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論 文

A Study on the Analysis of Container Logistics System by Simulation Method

- with reference to BCTOC -

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시뮬레이션에 의한 컨테이너 터미널 물류시스템의 분석에 관한 연구 (BCTOC를 중심으로)

임 봉 택 · 이 재 원 · 성 경 빈 · 이 철 영

Key Words : container terminal(컨테이너 터미널), container logistics system(컨테이너 물류시스템), basic statistics analysis(기초통계분석), BCTOC(부산컨테이너부두운영공사), exponential · erlang · normal distribution(지수 · 얼랑 · 정규분포), chi-square test(카이스퀘어 검정)

Abstract

For the purpose of building the simulation model on cargo handling capacity in container terminal, we composed a model of container logistics system which has a 4 subsystems; cargo handling, transportation, storage and gate complex system. Several date are used in simulation which were gained through a field study and a basic statistic analysis of raw data on BCTOC from January to Jane in 1998.

The results of this study are as follows;

First, average available ratios of each subsystems were 50% for G/C, 57.5% for Y/T, 56% for storage system and 50% for gate complex. And there were no subsystems occurring specific bottleneck. Second, comparing the results of simulation to the results of basic statistics analysis, we can verifying the suitability of this simulation model. Third, comparing the results of this study to the results of existed similar study in 1996, we were able to confirm the changes of container logistics system in BCTOC.

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1. Introduction

In recent years, Korea container terminals have faced with many environment changes; increasing container volumes, opening of new container terminals, IMF situation etc.. Such changes have direct impacts on the operating of existing terminals. For analyzing the impacts, the simulation model of container logistics systems on BCTOC is constructed. Some data on BCTOC were gained through a filed study and basic statistics analysis.

The models are then applied to examine the utilization of terminal resources such as quay, cranes, storage yard and gate complex. From the results, some implications for the terminal operations are derived.

2. The situation of BCTOC

BCTOC, which is the first container terminal in Korea has five berths; four berths for 50,000 ton class vessels and one berth for 10,000 ton class feeder vessels. Facilities and equipment situation were presented at Table 2.1 and the treatment volumes were at Table 2.2.

Table 2.1 Facilities and equipment of BCTOC

Session	Item	Area & Capacity
Facilities	Area	647,566 square meters
	Berth	1,447 metes
	Berth Capability	Four 50,000-ton-class vessels One 10,000-ton-class vessels
	Handling Capability	Year 1,000,000 TEU/year
	CY	119,297 square meters
	CFS	3 Warehouses 7,598 square meters
Equipment	G/C	13
	T/S	31
	S/C	16
	Y/T	56
	F/L	24
	Chassis	278

Table 2.2 Container volumes of BCTOC in the year

Year	'93	'94	'95	'96	'97
Total	1,162,020	1,470,425	1,618,416	1,697,761	1,831,091
Import & Export	1,070,354	1,210,863	1,267,153	1,566,571	1,397,000
T/S	47,430	112,609	130,536	131,190	434,091
Contract capability	159.6	163.4	177.6	·	·
Contract previous year	97.9	126.5	108.7	·	·
Berth occupancy ratio	86.6	86	89.1	·	·

3. The construction of simulation model

(1) The model of berth operation ability

Average waiting time is the most general figures for indicating the berth operation capacity.

For calculating the average interval of ship arrival time and average waiting time, the analysis of basic statistics is accomplished which deal in the chapter 4.

Fig. 3.1 is showing the simulation flow chart of berth operation capacity.

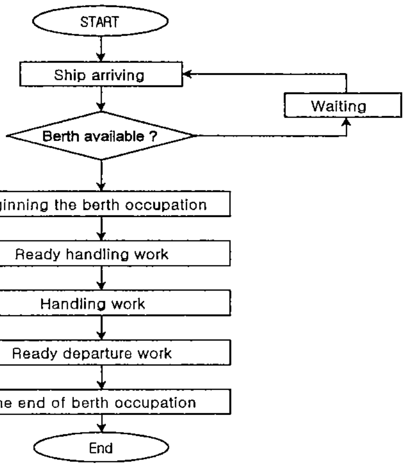

Fig. 3.1 The simulation flow chart of berth operation capacity

(2) The model of logistics system in container terminal

Logistics system model has four sub-systems, which changes the sea-container cargo to the land-container cargo during the container treatment time in terminal. Fig. 3.2 is showing the simulation flow chart of container logistics system.

