A Study on the Efficiency of Transportation Equipments at Automated Container Terminals

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Abstract: - Since the vessels are getting larger and the efficiency of container terminals is more required, highly automated container terminals are being developed and operated. The ECT in Netherlands and the CTA in Germany - fully automated container terminal (ACT) – have improved productivity through automated yard and transportation areas. But after building these terminals, Automated Shuttle Carriers (ASCs) were developed to make up for the weak points of Automated Guided vehicles (AGVs) through technical development. And these ASCs are in operation at Brisbane berth 7 in Australia. This study presents important considerations to be taken in the design of ACT using ASCs through the analysis of ASC characteristics. It also analyzes and compares the performance of two equipments by using a simulation method.

Key-Words: - simulation, transportation equipment, analysis of performance, automated container terminal

1 Introduction

Since the development of a container terminal requires a huge amount of capital investment, the selection of optimum handling system alternatives is very important in planning the development of a container terminal. In order to determine the handling system that meets productivity and economic feasibility while planning terminal development, various scientific methods are being used, and this is an important element that determines the success or failure of the terminal development. General automated container terminals, which are currently in operation, adopt a handling system that uses automated guided vehicles (AGVs) as transfer equipment and automated transfer cranes (ATCs) as yard equipment. But in the case of AGVs, since they don't have pick-up ability, they have the demerit of reduced productivity and increased amount of equipment to be invested due to the standing by that occurs while interacting with CCs and ATCs. Automated Shuttle Carriers (ASCs), which complement AGVs' demerits, are developed and utilized in 7th Berth of Brisbane Port, Australia since 2004.

In this research, the characteristics of transfer equipment, which is the core equipment in an automated container terminal, are comparatively analyzed, and the productivity of the two equipments is to be measured and compared through the

simulation of fully automated container terminals that use AGVs and ASCs.

2 Automated Container Terminal Development

2.1 Alternative Plans of Handling Systems for ACTs

The method of selecting the optimum handling systems alternative along with planning container terminal development is as follows: for selection of a handling system, general plan for the amount of cargo handled and terminal development strategy must first be established. Then, in order to select the handling system that fits the established strategy, various alternatives are presented. Finally through the evaluation of productivity and economic feasibility of the presented alternatives, the optimum alternative that is suitable for the terminal to be developed is selected. When selecting a container handling system like this, there are some cases that the handling system is selected according to the scale, use and technology level, such as the cases of Hong Kong or Singapore.

Since the calculation of handling equipment requirement affects terminal's economic feasibility, decreasing the time of vessels at berth and increasing the overall productivity of the terminal, the types and the required number of berth equipment, yard equipment and transfer equipment should be calculated according to their handling capacity by considering container handling operation form. For this, the number of the equipment is generally calculated by mathematical methods or a partial simulation method.

A lot of researches have been carried out according to handling system selection and calculation equipment requirement, such as the following. Daganzo, de Castilho (1993) presented an optimum operation plan about the cost that occurs during the operation of ship, crane, etc. that occurs continuously in the container terminals. One side, the researches about a plan simulation have been mainly carried out as those which analyze the performance of the port, and the researches that seize the handling capacity of a real terminal by analyzing the utilization rate of handling equipment and the amount of handled container also have been made.

Simulation systems that are developed exclusively for ports are being developed, led by the software program developing companies such as Jordan, Woodan and Dobson (JWD) and Total Soft Bank Ltd. (TSB). Container terminal planning simulation that can be used when expanding a terminal or building new terminals and terminal operating simulation system programs that can increase the productivity of a terminal are also being developed. Research about transfer equipment in container terminal operation is mainly related to equipment scheduling and task assignment problem to increase the task performance of the transfer equipment. As representative examples, AGV scheduling has been proposed by Chen et al..

