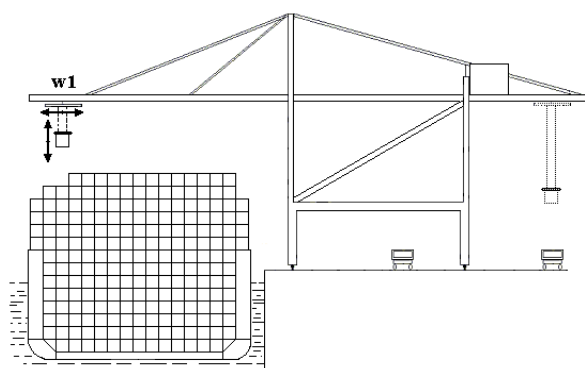


Fig. 1. STS with one trolley

Rys. 1. Suwnica z jednym wózkiem

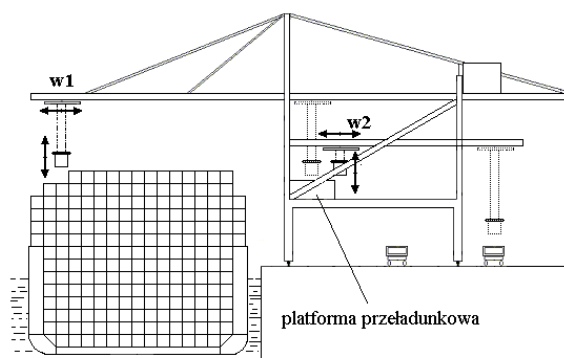


Fig. 2. STS with two trolley and reloading platform

Rys. 2. Suwnica wyposażona w dwa wózki i platform przeładunkową

Considering the modifications introduced so far, we can say that even though the essence of reloading with the gantry crane remains the same, yet due to their structural changes the super post-panamax crane is significantly better concept comparing to the feeder crane.

An interesting solution of reloading a containership in lo-lo system is presented in Fig. 3. The ship is loaded and unloaded by the cranes situated on both sides. This system requires building a special quay therefore is not frequently applied.

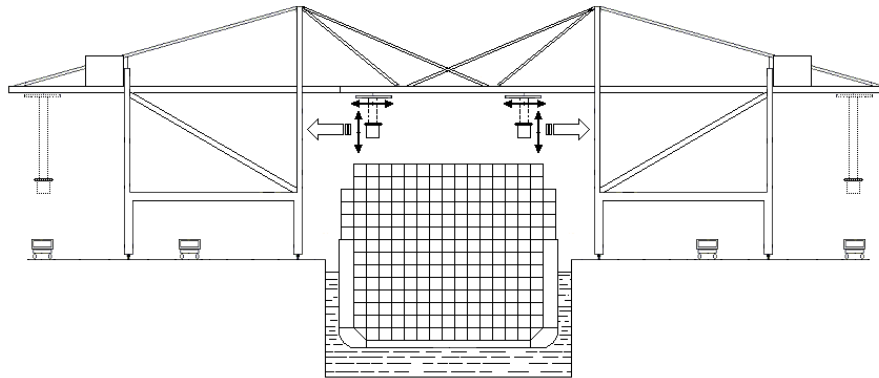


Fig. 3. Reloading on both sides
Rys. 3. Przeładunek z obu burt

Together with the development of the crane construction also the spreaders have been changed: from the simplest for one 20' container to devices for taking four containers (so called tandem spreaders [4]). Modern spreaders are equipped with the container position stabilization systems and systems for adjustment of spreader dimensions to container size. An obvious fact is that lift reloading systems where a containership is serviced by cranes having capacity of 120 t, equipped with two trolleys with tandem spreaders is significantly more efficient than other configurations. It seems, however, that despite presently existing spreaders for transportation of two 45' or four 20' containers, it is unrealistic to make use of the lifting capacity of the spreader. Producer [4] determines it to be 130 t, what, with the spreader weight of 31 t, means the crane capacity capable of optimal applying the spreader must be approximately 165 t.

Presented technical solutions of the container cranes and their equipment and supported by the most modern computer technology. The objective is also the reduction of sway of the container spreader, precise positioning containers during reloading, optimization of the transportation way or conditions of non-colliding operation. The cranes are also required—reliably and safely operating containerships – to cooperate with the container reception systems, often fully automated [5].

2.2. Innovative solutions

Suggestions of innovative solutions of reloading containers between ship and quay are presented in this chapter. They are often conceptual solutions, some of them being implemented. These solutions can be considered as worth applying which can significantly reduce the time of operation at profitable implementation cost.

