

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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MODELLING OF THE CONTAINERS HANDLING'S CYCLE IN THE INTERMODAL TRANSPORT TERMINAL

SUMMARY OF DOCTORAL DISSERTATION

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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Jurgita BARYSIENĖ

KONTEINERIŲ APTARNAVIMO CIKLO MODELIAVIMAS INTERMODALINIO TRANSPORTO TERMINALE

DAKTARO DISERTACIJOS SANTRAUKA

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Introduction

The research problem

The transport sector faces serious problems, which have economic and social impact due to the high congestion on the roads. Traditional methods of the development of separate transport modes fail to resolve increasing problems of the transport system. The integration of transport modes, which is based on the shift of freight from road transport to alternative transport modes, is considered as the main solution to the problem.

Recently the importance of intermodal transport is emphasized more and more, and various political and financial tools are allocated to support and to promote it. It is beneficial not only for the participants of the freight chain, but also for the whole society. Collective advantages of intermodal transport are the reduction of infrastructural and external costs.

However, the intermodal transport is a complex transportation form of the transport system, which includes a variety of transport modes. A close interoperability in the terminal is necessary for the smooth integration of the transport modes. The infrastructure and the superstructure used in terminals allow the transfer of freight between separate transport modes. However, the available technical capacity does not guarantee the effective performance of the terminal. One of the assumptions for the efficient terminal activity is properly selected technology.

The relevance of the work

Along with the rapid growth of container traffic volumes, container terminals at ports have become very important transport network nodes that serve as an interface between water and land transport and ensure continuous flows of freight traffic. Container terminals, serving ships fast and qualitatively, determine port competitiveness in the region. In order to maintain or strengthen their position in the competitive market, the stevedoring companies are forced to look for ways to improve the efficiency of a terminal. For this reason new activity planning strategies are developed, investments in advanced information technologies and automated guided vehicle systems are made. However, hasty investments may not always be successful and solve problems, especially if the terminal infrastructure is not adapted to modern technologies. Therefore it is necessary to select the suitable technology as terminal's processes are an integral part of a whole transport process and directly affect overall freight shipment time. The minimization of container handling's duration in a terminal would reduce the total transportation time and create preconditions for the increase of the transport chain's efficiency.

The object of the research

The object of the research involves the technological cycle of container handling in an intermodal transport terminal.

The aim of the work

The aim of the work is to create a mathematical model of the container handling's cycle, which enables to perform a multi-attribute assessment of the terminal technologies and to determine which of the technologies is the most efficient at the supposed conditions, ensuring the shortest container handling's duration.

The tasks of the work

In order to achieve the aim of the work, the following tasks have been formulated:

1. To reveal the significance of a terminal for intermodal transportation and to identify its operational problems.
2. To carry out the analysis of multi-attribute decision making methods, their application and to select the particular method for the solution of the problem.
3. To create a mathematical model representing the cycle of the container handling in a terminal. On the basis of the formulated container handling's cycle to identify the factors influencing the container's cycle and to estimate the significance of each factor for the overall handling's duration.
4. On the basis of the adapted multi-attribute assessment method to perform an evaluation of the terminal's technologies and to determine the most efficient technology for the application in a hypothetical terminal.

The methodology of the research

The methodology of the research is based on the analysis of the publications of Lithuanian and foreign scientists' studies in this field. The mathematical modelling, the expert survey, the classification and the processing of the statistical data (using the SPSS program), the multi-attribute assessment methods are applied in this work. The results of the observation research in the container terminals of Klaipėda State Seaport are also used in the dissertation thesis.

The scientific novelty

1. The mathematical model describing the cycle of the container handling in a terminal was designed, which helps to determine the most efficient container handling's technology in a terminal.
2. The system of the factors influencing the cycle of the container handling was determined, which allows performing an integrated assessment of the terminal's technologies.
3. On the basis of the adapted multi-attribute assessment method the approach for the terminal technologies' evaluation was composed and practically applied.

The practical value

1. The designed mathematical model of the container handling's cycle may determine the most efficient technology, which may be applied in terminals of any size.
2. The identified container handling cycle's factors and estimated significance may be used for the comparative analysis of different terminal's equipment.

Defended propositions

1. The designed mathematical model of the container handling's cycle enables to determine the most efficient container handling's technology of a terminal.
2. The system of the factors influencing the container handling's cycle constitutes the system of criteria for the multi-attribute assessment and enables to perform the integrated assessment of terminal's technologies and to compare them.