The research of Iris F.A. et al. (2004) and Yang et al., which compares AGV and ALV (Automated Lifting Vehicles), can be given as an example about comparison of transfer equipment in an automated container terminal. Although Iris F.A. et al., by using simulation, have experimented the efficiency of AGVs and ALVs in container handling, it has some constraints such as yard scale and unrealistic ATC number, and it measured the efficiency of two equipment only with respect to productivity. The research of Yang et al. have compared AGVs and ALVs and evaluated the productivity of ATCs. In these researches, analyses about the characteristics of transfer equipment are not enough, and due to focusing mainly on productivity evaluation, they have such problems as unrealistic simulation contents and not dealing with the economic aspect of the terminal as a result of equipment introduction. Lim et al. have proposed a dispatching method for AGVs based on a bidding concept and discussed the theoretical rationale behind the distributed dispatching method. And the performance of the method is compared with that of a popular dispatching rule using simulation1). Grunow et al. have discussed a priority rule based algorithm for the dispatching of multiload vehicles in automated container terminals.

Thus, this research analyzes the characteristics of AGVs and ASCs, which are automated transfer equipments that can be applied to automated container terminals, analyzes the productivity of the transfer equipment using a simulation method, and compares the difference of the terminals that use these two equipments through economic analysis.

2.2 Current Situation of Automated Container Terminals

Europe Container Terminal (ECT) of Netherlands is operating DDN (Delta Dedicated North), which is the first automated container terminal in the world opened in 1993, as well as DDE (Delta Dedicated East) and

DDW (Delta Dedicated West) terminals. ECT is operated by utilizing ASCs (Automated Stacking Cranes) as automated yard equipment and AGVs (Automated Guided Vehicles) as transfer equipment. Container Terminal Altenwerder (CTA), which complemented the demerits of ECT, started operating the first stage in 2001, and has now completed the development of the second stage and put into operation in 2005. It is utilizing dual rail mounted gantry cranes (DRMGs), two of which operate in one block by one passing over the other, and AGVs as a container handling system. Different from those, ASCs that can perform both transfer and yard tasks at a time, has been developed and being used in the 7th berth of Brisbane Port, Australia.

As transfer equipment, which is the core of the automated container terminal equipments, AGVs were first used by ECT in 1993. The speed of the first AGVs was 4m/sec, and now the speed of the AGVs that are being operated in DDW of ECT has been increased up to 8.3 m/sec, and the routing method has been shifted from "closed looped method" to "cross lane method", and the number of AGVs dedicated to each container crane has been reduced from 8 to 6. By the development of ASCs, automated container terminals, such as 7th Berth of Brisbane Port, Australia, are being developed and operated using ASCs instead of AGV and ATCs.

By the appearance of ultra-large container vessels and in order to be a hub port, not only the port equipment but also an integrated management system that can rapidly handle big scale cargo is needed as a new concept. For this, container terminals, which have automated transfer and yard operation, have already been developed and operated in the advanced ports, and domestically automated container terminals are being planned for Busan New Port and Kwangyang Port.

3 The Characteristics of Automated Transportation Equipments

Due to the development of high-speed cranes, the transfer system between the berth and the stacking yard, which is more efficient than ever, is needed in order not to be faced with bottlenecks in the terminal. Transfer equipment is the one that is used between the berth and the stacking yard. The representative one among the transfer equipments are generally used YT (Yard Tractor Trailer System), but there are other systems, which are exclusively developed for the terminal, such as Multi Trailer System in Delta Multi User Terminal of ECT, Netherlands, or Double Stack Trailer in Port of Singapore Authority. Also there are AGVs used in automated terminals and ASCs, which are recently developed by Kalmar.

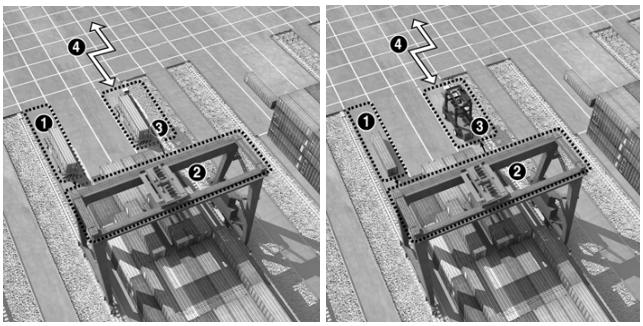
Fig. 1 Automated transportation equipments for ACT-AGV, ASC

AGVs and ASCs are being used as a handling system for fully automated container terminals. Characteristics of two equipments are as follows.