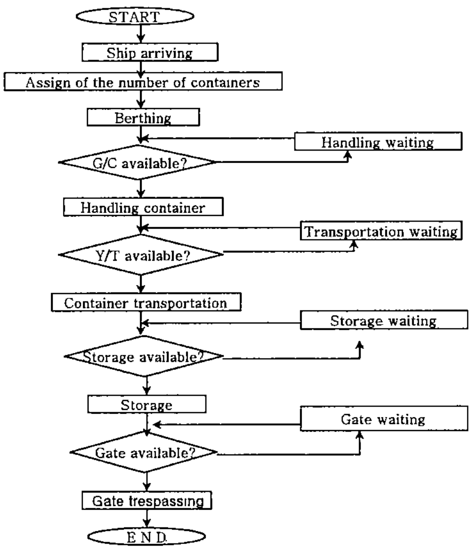

Fig. 3.2 The simulation flow chart of container logistics system

4. The analysis of basic statistics

For analyzing the interval distribution of ship arriving time, handling container distribution per ship, import-export container storage distribution, gate enter-leave pattern, a basic statistic analysis is accomplished in this chapter. The electronic data of BCTOC is used in this analysis.

(1) The interval distribution of ship arriving time

During this period, the results of basic statistic analysis are average tonnage of ship(32,600G/T), maximum(70,760G/T), minimum (3,117G/T), total ships(686). Regarding this result, the main tonnage class of entered ships to BCTOC is 20,000~50,000 G/T.

Fig. 4.1 is showing the interval distribution of ship arriving time. The average interval of ship arriving time is 6.17 hours with standard deviation 5.63 hours.

According to the existed study, the interval distribution of ship arriving time was known that general berth depends on exponential distribution and specialized container berth depends on erlang-2 distribution.

Comparing the observed number of ship to the two distributions(exponential and erlang), the

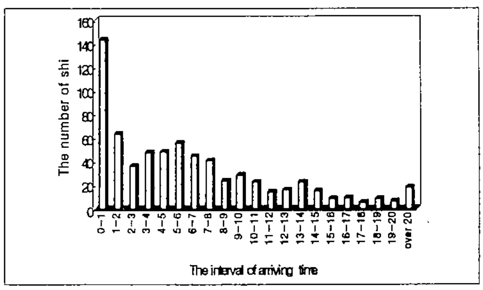

Fig. 4.1 Distribution of the interval of ship arriving time in BCTOC

pattern is more similar to exponential distribution(see Fig. 4.2).

For more mathematical analysis, chi-square test was accomplished on it. From the results of this test, the hypothesis of exponential and erlang-2 distribution was rejected.

But we can not help selecting the special distribution for modeling. The best method is the selection of exponential distribution on this condition. And existed studies on BCTOC, it was confirmed that the interval of ship arriving time is following the exponential distribution.

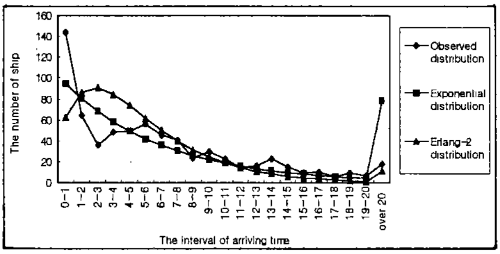

Fig. 4.2 Distribution of the interval of ship arriving time

(2) The number of handling container

Fig. 4.3 is showing distribution of the number of handling containers in the same period. The average number of handling container is 775.6 units with standard deviation 469.0.

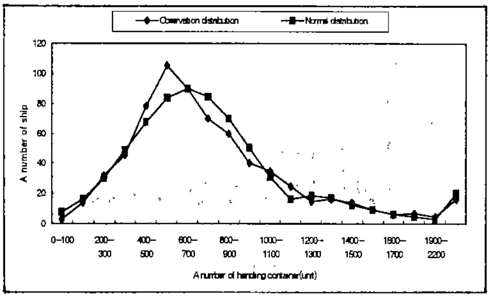

Fig. 4.3 The number of handling containers and adjusted normal distribution

Fig. 4.3 is showing that it is approximately normal distribution that the distribution of the number of handling containers by ship unit. But assuming the distribution to general normal distribution, the result of chi-square test has serious errors. So this distribution is divided into 2 parties; normal distribution part(0-1,300units), exponential distribution part (1,300-over 2,200 units). Fig. 4.4 is showing the real data of normal distribution part and normal distribution with average 653.2, standard deviation 270.0.