The scope of the work

The work consists of the general characteristics of the dissertation, four chapters, conclusions, a list of literature sources, a list of publications and annexes. The total scope of the work is 122 pages, 25 figures, 12 tables and 8 annexes.

1. The significance of a terminal for the intermodal transportation system

A container terminal at a port is the place where container ships are dock on berths, the inbound containers are unloaded and the outbound containers are loaded. Accordingly a container terminal serves as an interface between ocean

and land transportation. A terminal at a port is an important link for the overall container transportation's chain as it serves containerships, handles and stores containers, collects important information about ships' traffic and data about the road transport's situation, forecasts containers' demand and supply.

In recent years operations management in container terminals have received considerable importance. Therefore an ever increasing number of publications on container terminals have appeared in the literature. Some scientists claim that the efficiency of a container terminal's port is an important factor for the country's international competitiveness. For that reason, intensive studies by researchers have been carried out in order to determine the ports' performance across all regions of the world. The analysis of the scientific literature suggests that the key elements of the effective functioning of the container terminal at a port are the adequate terminal's space and the correctly chosen technology.

Scientists emphasize the role of the technical equipment in the terminal's operations, as terminals are faced with more and more containers to be handled in short time, consequently they are forced to enlarge handling's capacities and strive to achieve gains in the productivity. Accurately selected handling's technology could solve capacity problems of terminals. This problem in the dissertation is dealt by the research of container handling's operations by different technologies, when the objective function is the optimization of the container handling's cycle by assessing the parameters of terminal's technical systems.

2. The review of the multi-attribute decision-making methods

Multi-attribute evaluation is a decision-making tool developed for complex multi-criteria problems that include qualitative and/or quantitative aspects of the problem in the decision-making process. In recent years the multi-attribute evaluation methods have been increasingly used in theoretical research and practical decision making. There is a variety of multi-attribute decision-making methods in the world and they are widely used in various fields of human activity.

In the second chapter of the dissertation thesis the most popular multi-attribute evaluation methods are discussed. Methods are examined with respect to their suitability for a choice of a terminal container handling's technology. The analysis of multi-attribute decision-making methods revealed that each method has its inner logic and differentiates according to their complexity, but all of them are versatile and can be applied for any problem decision.

For the solution of the problem under consideration in the dissertation thesis the COPRAS-G (*Complex Proportional Assessment of alternatives with Grey relations*) decision-making method was selected, as it allows determining the priority of each alternative and calculating the utility degree, which facilitates a visual assessment of the alternatives' efficiency. Most of multi-attribute decision-making problems must be determined not with exact attribute values, but with fuzzy values or values in some intervals. The idea of the COPRAS-G method with attribute values expressed in intervals comes from the application of the Grey system theory and real conditions of decision making.

The procedure of the multi-attribute assessment using COPRAS-G method includes the following steps:

1. Selecting the set of attributes, describing the alternatives, and determining the weights of attributes.
2. Constructing the grey decision-making matrix, the normalized decision-making matrix and the weighted decision-making matrix.
3. Performing calculations of the attribute values and calculating the relative weight and the utility degree of each alternative.
4. Making the general decision.

The COPRAS-G method has been applied to solution of various problems in construction, economics, civil engineering and management before.

3. Modelling of the container handling's cycle and identification of factors influence it

In the dissertation the container cycle is considered as the duration of a container movement in a terminal, starting from a container pickup by a quay crane off a ship to export by client truck through terminal gates. This means that container is performed by wide number of handling operations. These are:

- a transshipment between a ship and a quay,
- a transportation between a quay and a storage yard,
- a transshipment between a terminal vehicle and a storage place,
- a storage,
- a transshipment between a storage place and a customer vehicle,
- a transportation from a terminal,
- an inspection of documents and container's condition at the exit gates.

All mentioned operations are performed with every container in a terminal, therefore it is assumed that each operation equivalents separate stage of the container cycle and the whole of operations constitutes the overall cycle of the container handling.

The models of the container handling's cycle in the intermodal terminal are presented, according to the handling equipment operating in the storage yard (Fig. 1 and Fig. 2).