Table 1 Comparison between automated transfer equipments

		AGV	ASC
Speed	Travel	Max. 6m/s	Max. 8.5m/s
	Hoist	-	Full: 13m/min Empty: 20m/min
Turning radius		10m	4.55 / 10.58m
Characteristics		No function for pickup of containers Buffer zone only to queue AGV	Have a function for pickup of containers Available in the buffer zone of container storage yard
Operation terminal		ECT (Amsterdam), CTA (Hamburg)	Patrick Terminal (Brisbane)
Development Co.		Gottwald Port Technology GmbH, Hyundai Heavy Industries Co., Ltd	Kalmar

For AGV can't pick up a container itself, it must queue like 1- , on yard transfer point until ATC operates. AGV can move like 1- for a different job after completion of ATC' job. But after ASC puts down containers on the yard transfer point, it can move like 2- , , for a different job



1. AGV' operation at yard TP 2. ASC' operation at yard TP

Fig. 2 Operations of automated transportation equipments at yard TP

4 Simulation

4.1 Simulation Model

This study suggest simulation model to consider the operation characteristics of AGVs and ASCs. Simulation models are as follows.

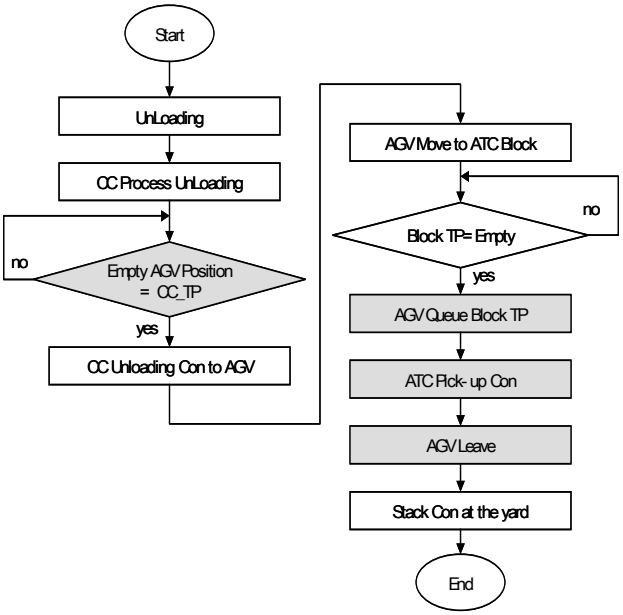


Fig. 3 Process of AGV operation

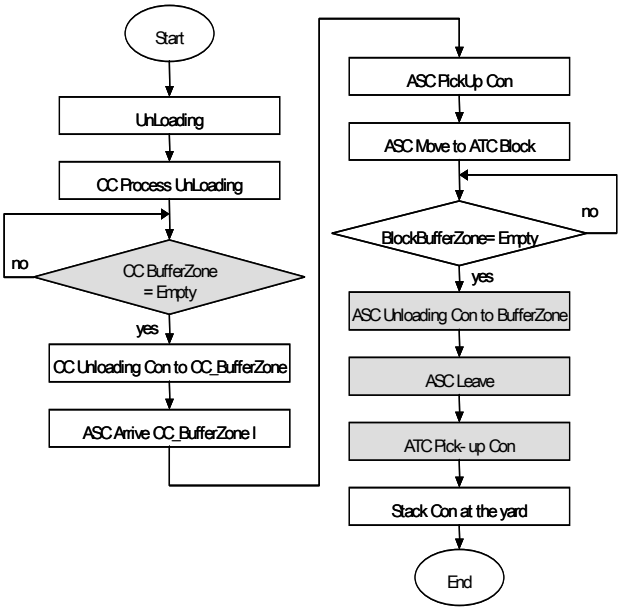


Fig. 4 Process of ASC operation

To simulate the above model, the ARENA, 10th version, is used. The reason for utilizing this simulation package is that it has some strong points for modeling the process such as ship arrival and queuing, container crane and yard tractor service pattern, etc.

