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論 文
A2-2

On the analysis of container physical distribution system by simulation(Centering on BCTOC)

B. T. Lim[1] · J. W. Lee[1] · K. B. Sung[1] · C. Y. Lee[2]

시뮬레이션에 의한 컨테이너 물류시스템의 분석에 관한 연구(BCTOC를 중심으로)

임봉택 · 이재원 · 성경빈 · 이철영

Key Words : container terminal(컨테이너 터미널), container logistics system(컨테이너 물류시스템), basic statistics analysis(기초통계분석), BCTOC(부산컨테이너부두운영공사), exponential, erlang, normal distribution(지수, 얼랑, 정규분포), x^2-test(카이스퀘어 검정).

Abstract

For the purpose of building the simulation model on cargo handling capacity of container terminal, we composed a model of container logistics system which has a 4 subsystems; cargo handling, transportation, storage system and Gate complex system.

Several date used in simulation gained through spot research and basic statistic analysis using raw data from January to Jane in 1998.

The results of this study are as follows;

First, average available ratio of each subsystem was G/C 50%, Y/T 57.5%, storage system 56%, Gate complex 50%, and there was no subsystem occurring specific bottleneck.

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

Third, Comparing the results of this study to the results of existed study, we were able to confirm a change of BCTOC container logistics system under IMF situation.

1) A regular member, the graduate school of Korea maritime university
2) A regular member, Korea maritime university, professor

1. Introduction

Now a day, many ports cannot help accepting container logistics system for the native power and competitive power by itself in a world market. It is very important that the container terminal is composed by efficiency sub systems for economic and efficient treatment of container.

In this paper, the container terminal(BCTOC) is organized from systematic view point and modeled by computer simulation method.

This model constructed by the basic statistics analysis for the actual data in BCTOC. It has very similar elements to compare the real container terminal structure in some points; the interval distribution of arriving time, the service time distribution of each facilities, container storage situation etc..

2. The situation of BCTOC

BCTOC which is the first container terminal in Korea has the 5 berths; four 50,000 ton class vessel and one 10,000 ton class feeder vessel. Facility and equipment situation were presented at Table 2-1, and the treatment volumes Table 2-2.

Table 2-1 Facilities and equipments 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
Equipments	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

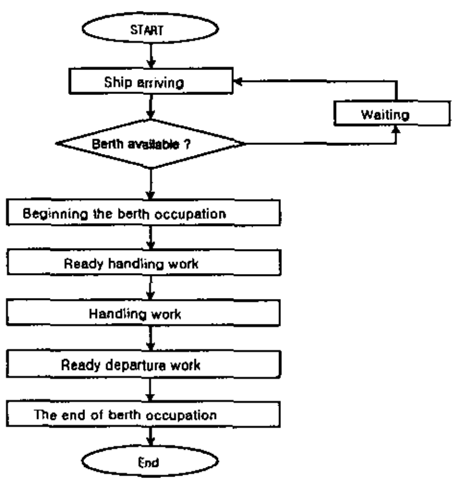

Fig. 3-1 The simulation flow chart of berth operation capacity

Average waiting time is the most general figures for indicating the berth operantion capacity. So, calculating the average interval of arriving time and average waiting time is accomplished by basic statistic analysis. Fig. 3-1 is showing the simulation flow chart of berth operation capacity.

(2) The logistics system model of the container terminal

System model have four sub-system and facilities which can change the sea-container cargo to the land-container cargo during treatment time in terminal. Fig. 3-2 showing the simulation flow chart of container logistics system.

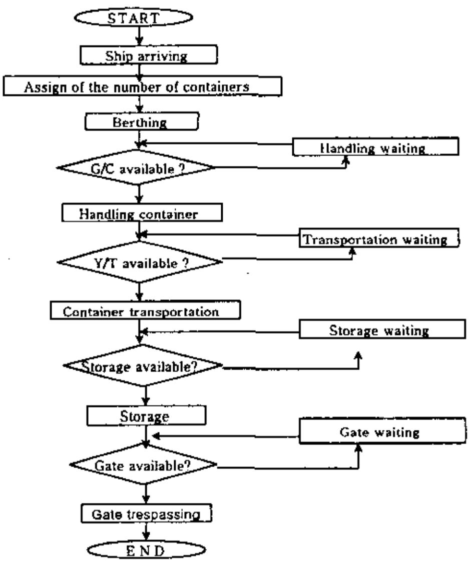

Fig. 3-2 The simulation flow chart of container logistics system

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 raw data is collected by the first half of the 1998 electronic data in BCTOC.

(1) The interval distribution of ship arriving time

In most of ports, ship's enter-leave time is not regular and ship arriving pattern due to the probability distribution. So, if ship arrival interval and service pattern was approved depending on special distribution, ship's waiting time can be calculated by it.