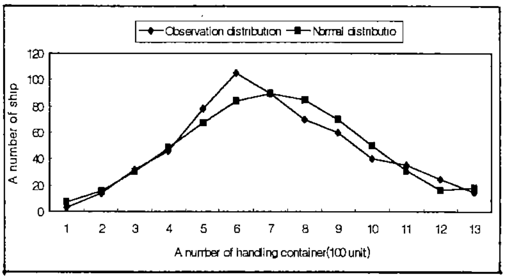

Fig. 4.4 The comparison of the number of handling containers and normal distribution

From the result of Chi-square test, the normal distribution with average 653.2, standard deviation 270.0 is accepted appropriately.

As same way, Fig. 4.5 is showing the real

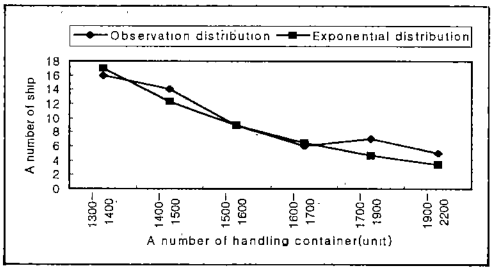

Fig. 4.5 The comparison of the number of handling containers and exponential distribution

data of exponential distribution part and exponential distribution with λ=0.32, and the result of Chi-square test is accepted appropriately too.

Exactly, Fig. 4.3 is showing the real data and adjusted normal distribution(combination of normal and exponential distribution).

(3) Distribution of service time

Service time is the other name of port time that means the average time of ship assumption time in terminal. Based on the statistic analysis, the average handling time of each berth is 16.65 hours. Considering the ship's standby time(before and after berthing time, set total 1.83 hours), the actual average handling time is 18.48 hours.

Fig. 4.6 represents the linear relation of the number of handling containers and port time. This result implies that the ratio of the number of handling container to the port time is constant, and constant G/C is assigned to ship.

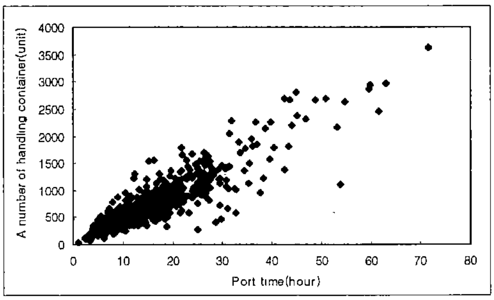

Fig. 4.6 The relation of the number of handling container and port time

(4) Container storage period

During the first half of the 1998, average storage period is 2.2 days in import, and 2.5 days in export in BCTOC. Fig. 4.7 is showing the storage period and its distribution. In the case of transit container, average storage period is 3.3 days, which is longer than the period of import and export.

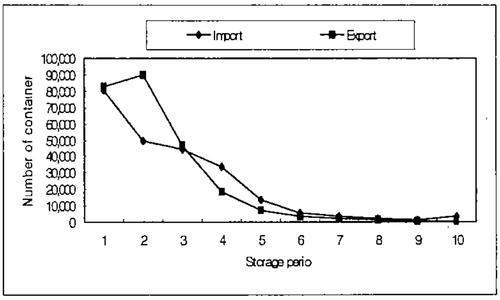

Fig. 4.7 The distribution of storage period in BCTOC

(5) The pattern of gate trespassing

The data on gate trespassing in BCTOC are derived from basic statistic analysis. The gate is close 2 times everyday from A.M. 7 to 8 and from P.M. 6 to 7. So the congestion of container volumes are existed from P.M. 5 to 6. Fig. 4.8 shows that the 66% of gate in containers and more then the 73% of gate out containers are treated in the daytime(from A.M 8 to P.M. 6), and 36% of gate in containers and the 27% of gate out containers are treated in the nighttime.