In [1] it is indicated that reloading a containership between two quays with the use of the gantry crane (Fig. 4) equipped with two trolleys is one of the possible solutions. Initially it was estimated that the reloading efficiency can reach 52 TEU/h. Considering changes in the crane structures in recent years (especially in the working speed) it can be assumed that the efficiency of such a system can be as much as 75÷80 TEU/h. In another, similar solution (Fig. 5) it is suggested to service the ship with the use of the single trolley capable of transporting several or more than ten containers forming a loading unit. In this case both significant increase of the crane mass is to be considered as well as special preparation of the substructure of the track. However, it is worth noting here that the idea of forming containers in larger loading units for transportation and reloading may become more significant in the nearest future [6, 7, 8]. Even today it is technically feasible to transport packages composed of four TEU employing so called Terminal Cassette System [9]. They are reloaded employing the ro-ro system (not covered in the present paper) [2].

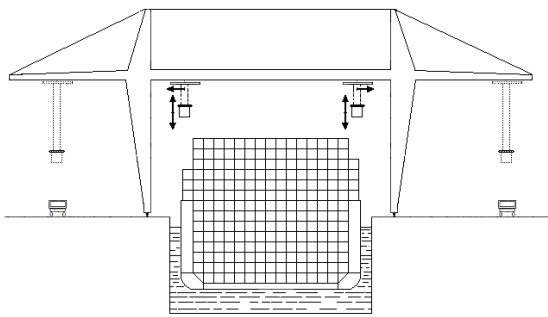


Fig. 4. Reloading with gantry crane with two independent trolleys

Rys. 4. Przeladunek suwnicą bramową wyposażoną w dwa niezależne wózki

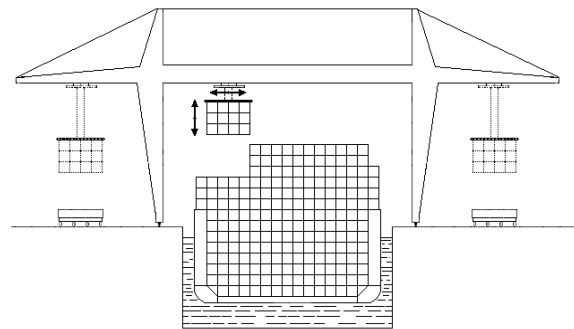


Fig. 5. Container pallets reloading

Rys. 5. Przeladunek palet kontenerów

In both presented concepts the ship is assumed to be serviced using the crane supported on two quays. Therefore the gears can be unique and adaptation of them for other terminals hardly possible.

A concept of reloading presented in Fig. 6 is an interesting innovation. The reloading system of the crane called by the authors SUPERTRAINER [10] is formed by the system of three trolleys (w1÷w3). One of them transports containers vertically within the hold, another transport containers horizontally, while the third in the area of loading and unloading of vehicles. It is estimated that transporting single containers it will be possible to increase the efficiency of operation more than twice comparing to the one-trolley crane. It is also indicated that this solution reduces the influence of rope sway on the transportation process.

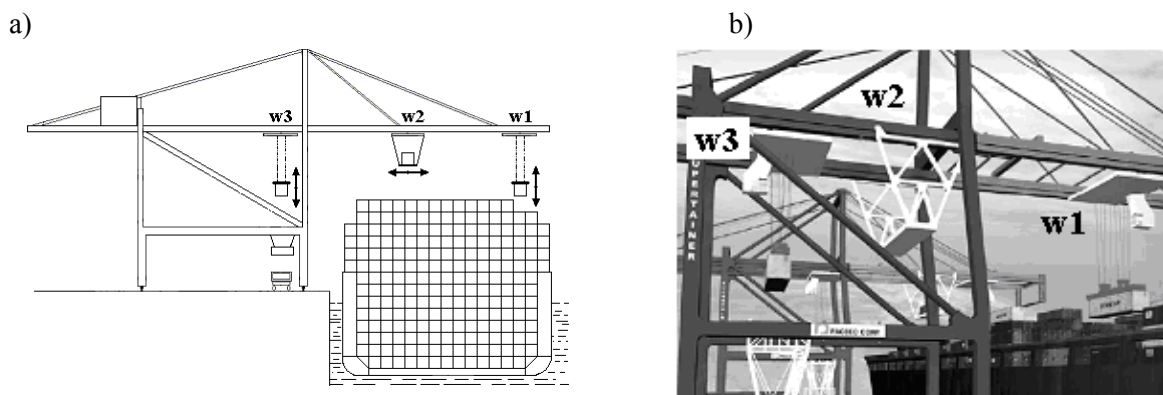


Fig. 6. SUPERTRAINER Crane a) concept of solution, b) visualization of trolley system (published with consent of PACECO CORP.: <http://pacecocorp.com>)

Rys. 6. Suwnica SUPERTRAINER a) koncepcja rozwiązania, b) wizualizacja systemu wózków (publikuje się za zgodą PACECO CORP.: <http://pacecocorp.com>)

In the discussed concept it is assumed that the crane will be capable of cooperation with a self-propelled reloading gear which concept is presented in Fig. 7. Its job will be to take containers from the trolley operating at the quay (w3) and loading them on semitrailers. This solution assures the lack of direct contact between the crane elements and vehicles.

