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RESEARCH ARTICLE

Significance of Proper Selection of Handling Equipment in Inland Intermodal Transport Terminals

Jan Lizbetin[1], Ladislav Bartuska[1*]

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Abstract

The paper deals with the methodology of handling equipment designing in intermodal transport terminals. The overall performance of the intermodal transport terminal, and hence its effectiveness, is most affected by the capacity of handling equipments that transfer intermodal transport units between transport modes. The first part of the paper describes the various types of handling equipments conventionally used in intermodal terminals. The second part of the paper contains the basic characteristics of the methodology of designing specific handling equipment and provides a calculation methodology for determining the operational needs of intermodal transport terminals.

Keywords

Intermodal freight transport, Intermodal transport terminal, Handling equipment, Operational needs of intermodal terminal

[1] Department of Transport and Logistics, Faculty of Technology, The Institute of Technology and Business in České Budějovice, Okruzni 10, České Budějovice, 370 01, Czech Republic

[*] Corresponding author, e-mail: bartuska@mail.vstecb.cz

1 Introduction

Intermodal transport terminal (hereinafter ITT) constitutes one of the most significant elements of intermodal transport infrastructure where the various modes of transport are interconnected. It represents a systemic point for transport interchanging (railway, water, road transport) when handling of the intermodal transport units (large containers, swap bodies, road semi-trailer and others) and enables the cooperation of all concerned modes of transport (Lizbetin and Caha, 2015).

According to the (AGTC, 1991), the intermodal freight transport (hereinafter IFT) is transport of goods in intermodal transport units (hereinafter ITU) by at least two transport modes. When changing the mode of transport, the ITU only is manipulated.

The intermodal transport infrastructure in a broader sense of the term is a summary of all devices necessary for complex providing of intermodal transport services (stable and mobile basis for IFT including ITU, intermodal transport vehicles as well as transport infrastructure and ITT).

The infrastructure of intermodal transport in the narrower sense of the term (basic IFT infrastructure) consists only of a specialized stable and mobile technical basis of IFT, which is used to perform basic (obligatory) IFT functions. The IFT infrastructure includes handling, maintenance or reloading tracks or sidings, other intermodal yard parts, internal road network, parking and storage areas, stationary and mobile handling equipment, loading ramps, intermodal transport unit terminals, administrative building, gateways (entry and exit points to ITT for road transport vehicles), repair and service equipment of ITT and others (Kovac, 2008).

Handling equipment is used for ITU handling operations in the intermodal yard and other storage areas. In addition to these facilities, the trucks for semi-trailers, various forklift trucks used for loading and unloading the cargo into or from the ITU, and other devices can be located in intermodal yard. Handling equipment has significant influence on technology, performance and economic parameters of intermodal transport terminal (Nader et al., 2017).

2 Characteristics of individual types of handling equipment used in inland ITT

The handling equipment used in the intermodal transport terminals (also used in other trans-loading facilities of various transport providers) are:

- cranes:
  - rail-mounted gantry and portal cranes,
  - rubber tyred gantry crane,
  - overhead (bridge) cranes suspended from a freestanding gantry,
- stacking vehicles:
  - container handler (stacker) with front lift,
  - side-loader with spreader,
  - large counterbalanced forklifts with spreader on expendable boom (reach stackers),
  - straddle carriers,
- Reloading and handling devices on road semi-trailers chassis.

Cranes and stacking vehicles are used in the intermodal terminal yards for vertical handling of intermodal transport units. These devices can perform handling operations with the ITUs - loading, unloading, reloading or stacking. Reloading and handling equipment on road semi-trailer chassis in combination with trucks can also be used to manipulate and to deliver large containers to customers (consignees) (Cujan and Fedorko, 2016).

2.1 Cranes

In the tri-modal transport terminals (road - rail - water), powerful portal gantry cranes with overhanging bridge ends that extend over the water surface are used for unloading or loading the ships. In inland intermodal terminals, gantry or bridge cranes are used as the primary handling device, either with one overhanging end, with both overhanging ends or without overhanging ends (Brumercik and Krzywonos, 2013).

Gantry cranes are among the most efficient handling devices in larger intermodal terminals. The most commonly used gantry cranes are moving on the rail tracks and both ends of the bridge overhang the supports (Fig. 1). The internal span of gantry cranes used in terminals is usually between 22 and 27 meters, the lifting height is at least 8.5 meters and the operational railway length for one crane is from 200 meters to 300 meters. However, there are also cranes with larger or smaller spans and higher lifting heights. Other technical parameters influencing the crane efficiency are for example hoisting and travel speed, safe working load, wheel load or outreach (Bartuska et al., 2016).

The rubber tyred gantry crane is structurally similar to a rail-mounted gantry crane, but there are no overhanging ends and all the structure moves over the solid surfaces via a wheeled chassis. The internal crane span should allow the operation of at least three handling workplaces and the stacking of the containers in at least three layers. But cranes with doubled gantry span and lifting height of up to 13.5 meters are produced as well (Cerna and Masek, 2015; Gasparik and Zitricky, 2010).