During this period, the results of basic statistic analysis are like this; 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 arriving time is 6.17 time with standard deviation is 5.63 time.

Mostly, the interval distribution of ship arriving time was known that general berth depending on exponential distribution but specialized container berth depending on erlang-2 distribution.

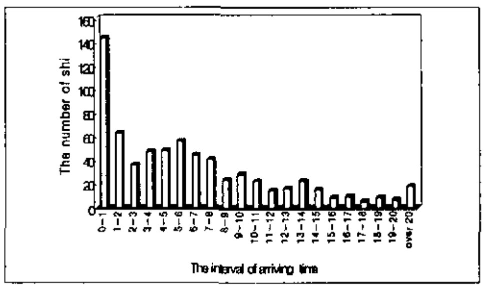

Fig. 4-1 The distribution of ship arriving time interval in BCTOC

Comparing the observed arriving number of ship with the two distributions(exponential and erlang), the pattern is more similar to exponential distribution.

For more mathematical analysis, x^2-test was accomplished on it. And the results of this test, the hypothesis of exponential and erlang-2 distribution was rejected.

But cannot help selecting the special distribution for the modeling, the best method is the selection of exponential distribution. Fig. 4-2 is showing the fitting pattern of exponential distribution. And existed studies on BCTOC, it was confirmed that the interval of arriving time is following the exponential distribution.

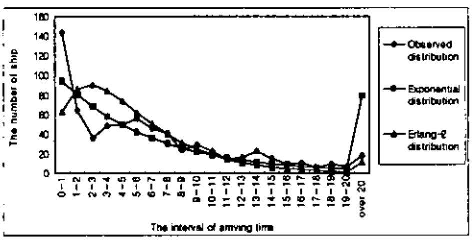

Fig. 4-2 The distribution of ship arriving time interval

(2) The number of handling container

Fig.4-3 is showing the 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.

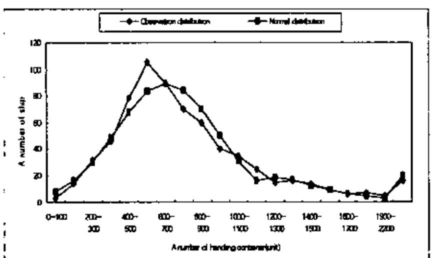

Fig. 4-3 The number of handling containers and adjusted normal distribution

Fig.4-3 is showing that it is approximately normal distribution that the distribution of the number of handling containers by the ship unit. But assuming this distribution to general normal distribution, the result of comparing with normal distribution has serious errors. So this distribution divide into 2 parties; normal distribution part (0-1,300units), exponential distribution part (1,300-over 2,200units). Fig.4-4 is showing the real data of normal distribution part and normal distribution with average 653.2, standard deviation 270.0.

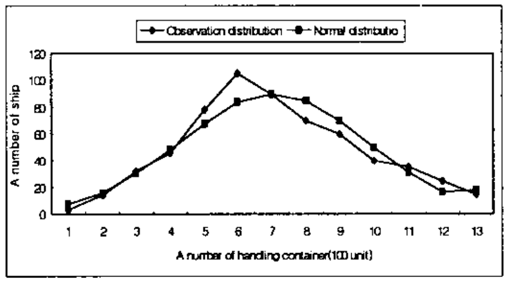

Fig. 4-4 The comparison of the number of handling containers and normal distribution

From the result of Chi-square test, the normal distribution with average 653.2, standard deviation 270.0 is regarded as appropriate.

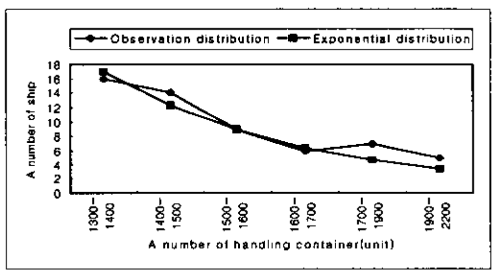

Fig. 4-5 The comparison of the number of handling containers and exponential distribution

As same way, Fig.4-5 is showing the real data of exponential distribution part and exponential distribution with λ=0.32, and the result of Chi-square test is regarded as appropriate too.

Exactly, Fig.4-3 is showing the real data and adjusted normal distribution(combination of normal and exponential distribution).

(3) The distribution of service time

Service time is the other name of port time which means the average time of ship assumption time in terminal. Based on the statistic analysis, the average handling time of each berths is 16.65 hours in BCTOC. 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 represent the linear relation to the number of handling container and port time. This result implies that the ratio of the number of handling container by the unit handling hour is constant, and constant G/C is assigned to ship.