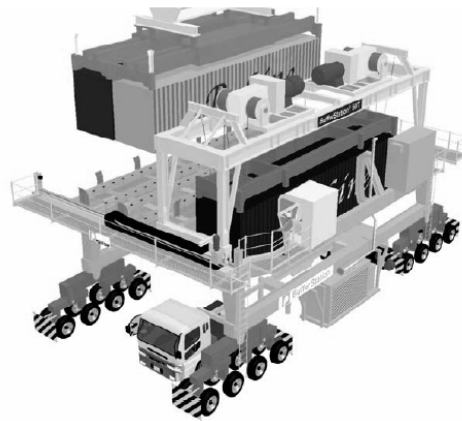


Fig. 7. Concept of reloading vehicle (published with consent of PACECO CORP.: <http://pacecocorp.com>)

Rys. 7. Koncepcja pojazdu przeładunkowego (publikuje się za zgodą PACECO CORP.: <http://pacecocorp.com>)

Discussing propositions of modifications concerning the vertical reloading of containers also a concept of cooperation of the quay crane with a special conveyor should be found interesting [11]. Application of the conveyor for taking away and delivering containers directly from the crane working area may lead to limitations of congestions in reloading containerships. Positioning the conveyor significantly above the crane track level may lead to shortening the time of lowering and lifting resulting in shortening the crane reloading cycle.

3. SUMMARY

Necessity of creation and implementation of innovations in the field of containership reloading technologies (similarly to the other technical components of the transportation process) is the effect of pursuit of obtain satisfactory efficiency, reliability, reduction of time of the stay ships in the ports and reducing costs. Such activities are not always immediately effective. The important thing is that they are observed in the certain time perspective, considering also developmental trends both in the country economics and on the global level.

Analysis of tendencies in the containership structural design tendencies indicates that for the largest vessels having capacity of more than 10000 TEU solutions typical for typical containerships will be dominant. They will be thus serviced applying the lo-lo system. Analysing the relationship between the ship breadth and her containership capacity (Fig. 7) it can be concluded that the length of the girders of the cranes built in the nearest future should not exceed 60÷65 m.

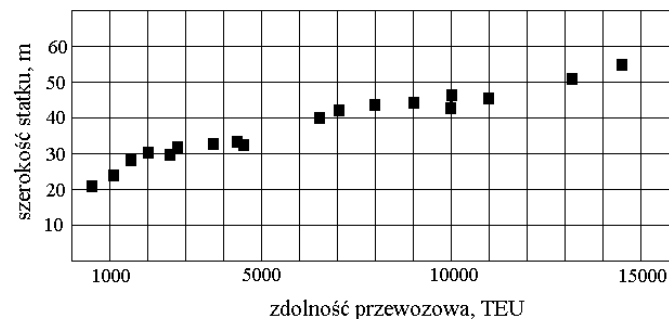


Fig. 8. Relationship between breadth of container ship and her container capacity

Rys. 8. Zależność szerokości kontenerowca od jego pojemności kontenerowej

The containership reloading efficiency has reached the level which will not be changed significantly in the nearest future. It would require application of new crane solutions having significantly larger lifting capacity and/or working motion velocities. Further shortening of the time of stay of ships in the way of increasing the number of cranes servicing ships is also impossible since the number of cranes is already optimal. Activities should be rather expected leading to e.g. optimizing container relocation track in the reloading cycle resulting to shortening the cycle. We can say that for the large containerships having capacity of 20000 TEU and larger it is not the reloading system but the suitable depth at the quays corresponding to their draught which will be the primary problem concerning servicing these ships.

Analysis of the so far achieved results in developing containership reloading systems and technologies show that we deal with the so called continuation technologies based on the rationalization and improvement of existing systems. Therefore a conclusion can be formulated that there are no premises indicating the possibility of occurring reloading technologies radically different than the present with the reservation, however, that it is only one possible vision of the future. It is worth to recall at this point that only several years ago nobody would have treated seriously forecasts concerning operation of containerships of length reaching 400 m and capacity of 15000 TEU.

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