Fig. 1 Rail mounted gantry crane in Zilina ITT, Slovakia. Source: authors

2.2 Stacking vehicles

Lift trucks are used mainly as additional handling equipment in large ITT, but can serve as the basic handling unit as well. They are especially designed to stack the containers on depot areas - hence the name stacking vehicles, but they allow to perform other handling operations with ITU (loading, unloading, reloading, etc.) as well. In terms of construction, there are vehicles with lift on side, with front lift, with telescopic arm (reach stackers) or with crane (straddle carriers) (Chovancova and Klapita, 2016).

Front lifted stacking vehicles are especially designed to stack large containers up to 6 levels but only in one row. In terms of construction, it is a front forklift truck with a side or top container handling frame (spreader). Telescopic or stable handling frame (can be also equipped with a specific attachment for handling of trailers, swap bodies and bottom lift containers) is attached to the fork by the mounting device. The capacity of the front-lifted container stacker used for handling of full loaded containers is between 25 and 50 tons.

Reach stackers are technically derived from expandable arm crane trucks. The device consists of a wheeled chassis on which a massive telescopically extended non-rotatable arm with a spreader (or a combined attachment) at its end is mounted. It allows all handling operations with large containers, including their stacking. In the case of special attachment it allows also handling of swap bodies or road semi-trailers which are not stackable, and must be lifted by the bottom frame. The reach stacker according to the construction design stacks up into five levels (some special constructions allow stacking up to ninth level). In addition, it allows us to place the containers up to the third row, which significantly reduces the demands on the total range of handling workplace.

Fig. 2 Container stacker with front sided lift. Source: www.directindustry.com

The capacity of the reach stackers is from 28 to 70 tons (some special construction designs have a lifting capacity at load center up to 120 tons), but due to the extension of the boom and the boom angle, the lifting capacity of the device decreases significantly. For example, if the reach stacker's lifting capacity at load center is 42 tons, when extension of the boom is at 6.4 meters from the vehicle (the third row of containers) the lifting capacity is only 13 tons (Majercak et al., 2016).

Fig. 3 Reach stacker with special attachment for handling of the ITU (DB Megabox), Source: authors

3 Systematics of handling facilities selection for using in ITT

The following handling equipment requirements are used in the common inland ITT (Teye et al., 2017; Meers et al., 2017):

- handling equipment must should be able to manipulate any of the ITU,
- permanent operability of the terminal should be guaranteed (at least one hundred percent backup) by standby handling equipment in case of failure (in ITT should therefore always be each pair of vehicles or equipment with the same performance and the ability to handle any ITU),
- load capacity of the handling equipment must correspond as minimum to gross weight of manipulated ITU (about 40 - 42 tons).

The main principle of the handling equipment designing for using in ITT is to equip the terminal with two types of handling devices (the number of individual types depends on the assumed number of handling operations), one type of handling device operates in the "main/basic facility" position and the other operates in the "complementary facility" position. This principle is based on the requirement of 100% backup of the main handling equipment, for example in the event of some failure or a sudden increase in load time or freight volume in ITT (caused by rail, road or water transport).

In the case of an intermodal terminal of international importance construction (where the direct railway connections to other major foreign ITT, for example at European level or connections with seaports are provided), a crane facility is proposed as the main handling facility due to its high performance (organization of the most terminal operations depends on the crane performance). Stacking vehicles are used at these terminals as complementary facilities for handling of empty ITUs (containers) that are returned from customers or rented to customers.

Intermodal terminals of regional importance operated for freight collection within the region (or terminals in which unified logistics trains are not formed, but only groups of wagons with ITUs that are transported to major "international" terminals are formed) are equipped with stacking vehicles, in particular intermodal crane trucks (reach stackers), which serve either for handling operations (direct reloading between transport modes) and handling of empty ITUs (Rozic et al., 2016; Garcia, 2015).

4 Required number of handling facilities determination

When calculating the total demand for handling equipment in the ITT, the estimated number and volume of loading operations (transloaded ITU) is assumed. Expected loading operations should be divided in a given ratio between the main (basic) and complementary facilities.

The total need for handling equipment is determined by the following formula:

$$n_{MP}^{TKD} = \frac{N_{LO} * k_{vo} * t_{lo}}{\left(T - T_{tp}\right) * \alpha_{pv}} * \left(1 + \frac{r}{100}\right), \quad (1)$$

and the total number of loading operations is determined according to:

$$N_{LO} = \left(N_{IPJ}^{P} + N_{IPJ}^{O}\right) * k_d, \quad (2)$$

where:

N_{LO}	number of loading operations,
N^{P}_{IPJ}	number of ITUs received by rail transport,
N^{O}_{IPJ}	number of ITUs sent by rail transport,
k_d	double handling coefficient,
k_{vo}	secondary operations coefficient,
t_{lo}	average time of one load operation,
T	operation time of ITT within a day,

T_{tp}	technological breaks during daily working time,
α_{pv}	coefficient of operational use of the handling equipment,
r	time reserve for regular maintenance and scheduled repairs of the handling equipment.