According to the container handling's cycle the system of the factors, directly related to the container handling activity, was composed. It was identified that the cycle of container handling is influenced by 36 factors, which are:

- During a transshipment between a ship and a quay:
 - 1) the spreader's position fixing above the container and its lock time t_n , $t_{už}$,
 - 2) container's lifting height $H_{kont.pak}$,
 - 3) container's lifting speed $V_{kont.pak}$,
 - 4) container's lowering height $H_{kont.nul}$,
 - 5) container's lowering speed $V_{kont.nul}$,
 - 6) container's transfer distance in a horizontal direction L_v ,
 - 7) container's transfer speed in a horizontal direction V_v ,
 - 8) operations' overlapping φ ,
 - 9) container's position fixing above a landing place and its unlock time t'_n , t_{at} ,
 - 10) crane mechanisms' actuate and disengage time t_{vald} .
- During a transportation between a quay and a storage yard:
 - 11) container's transportation distance from a quay to a storage sector L_t ,
 - 12) vehicle's movement speed V_t .
- During a transshipment between a terminal vehicle and a storage place:
 - 13) spreader's position fixing above the container and its lock time t_n , $t_{už}$ either t_1 ,
 - 14) container's lifting height $H_{kont.pak}$,
 - 15) container's lifting speed $V_{kont.pak}$,
 - 16) container's lowering height $H_{kont.nul}$,
 - 17) container's lowering speed $V_{kont.nul}$,
 - 18) container's transfer distance in a horizontal direction L_v either L_{kraut} ,
 - 19) container's transfer speed in a horizontal direction V_v either V_{kraut} ,
 - 20) operations overlapping φ ,
 - 21) container's position fixing above a storage place and its unlock time t'_n , t_{at} either t_6 ,
 - 22) equipment's mechanisms actuate and disengage time t_{vald} either t_9 .

- During a transshipment between a storage place and a customer vehicle:
 - 23) containers' rearrangement,
 - 24) spreader's position fixing above the container and its lock time t_n, t_{uz} either t_1 ,
 - 25) container's lifting height $H_{kont.pak}$,
 - 26) container's lifting speed $V_{kont.pak}$,
 - 27) container's lowering height $H_{kont.nul}$,
 - 28) container's lowering speed $V_{kont.nul}$,
 - 29) container's transfer distance in a horizontal direction L_v either L_{kraut} ,
 - 30) container's transfer speed in a horizontal direction V_v either V_{kraut} ,
 - 31) operations overlapping ϕ ,
 - 32) container's position fixing above a vehicle and its unlock time t'_n, t_{at} either t_6 ,
 - 33) equipment's mechanisms actuate and disengage time t_{vald} either t_9 .
- During a transportation from a terminal:
 - 34) container's transportation distance from a storage sector to a exit gate L_{kl} ,
 - 35) vehicle's movement speed V_{kl} .
- During an inspection at the exit gates:
 - 36) documents and container condition inspection's time.

The parameters of the crane movement (L_{kr} and V_{kr}) are not considered as serving the single container crane is not travel along the quay or storage sector.

The storage stage is considered as *const* because the storage period of container is independent of the handling system operating in a terminal.

All mentioned factors depend on such aspects as the terminal activity's specification, the terminal's size and the layout, the handling equipment and the human factor.

The significance of the factors has been evaluated by the expert assessment. The experts were given the task to estimate the importance of each factor considering the overall container handling time in the terminal. The compatibility of the experts' opinions was certified by calculating the Kendall's concordance coefficient W and its significance χ^2 . After the results being assessed as reliable, the significance of each factor was calculated and it was estimated that the greatest impact on the container cycle have the documents and container condition inspection's time at the exit gates, and container's lifting and lowering speed in each stage of the handling's cycle.