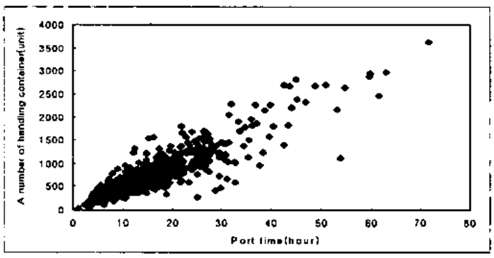

Fig. 4-6 Relation to the number of handling container and port time

(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.

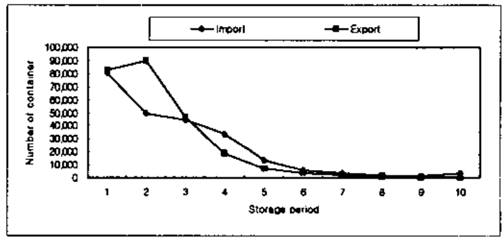

Fig. 4-7 The distribution of storage period in BCTOC

(5) The pattern of gate in and out

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 night time.

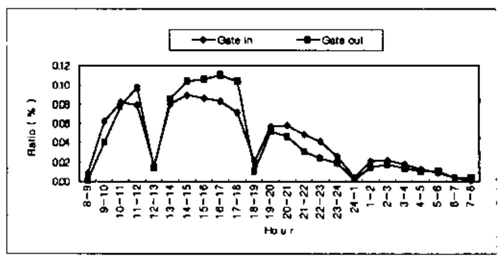

Fig. 4-8 Distribution of gate trespassing containers

5. Simulation Analysis

(1) Berth handling capacity analysis

Simulation steps and data are as follows;

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

Second, the average service time of ships is different by the number of handling container. So 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, in this model it is assumed that the standby time of before and after ship's berthing is 1 and 0.83 hour.

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 berthing 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 arriving time in ATRIB{1}, and the number of handling container which is generated by adjusted normal distribution 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 and below 12,000G/T can be assigned 5 berth but feeder berth prior. It is used for handing the container that ATRIB{2}/46.6 hour for handing the container and 1.83 hour for standby time of before and after berthing. 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 handling number of container are 734.6 and 528,900 containers. Average berth utilization (occupation) and available ratio 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 items, 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.

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.), and the total container volumes are decreased by IMF.

Table 5-1 The comparison of simulation results to the basic statistic data

Item	Simulation result	Statistics data	Common
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

Table 5-2 The comparison of simulation results with existed similar study in 1996

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

In the mean time, it is accepted very ironically that the decreasing of volumes greatly improved the container physical distribution system in BCTOC in which the chronic congestion of cargo and ship was pointed out, but the diminishing earnings suppress the management of BCTOC.

(2) The simulation analysis of container physical distribution system

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

The ships arriving is generated by exponential distribution with average 6.17 hours, and the number of handling containers are 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 which based on the existed research data and the average storage period which is deduced by basic statistic analysis.

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

(가) Results and analysis

The simulation results of this model are as follows;

First, the results of average utilizations (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 bottle necks are not pointed out.

Second, to comparison the total number of container(simulation result 537,640 units, the basic statistic analysis 532,000 units), this model reflect well the real system in some aspects.

Third, Table 5-3 show the comparison of simulation results with existed similar study in 1996.

In the results of Table 5-4-centering on the utilization of G/C and storage system-we can verify the well reflection of this model. That is to say, the volumes of import and export containers in BCTOC are decreased about 20%(the first half of the 1997, 915,000TEU, the first half of the 1998, 720,000TEU), this figures are matched with the decreased utilization ratio of G/C and storage system.

Table 5-3 The comparison of simulation results with existed study in 1996

Session	Simulation result	Existed study result	Common
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 was 59%, total observed ship is 720, and average available ratios of each subsystem were; G/C 50%, Y/T 57.5%, storage system 56%, Gate complex 50%. There was no subsystem 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 existed study, we were able to confirm the changes of BCTOC container logistics system under IMF situation.

It is accepted very ironically that the decreasing of volumes greatly improved the container physical distribution system in BCTOC in which the chronic congestion of cargo and ship was pointed out, but the diminishing earnings suppress the management of BCTOC. But, because of this result, BCTOC will come to strengthen customer service system and competitive power through starting on-dock service system in the long term.

〈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 하위시스템의 평균이용률은 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 관측선박수, 평균재항시간, 평균 컨테이너개수, 총 컨테이너개수 등에서 매우 근접한 결과를 도출함으로서, 본 시뮬레이션 모델의 적합성을 검증할 수 있었다.

셋째, 본 연구의 결과를 기존의 유사 연구결과와 비교시 IMF에 의한 BCTOC 컨테이너 물류시스템의 변화를 확인할 수 있었다.

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