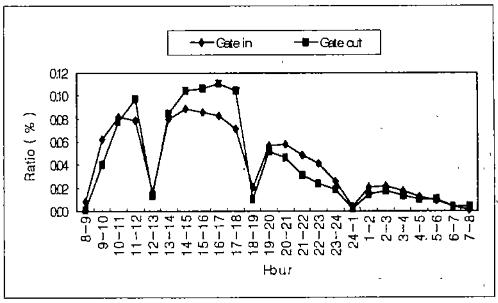

Fig. 4.8 The distribution of gate trespassing containers

5. Simulation Analysis

(1) Berth handling capacity analysis

Simulation steps and data are as follows;

First, the ships are arriving at the terminal by Poisson manner. Exactly, the ships are arriving at the terminal with average arrival interval time(6.17 hours) which has the exponential distribution.

Second, the average service time of ships is different by the number of handling container. It is used in this step that the number of handling container distribution which come from the basic statistics analysis. Exactly, it is used in this value that the adjusted normal distribution which was induced from the combination of normal distribution and exponential distribution.

The handling capacity of C/C(Container Crane) is calculated by the equation(total number of handling container/total port time) which was derived from the linear relation of total number of handling container and total port time. The value is 46.6(number of container/hour) in this study.

Third, it is assumed that the standby time of before and after ship's berthing is 1 and 0.83 hour in this model.

Fourth, the number of berth is 5 in this model, but 1 of this is feeder berth for 10,000G/T class ship. So the ships of below 12,000G/T can berth the 5 berths but feeder berthing has the priority.

(가) Composition of Model

In this model, AweSim simulation language is used for simulation.

The arriving of entities(ships) is generated by exponential distribution. The entities recording the arrival time in ATRIB{1}, and the number of handling container, which is generated by adjusted normal distribution is recorded in ATRIB{2}. The entities of ATRIB{1} which waiting the berth are assigned the berth by two ways, the ships of over 12,000G/T are assigned 1 of 4 berths(50,000ton class berth) and below 12,000G/T can be assigned 5 berth(50,000ton class berth + feeder berth) but feeder berth has priority. ATRIB{2}/46.6 hours(for handing the container) and 1.83 hours (for standby time of before and after berthing) are used for total handing time. The departure entities restore the source(berth) and recording the several data before terminate.

(나) Results and analysis

The simulation results of this model are as follows;

First, the average waiting time and service time of ships are 2.95 and 20.5 hours, and average and total number of handling container are 734.6 and 528,900 units. Average berth utilization (occupation) and available ratios are 59% and 41%, and the total ship of observation is 720 units.

Second, table 5.1 showing the comparison of simulation results to the basic statistic analysis. In each item, the simulation results and statistic data are showing the similar values.

Third, table 5.2 is showing the comparison of simulation results to existed similar study in 1996.

Table 5.1 The comparison of simulation results to the basic statistic data

Item	Simulation result	Statistics data	Remark
Number of ship	720	686	+34
Average port time(hour)	18.71(+1.83)	16.7	+2.01
Average containers	734	755	-21
Total containers	528,927	532,042	-3,075

The result of this analysis implies that the breakup volumes of container, which concentrated on BCTOC in the past distributed to the new container terminals(Gamchen, Uam, Gamman etc.).

Table 5.2 The comparison of simulation results to existed similar study in 1996

Session	Simulation result	Exitisted study result	Remark
Berth occupation ratio	59%	81%	-22%
Average weighting time(hour)	2.95	12	-9
Number of ship	720	897	-177

(2) The simulation analysis of container logistics system

The simulation input data are based on the results of basic statistic analysis and field studies. And Awesim simulation language is used for modeling.

The ship's arriving is generated by exponential distribution with average 6.17 hours, and the number of handling containers is generated alternatively by 2 distributions which have the normal distribution with average 747.7, standard deviation 379.1 and exponential distribution with average 1,802. And the capacity of G/C for handling the 1 unit is assumed 0.04 hour which is calculated by the ratio of 1hour/24unit(the general capacity of G/C in container terminals).