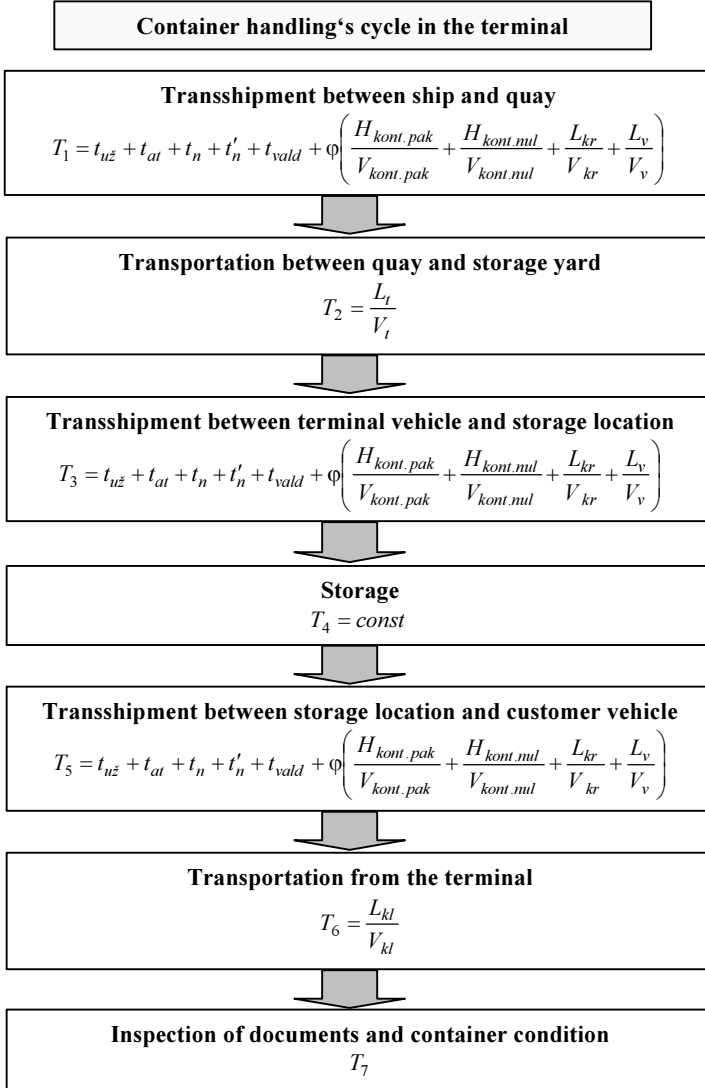


Fig. 1. The model of the container handling's cycle when the gantry crane operates in the storage yard

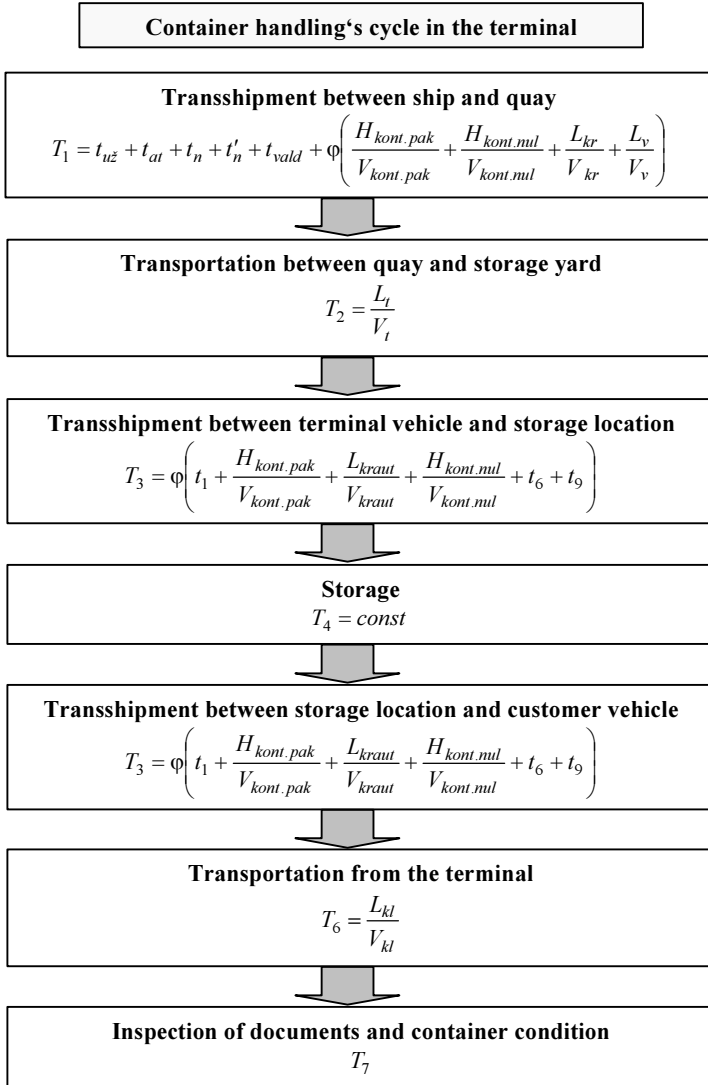


Fig. 2. The model of the container handling's cycle when the reach stacker operates in the storage yard

4. The multi-attribute assessment of the terminal's technologies

The theoretical study has shown that different type of material handling equipment is used to handle containers in the terminal. In the fourth chapter of the dissertation thesis the multi-attribute assessment of technologies was carried out using decision-making COPRAS-G method.