5 Conclusion

The overall performance of the ITT is most affected by the performance of handling facilities that manipulate with the intermodal transport units. The performance of the handling equipment is determined from the average time required to transload one intermodal transport unit (arithmetic average of the transloading time of ITU that is closest to the handling facility and of ITU that is farthest from the handling facility). However, the determination of the average time is affected by the number of intermodal handling equipment, since the length of the handling distance changes (for example when there are two cranes at intermodal yard) (Bakesova and Bakes, 1979).

In specific calculations it is necessary to take into account the type and amount of handling equipment, handling speed etc. The performance of handling equipment can be considered as an upper boundary of the terminal total performance (i.e. the maximum possible performance), where the difference between the handling equipment performance and the total ITT performance minimizes the performance of other elements in the terminal which follow, or rather supplement, the handling equipment. For example, an incorrect or inappropriately designed transloading area of intermodal yard may negatively reduce the overall ITT performance (Lizbetin and Caha, 2016).

References

Bakesova, M., Bakes, J. (1979). Kritéria pro stanovení výkonnosti kontejnerových prekladišť. (The criteria for determining the efficiency of container terminals.) *Železniční technika*, 4.(in Czech)

Bartuska, L., Hanzl, J., Lizbetinova, L. (2016). Possibilities of Using the Data for Planning the Cycling Infrastructure. *Procedia Engineering*. 161, pp. 282-289. https://doi.org/10.1016/j.proeng.2016.08.555

Brumercik, F., Krzywonos, L. (2013). Integrated transportation system simulation. *Logi - Scientific Journal on Transport and Logistics*. 2(4), pp. 05-10.

Cerna, L., Masek, J. (2015). The proposal the methodology of the supply chain management in transport and logistic company. In: *Transport Means - Proceedings of the International Conference*. pp. 567-570.

Cujan, Z., Fedorko, G. (2016). Supplying of Assembly Lines Using Train of Trucks. *Open Engineering*. 6(1), pp. 426-431. https://doi.org/10.1515/eng-2016-0057

European Agreement on important international combined transport lines and related installations (AGTC). (1991). *Economic Commission for Europe*. Geneva.

Garcia, A. (2015). Study of alternative operation strategies in railroad terminals using simulation. *Proceedings of 2015 International Conference on Industrial Engineering and Systems Management, IEEE IESM,* art. no. 7380239, 725-732. https://doi.org/10.1109/IESM.2015.7380239

Gasparik, J., Zitricky, V. (2010). A new approach to estimating the occupation time of the railway infrastructure. *Transport*. 25(4), pp. 387-439. https://doi.org/10.3846/transport.2010.48

Chovancova, M., Klapita, V. (2016). Draft set of criteria for the inventory level optimization. *Logi - Scientific Journal on Transport and Logistics*. 1(7), pp. 27-36.

Kovac, M. (2008). Výklad pojmov infraštruktúra kombinovanej dopravy a infraštruktúra terminálov kombinovanej dopravy. (Interpretation of terms of combined transport infrastructure and infrastructure of combined transport terminals.). *Railway Transport and Logistic*. 4(3), pp. 1336-7943. (in slovak)

Lizbetin, J., Caha, Z. (2015). The optimization of the intermodal terminals. *Nase More*. 62, pp. 97-100. https://doi.org/10.17818/NM/2015/SI2

Lizbetin, J., Caha, Z. (2016). Theoretical Criteria for The Evaluation of the Operational Performance of Intermodal Transport Terminals. *Procedia Engineering*. 161, pp. 1197-1203. https://doi.org/10.1016/j.proeng.2016.08.540

Majercak, J., Kudlac, S., Ponicky, J. (2016). Innovative management of supply chains. *Logi - Scientific Journal on Transport and Logistics*. 1(7), pp. 98-107.

Meers, D., Macharis, C., Vermeiren, T., van Lier, T. (2017). Modal choice preferences in short-distance hinterland container transport. *Research in Transportation Business and Management*. 23, pp. 46-53. https://doi.org/10.1016/j.rtbm.2017.02.011

Nader, M., Kostrzewski, A., Kostrzewski, M. (2017). Technological conditions of intermodal transhipment terminals in Poland. *Archives of Transport*. 41(1), pp. 73-88. https://doi.org/10.5604/01.3001.0009.7388

Rozic, T., Rogic, K., Bajor, I. (2016). Research trends of inland terminals: A literature review. *Promet - Traffic - Traffico*. 28(5), pp. 539-548. https://doi.org/10.7307/ptt.v28i5.2090

Teye, C., Bell, M.G.H., Bliemer, M. C. J. (2017). Urban intermodal terminals: The entropy maximising facility location problem. *Transportation Research Part B: Methodological*, 100, pp. 64-81. https://doi.org/10.1016/j.trb.2017.01.014