The number of G/C is assumed 10 units in BCTOC(BCTOC has total 13 G/C's but only 10 G/C's are available because it maintains 10 gangs for terminal operations). The number of Y/T is assumed 40 units(BCTOC has total 56 Y/T's but only 40 Y/T's are available for ship containers handling because it assigned 9 Y/T's for train and CFS, and supposed the 15% average breakdown ratio). And the transportation time of Y/T for transportation the 1 unit is assumed 0.17-0.19 hour that based on the existed research data. The daily storage capacity is assumed 12,156TEU that based on the existed research data and the average storage period that are deduced by basic statistic analysis.

At the gate complex, based on the existed research data, 24units/1hour capacity is assigned to the case of gate-in, 48units/1hour capacity is assigned to the case of gate-out. And 8 lanes are assigned in BCTOC as gate lanes(5 lanes for gate-in, 3 lanes for gate-out, there are 11 lanes in BCTOC).

(가) Results and analysis

The simulation results of this model are as follows;

First, the results of average utilization (occupations) of each sub systems are G/C 49.8%, Y/T 57.5%, storage system 56.0%, gate complex 49.3%. And the observed total number of container is 537,640 units. On the whole, total average utilization of each sub system maintains about 50%, and the special bottlenecks are not pointed out.

Second, to comparison the total number of containers(simulation result 537,640 units, the basic statistics analysis 532,000 units), the results are showing the similar values.

Third, Table 5.3 shows the comparison of simulation results to existing similar study in 1996.

In the results of Table 5.3 (forcing on the utilization of G/C and storage system), we can verify the well reflection of this model. That is to say, the decreased volumes of import and export containers in BCTOC (about 20%) are matched with the decreased utilization ratios of G/C and storage system.

Table 5.3 The comparison of simulation results to the existed similar study in 1996

Session	Simulation result	Existed study result	Remark
Average available ratio of G/C	49.8%	79.5%	-29.7%
Average available ratio of Y/T	57.5%	63.95	-6.4%
Average available ratio of storage place	56.0%	71.1%	-15.1%
Average	54.43%	71.5%	

6. Conclusion

The results of this study are as follows;

First, as the results of simulation analysis, average berth available ratio and total observation ships were 59% and 720 ships. And average available ratios of each subsystems were 50% for G/C, 57.5% for Y/T, 56% for storage system and 50% for gate complex. There were no subsystems occurring specific bottleneck.

Second, comparing the results of simulation to the results of basic statistics, we can verify the suitability of this simulation model.

Third, comparing the results of this study to the results of previous similar study, we were able to find significant changes of container logistics systems in BCTOC(see Table 5.2, 3).

It is accepted very ironically that the decreasing container volumes greatly improved the container physical distribution systems in BCTOC in which the chronic congestion of cargo and ship was pointed out. However the diminishing earnings resulted from decreasing volumes suppress the management of BCTOC. In the long term, BCTOC will be able to strengthen the customer service and the competitive power through starting on-dock service systems.

요 약

본 논문에서는 컨테이너 터미널의 화물처리능력을 분석하는 시뮬레이션 모델을 구축하기 위하여 BCTOC의 컨테이너 물류시스템을 4개의 하위시스템 즉, 하역, 이송, 장치, Gate complex system으로 구분하여 모델을 구성하였다. 시뮬레이션에 사용하는 각종 Data는 1998년 1월부터 6월까지의 실제자료에 대한 기초통계분석과 현장조사를 통하여 구하였다. 본 연구에 의한 결과는 다음과 같다.

첫째, 각 하위시스템에서 G/C 50%, Y/T 58%, 장치시스템 56%, Gate Complex 50%의 평균이용률을 보이면서, 특별히 병목현상을 일으키는 하위시스템은 없었다.

둘째, 시뮬레이션에 의한 분석결과를 기초 통계량 분석결과와 비교시 관측 선박 수, 평균 재항시간, 평균 컨테이너 개 수, 총 컨테이너 개 수 등에서 매우 근접한 결과를 도출함으로써, 본 시뮬레이션 모델의 적합성을 검증할 수 있었다.

셋째, 본 연구의 결과를 기존의 유사 연구결과와 비교시 BCTOC 컨테이너 물류시스템의 변화를 확인 할 수 있었다.

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셋째, 본 연구의 결과를 기존의 유사 연구결과와 비교시 BCTOC 컨테이너 물류시스템의 변화를 확인 할 수 있었다.

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