Five alternatives of the container handling's systems were accepted for the research:

- 1) the multi-trailer system;
- 2) the yard gantry cranes system, which was divided in:
 - 2a) the rubber tyred gantry cranes system,
 - 2b) the rail mounted gantry cranes system;
- 3) the reach stackers system;
- 4) the straddle carriers direct system;
- 5) the straddle carriers relay system.

The results of the multi-attribute assessment of the container handling's technologies indicate that the best performance among the mentioned systems achieves the multi-trailer system. The utility degree of the rest of the systems is rather low and varies between 50–62 per cents comparing to the multi-trailer system.

Taking into account the practical storage capacity of the systems, the conclusion was made that the multi-trailer system can operate only in the terminal with low volumes of containers flows, as up to 250 TEUs per hectare can be stored in one hectare of the terminal yard area. Therefore this technology is not suitable for the use in the conventional terminal with medium or high workload, where generally intensive container flows are handled.

It was founded that if the container handling requires to store up to 500 TEUs or 750 TEUs per hectare, the most efficient technology to be applied in a terminal by both cases is the straddle carriers relay system.

When container traffic volumes are high and demand for storage capacity is up to 1000 TEUs per hectare and more, it was estimated that the most efficient system is the rail mounted gantry cranes system.

Fig. 3 presents the utility degree of compared container handling's technologies and possibilities of the application according to the storage capacity.

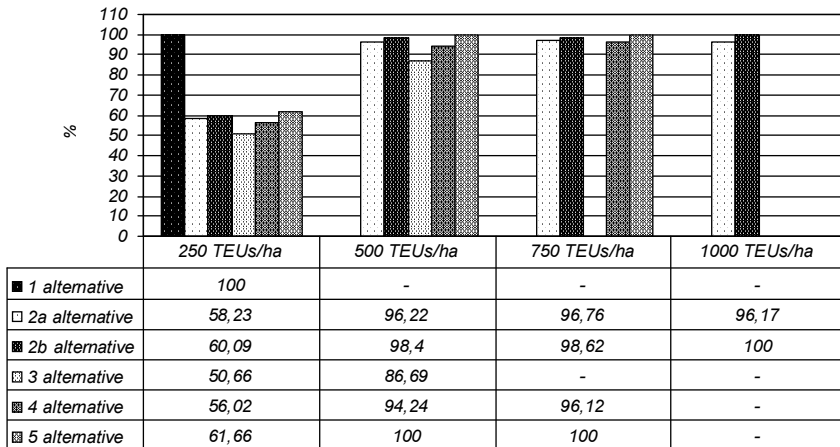


Fig. 3. The utility degree of the compared technologies, per cent

Which technologies are most efficient and recommended for the application in the terminal according to the storage capacity constraints are shown in the Table 1.

Table 1. The matrix of determination of the most effective container handling technology according to the storage capacity

No	Container handling's technology	Storage capacity, TEUs/ha			
		250	500	750	1000
1	Multi-trailer system				
2a	Rubber tyred gantry cranes system				
2b	Rail mounted gantry cranes system				
3	Reach stackers system				
4	Straddle carriers direct system				
5	Straddle carriers relay system				

The crossed out box indicates that the particular technology is not applicable at the determined conditions; the shaded box indicates that the particular technology is advisable at the determined conditions.

General conclusions

1. The analysis of scientific literature studying the intermodal terminal activity revealed that there are many models helping to improve the terminal's operational activity, however there are no models helping to determine which technology would be the most rational in the terminal.
2. It was estimated that the greatest impact on the cycle of container handling has the time of documents' and container condition's inspection (the significance coefficient of factor is 0,0336), container's lifting speed (the significance coefficient of factor in the quay is – 0,0329; in the storage yard – 0,0315 and 0,0329) and container's lowering speed (the significance coefficient of factor in the quay is – 0,0315; in the storage yard – 0,0322 and 0,0322).
3. The multi-attribute assessment showed that the highest utility degree reaches and therefore the most efficient technology is the multi-trailer system. The utility degree of the rest of the systems is rather low and varies between 50–62 per cent comparing to the multi-trailer system.
4. In the work it was ascertained that the application of technologies in terminal is restricted by their practical storage capacity. For this reason, the multi-trailer system can operate only in the terminal with low volumes of containers flows, when container handling is not exceeds 250 TEUs per hectare.
5. If the container handling requires to store up to 500 TEUs per hectare, there can operate the gantry cranes, the reach stackers and the straddle carriers systems in the terminal. It was founded that the most efficient technology is the straddle carriers relay system.
6. If the container handling requires to store up to 750 TEUs per hectare, there can operate the gantry cranes and the straddle carriers systems in the terminal. It was also revealed that the most efficient technology in this case is the straddle carriers relay system.
7. In the case where container flows are concentrated and the required storage capacity is up to 1000 TEUs per hectare and more, there can operate only the gantry cranes systems in the terminal. It was discovered that the rail mounted gantry cranes system is more efficient technology than the rubber tyred gantry cranes system.