The scopes of the simulation include only container shipment handling on the yard and vessel. The main factor values for simulation is is shown in table 2. And simulation models made using same parameter except for transportation equipment parameters. Because, In this study on the effect to transportation equipment on the ACT.

Table 2 Factors of simulation

Factor	Value for simulation
Number of QC	3
Number of ATC	7
Processing time of QC	N (60, 15)
Travel speed of ATC	2m/s
Speed of AGV	6m/s
Speed of ASC	8m/s

The layout of simulation model made by ARENA is suggested as in fig. 5. Run of simulation run is 10 times

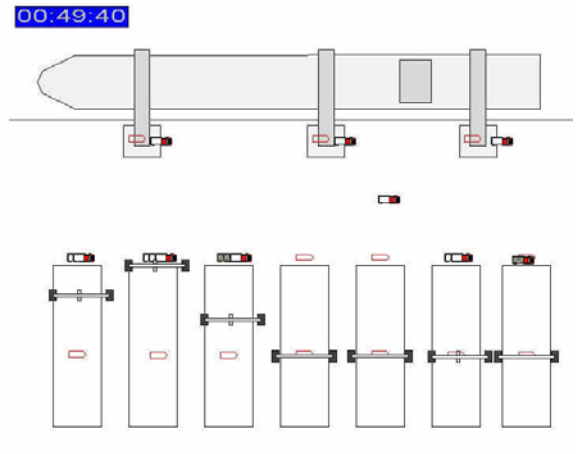


Fig. 5 The layout of simulation by ARENA

4.2 Results of simulation

The results of the simulation and test show that ASC is more efficient than AGV for transportation equipment. The following figure make-span to using ASC is more shorter than AGV. The case of using ASCs is need to 5-6 units per a berth to handle containers. On the other hand, AGV is need to 17-18 units.

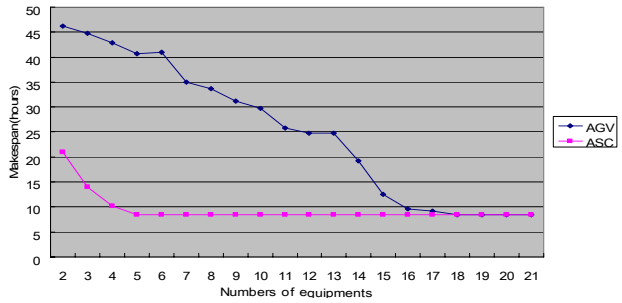


Fig. 6 Make-span according to equipments

In the case of equipment utilization of ATC, ASC seems low excellently then AGV. This is that ATC is less queue for transfer equipment work in case of using ASC. ATC has time to spare other work or re-handling, so it seems that yard operation more efficiently.

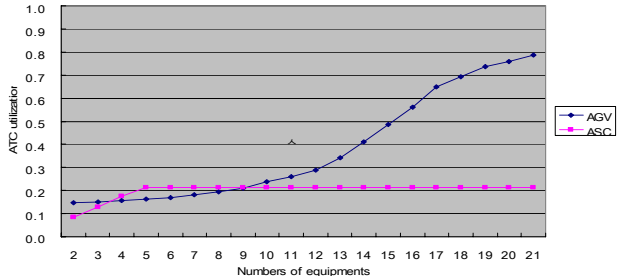


Fig. 7 ATC utilization according to equipments

According to the result of simulation, QC and ATC almost never queue in case using ASCs. Because QC and ATC have buffer areas, and ASCs speed is better than AGVs speed. It is very important topic for increase ACT efficiency.

5 Conclusion

ASCs were developed to make up for the weak points of AGVs through technical development. This study has tried to review the merits and demerits of AGVs and ASCs through analysis of their characteristics, suggesting a simulation model for performance evaluation of the two equipments. From now on we will try to perform operation evaluation under various surroundings through applying a simulation model, so that it will be the groundwork in selecting and designing a cargo handling system for a container terminal.

ASC's failure rate is higher then AGV but it's not including simulation.In this paper, We know that ASC can higher then AGV for container terminal operation.

In the future work, we'll be simulation of equipment evaluation including it.

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