List of Published Works on the Topic of the Dissertation

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In 2004, she graduated from Vilnius Gediminas Technical University, the Faculty of Transport Engineering and was awarded the Bachelor's Degree in Management and Business administration. In 2006, she graduated from Vilnius Gediminas Technical University, the Faculty of Transport Engineering and was awarded the Master's Degree in Management and Business administration. From 2007 till 2011 she was a PhD student of Vilnius Gediminas Technical University. In 2009, Jurgita Barysienė was on the internship at Institute for Transport Planning and Systems within Swiss Federal Institute of Technology in Zurich (ETH Zürich). 2005–2006 she was the Manager, at present – the Junior Researcher in Transport Institute of Vilnius Gediminas Technical University.

KONTEINERIŲ APTARNAVIMO CIKLO MODELIAVIMAS INTERMODALINIO TRANSPORTO TERMINALE

Problemos formulavimas

Transporto sektorius susiduria su rimtomis socialinių-ekonominių poveikių turinčiomis problemomis, kurias sąlygoja didelės transporto grūstys automobilių keliuose. Tradicinės priemonės, skirtos atskirų transporto rūšių veiklos tobulinimui, nepadedą išspręsti vis didėjančių transporto sistemos problemų. Pagrindiniu iškilusių problemų sprendimu yra laikoma transporto rūšių integracija, kurios principas paremtas krovinių perkėlimu iš kelių transporto priemonių į alternatyvias transporto rūšis.

Pastaruoju metu vis labiau pabrėžiama intermodalinio transporto svarba ir jam palaikyti bei skatinti skiriamos įvairios politinės ir finansinės priemonės. Jo teikiamų privalumų naudą pajunta ne tik krovinių vežimo grandinės dalyviai, tačiau ir visuomenė apskritai. Intermodalinio transporto pranašumai pasireiškia eksploatacinių infrastruktūros sąnaudų ir socialinių sąnaudų sumažėjimu.

Tačiau intermodalinis transportas yra sudėtingas vežimų būdas, kuris apjungia įvairias transporto rūšis. Ir tam, kad vyktų sklandi atskirų transporto rūšių integracija, privalo vykti glaudų jų sąveika terminale. Terminaluose

naudojama infrastruktūra bei superstruktūra leidžia atlikti krovinių perkėlimą tarp skirtingų transporto rūšių, tačiau esami techniniai pajėgumai dar negarantuoja veiksmingos terminalo veiklos. Viena efektyvaus terminalo funkcionavimo prielaidų yra tinkamai parinkta darbo technologija.

Disertacijoje nagrinėjami jūrų uosto konteinerių terminalų veiklos principai bei sprendžiama technologijų parinkimo problema. Problema sprendžiama analizuojant konteinerių aptarnavimo operacijas, kai tikslo funkcija yra konteinerio aptarnavimo ciklo optimizavimas. Tikslui pasiekti sudarytas konteinerio aptarnavimo ciklo matematinis modelis, kuriuo remiantis identifikuoti ciklą tiesiogiai įtakojantys veiksniai ir ekspertinio vertinimo metodu nustatytas kiekvieno veiksnio įtaka analizuojamam procesui. Gautų rezultatų pagrindu sukurta metodika intermodalinio terminalo technologijų vertinimui.

Darbo aktualumas

Kartu su sparčiu konteinerių srautų apimčių augimu, konteinerių terminalai uostuose tapo itin svarbiu transporto tinklo mazgu, kuris tarnauja kaip sąsaja tarp vandens ir sausumos transporto bei užtikrina sklandų srautų judėjimą. Greitai ir kokybiškai laivus aptarnaujantys konteinerių terminalai lemia uostų konkurencingumą visame regione. Siekiant išlaikyti ar pagerinti savo pozicijas konkurencinėje rinkoje, uostų krovos kompanijos priverstos ieškoti būdų kaip padidinti terminalų veiklos efektyvumą. Tuo tikslu yra kuriamos naujos darbo planavimo strategijos, investuojama į pažangias informacines technologijas ar konteinerių aptarnavimo automatinio valdymo sistemas. Tačiau gerai nepagrįstos investicijos ne visada gali pasiteisinti ir išspręsti kylančias problemas, ypačiai jei terminalo infrastruktūra nėra pritaikyta šiuolaikinėms technologijoms. Dėl šios priežasties kyla būtinybė teisingai parinkti efektyvią krovinių aptarnavimo terminale technologiją, kadangi terminaluose vykstantys procesai yra neatsiejama viso vežimo proceso dalis ir tiesiogiai veikia krovinių vežimo trukmę. Minimizavus konteinerių aptarnavimo terminale trukmę, būtų sumažintas viso vežimo proceso laikas ir sudarytos prielaidos transportavimo grandinės efektyvumui didinti.

Tyrimų objektas

Tyrimų objektas – konteinerio aptarnavimo technologinis ciklas intermodalinio transporto terminale.

Darbo tikslas

Šio darbo tikslas – sudaryti konteinerio aptarnavimo ciklo matematinį modelį, kuriuo remiantis būtų galima atlikti terminalo technologijų daugiakriterinį vertinimą ir nustatyti, kuri iš technologijų alternatyvų esant konkrečioms sąlygoms yra efektyviausia, siekiant trumpiausio konteinerių aptarnavimo laiko.

Darbo uždaviniai

Darbo tikslui pasiekti suformuluoti šie uždaviniai:

1. Išaiškinti terminalo svarbą intermodaliniams vežimams bei nustatyti veiklos problemas.
2. Išanalizuoti daugiakriterinio vertinimo sprendimų priėmimo metodus, jų taikymą ir parinkti metodą analizuojamai problemai spręsti.
3. Sudaryti matematinį modelį, aprašantį konteinerio aptarnavimo ciklą terminale. Remiantis sudarytu konteinerio aptarnavimo ciklu, nustatyti konteinerio ciklą lemiančius veiksnius bei įvertinti kiekvieno veiksnio įtaką konteinerio aptarnavimo trukmei.
4. Remiantis pritaikytu daugiakriterinio vertinimo metodu atlikti terminalo technologijų vertinimą ir nustatyti efektyviausią technologiją, taikytiną hipotetiniame terminale.

Tyrimų metodika

Tyrimų metodika pagrįsta Lietuvos ir užsienio šalių mokslininkų atliktų darbų šioje srityje analize, pritaikyti matematinio modeliavimo, ekspertinio vertinimo, statistinių duomenų grupavimo ir apdorojimo SPSS programa, daugiakriterinio vertinimo metodai. Darbe taip pat panaudoti stebėjimo, atlikto Klaipėdos valstybinio jūrų uosto konteinerių terminaluose, metu gauti duomenys.

Mokslinis naujumas

1. Sukurtas matematinis konteinerio aptarnavimo ciklą terminale aprašantis modelis, kuris sudaro sąlygas nustatyti efektyviausią terminale taikytiną konteinerių aptarnavimo technologiją.
2. Apibendrinta konteinerio aptarnavimo ciklą įtakojanti veiksnių sistema, kuri sudaro sąlygas atlikti kompleksinį terminalo technologijų vertinimą.
3. Naudojant patikslintą daugiakriterinio vertinimo metodą, sudaryta ir praktiškai pritaikyta metodika konteinerių aptarnavimo terminale technologijoms vertinti.

Praktinė vertė

1. Sukurtas konteinerio ciklo matematinis modelis skirtas efektyviausios technologijos, taikytinos bet kokių dydžių terminale, nustatymui.
2. Nustatyti konteinerio aptarnavimo ciklą lemiantys veiksniai bei įvertinti jų reikšmingumai skirti įvairios terminalo techninės įrangos lyginamajai analizei atlikti.

Ginamieji teiginiai

1. Sukurtas matematinis konteinerio ciklo modelis sudaro prielaidas nustatyti efektyviausią terminale taikytiną konteinerių aptarnavimo technologiją.
2. Apibendrinta konteinerio aptarnavimo ciklą įtakančių veiksnių sistema sudaro daugiakriterinio vertinimo rodiklių sistemą ir leidžia atlikti kompleksinį terminalo technologijų vertinimą bei jas tarpusavyje palyginti.

Disertacijos struktūra

Disertaciją sudaro įvadas, 4 skyriai, išvados, literatūros sąrašas, publikacijų sąrašas ir priedai. Bendra disertacijos apimtis – 122 puslapiai, 25 paveikslai, 12 lentelių ir 8 priedai.

Pirmajame skyriuje atskleista terminalų reikšmė intermodalinių vežimų sistemai. Atlikta mokslinės literatūros šaltinių, skirtų terminalo veiklos problemoms spręsti, analizė. Taip pat išanalizuotos dažniausiai uosto konteinerių terminaluose naudojamos techninės priemonės.

Antrasis skyrius skirtas populiariausių daugiakriterinio vertinimo metodų bei jų taikymo analizei. Parinktas priimtinausias daugiakriterinio vertinimo metodas, taikytinas technologijų alternatyvų įvertinimui.

Trečiasis skyrius skirtas konteinerio aptarnavimo ciklo tyrimui. Skyriuje pateiktas autorės sudarytas matematinis konteinerio aptarnavimo ciklo modelis bei nustatyti tiesiogiai jį įtakančios veiksniai.

Ketvirtajame skyriuje įvertinta konteinerio aptarnavimo ciklą įtakančių veiksnių įtaka. Gautų rezultatų pagrindu pritaikytas daugiakriterinio vertinimo metodas ir sukurta metodika intermodalinio terminalo technologijų vertinimui atlikti.

Bendrosios išvados

1. Atlikus mokslinės literatūros, nagrinėjančios intermodalinių terminalų veiklos problemas, analizę nustatyta, kad egzistuoja nemažai modelių, sudarančių sąlygas tobulinti operatyvinę terminalo veiklą. Tačiau modelių, suteikiančių galimybę nustatyti kuri technologija terminale būtų racionaliausia, nenustatyta.
2. Apskaičiuota, kad didžiausią įtaką konteinerio aptarnavimo ciklui turi dokumentų ir konteinerio būklės patikrinimo trukmė (veiksno reikšmingumo koeficientas yra 0,0336), konteinerio kėlimo greitis (veiksno reikšmingumo koeficientas krovos krantinėje metu yra 0,0329; krovos sandėliavimo aikštelėje metu – 0,0315 ir 0,0329) ir konteinerio nuleidimo greitis (veiksno reikšmingumo koeficientas krovos krantinėje metu yra 0,0315; krovos sandėliavimo aikštelėje metu – 0,0322 ir 0,0322).
3. Daugiakriterinio vertinimo skaičiavimais nustatyta, kad didžiausią naudingumo laipsnį esant priimtoms sąlygoms pasiekia ir dėl to efektyviausia laikytina vilkiko su platformų sąsata sistema. Kitų technologijų naudingumo laipsniai lyginant su šia sistema kinta nuo 50 iki 62 procentų.
4. Darbe išaiškinta, kad technologijų panaudojimą terminale riboja jų sandėliavimo pajėgumai. Dėl šios priežasties nustatyta efektyviausia sistema gali būti pritaikyta tik mažą darbo krūvį turinčiuose terminaluose, kai aptarnauti konteinerius sandėliavimo pajėgumų poreikis neviršija 250 TEU/ha.
5. Jei terminale aptarnaujamus konteinerius sandėliuoti reikalingi sandėliavimo pajėgumai siekia iki 500 TEU/ha, terminale gali būti naudojamos ožinių kranų ir krautuvų sistemos. Nustatyta, kad efektyviausia iš taikytinų technologijų yra ožinių krautuvų perstatomoji sistema.
6. Jei terminale aptarnaujamus konteinerius sandėliuoti reikalingi sandėliavimo pajėgumai siekia iki 750 TEU/ha, terminale gali būti naudojamos ožinių kranų ir ožinių krautuvų sistemos. Nustatyta, kad nagrinėjamu atveju efektyviausia taip pat yra ožinių krautuvų perstatomoji sistema.
7. Jei terminale aptarnaujamų konteinerių srautai yra intensyvūs ir sandėliavimo pajėgumų poreikis siekia 1000 TEU/ha ir daugiau, terminale gali būti naudojamos tik ožinių kranų sistemos. Nustatyta, kad efektyvesnė yra ožinių kranų ant geležinkelio bėgių sistema.

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MODELLING OF THE CONTAINERS HANDLING'S CYCLE
IN THE INTERMODAL TRANSPORT TERMINAL

A Summary of the Doctoral Dissertation
Technological Sciences, Transport Engineering (03T)

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