해양환경안전학회지 제17권 제4호 pp. 323-329, 2011. 12. 31. (ISSN 1229-3431)
Journal of the Korean Society of Marine Environment & Safety

The study On An Yacht Moorings Establishment Location Analysis Using Optimum Spiral Method

Sung-Hyeon Park* · Ki-See Joo**†
*, ** Division of Maritime Transportation System, Mokpo Maritime University, Mokpo 530-729, Korea

최적화 기법을 이용한 요트 계류장 입지분석에 관한 연구

박성현* · 주기세**†
*, ** 목포해양대학교 해상운송시스템학부

Abstract : *This study is to determine an optimal yacht mooring location candidate among many alternative candidates in order to obtain the maximized efficiency under the natural conditions using integer programming. To deal with marina's construction location, the optimal construction location is selected using 21 important factors analysis for 4 candidates in the Mokpo city. The development period and the initial investment cost weight are one and half times more than the others among 21 factors. The optimal spiral analysis of weighted linear model shows that the Peace Square sea area is selected as the most optimal place among 4 candidates. This proposed model has not been applied in the optimal marina's facility candidate selection problem yet. This paper will contribute to determine the most reasonable alternative. Also, this proposal model can be applied to other marina's facility candidate selection problem in other regions.*

Key Words : *Yacht mooring, Marina's construction location, Integer programming, Location analysis, Optimal spiral method*

요 약 : 본 연구는 최대의 효과를 달성하기 위하여 정수 계획법을 이용하여 주어진 자연조건하에서 여러 대안 후보 입지 중 최적의 요트 계류장을 결정 하기위한 문제이다. 목포시 인근의 4개의 요트 계류장 후보지 중 최적의 후보지를 선정하기 위하여 21개의 요소들이 각각의 후보지들에 대하여 분석된다. 총 21개 요소들 중 개발 기간과 초기 투자비용은 다음 요소들에 비해서 1.5배의 가중치를 갖는다. 가중치 선형모델 분석 결과 네 곳의 후보지중 평화광장 수역이 가장 합리적인 장소로 선정되었다. 본 논문에서 소개된 모델은 지금까지 요트 계류장 선정 시 적용된 적이 없는 새로운 방법이다. 본 논문은 가장 합리적인 위치를 결정하는데 공헌할 뿐만 아니라 마리나 관련된 다른 분야에도 응용 적용가능하다.

핵심용어 : 요트 계류장, 마리나 건설지, 정수 계획법, 입지 분석, 최적화 기법

1. Introduction

A new field of recent science, human important subjects are the space and the ocean development. The space development is processed by limited nation in the far away. However, since the ocean development is processed with intimately relationship by many nation, the maximum subject will be the ocean development in 21 century. The ocean must be developed keeping natural environment to help humankind . Specially, since the ocean area occupied about 70 % of the earth, and the ocean mean depth is almost 3,800m, the human race with dangerous factors such as limited territory, increasing population, and exhaustion danger of ground resource must develope the ocean which is treasure of unlimited resource(Yu, 1982).

All countries of the world have appointed the ocean development with new strategic industry of 21 century, concentrated industrial prosperity. The ocean sightseeing and leisure among ocean development are concentrated interest. Along expansion of social indirect establishment and improvement of standard living, the users who enjoy ocean leisure are steadily growing. However, since ocean leisure activation is not accomplished with infrastructure insufficiency to attract ocean tourists, the expansion of ocean leisure foundation establishment and development of various experience theme are demanded constantly.

Since Korea's territory and plain are small, also population is centralized metropolis, land use is limited. However, since Korea's territory is surrounded by ocean on three sides, ocean space development is required urgently more and more.

* First Author : shpark@mmu.ac.kr, 061-240-7171
† Corresponding Author : jksjoo@mmu.ac.kr, 061-240-7167

Ocean natural resources exist maritime space resource such as transportation, artificial island, maritime city, and sea power plant. Also, Ocean energy resources exist such as tidal, gravitational wave, temperature energy. On the grounds that numerous mineral resources at the sea exist such as chemistry substances, copper, boron, manganese, uranium, silver, gold, and magnesium, ocean is thought mineral treasure in the future.

In this paper, since marina's establishment is considered with high value added industry, geographical and natural conditions for proposed sites are analyzed to select optimal marina's establishment candidate in the Mokpo city neighborhood in an attempt to gain an early tourists and yacht lovers.

In conventional researches consideration, integer programming is applied such as public key code algorithm planning(Yong et al., 2000), application field related scheduling planning(Won et al., 2004; Lee et al., 2003; Hwang and Rgul, 2004; Hwang et al., 2002; Agha, 2006; Byun, 1992; Yoo and Yi, 1996; Zhao et al, 2004; Zhang et al, 2002), and military field(Soland, 1987). The research and application an instance for choosing optimal marina's establishment location are total nonexistence example. Therefore, in this paper, integer programming is applied in optimal marina's establishment location selection.

The object of this research selects is drew the most reasonable and efficient marina's location among four candidates such as the North port(Blue), the South port(Green), the Daebandong(Pink), and the Peace Square sea(Red) area as follow Fig. 1.

To extracted the optimal model, the circumstance analysis such as natural environment, local merits, and local demerits for location candidates in the Mopko city near is important.

Fig. 1. Marina's establishment location candidates.

The constraint equations and object function of this research model for selecting the optimal marina's establishment location are extracted. The object function consists of weighted factors such as weather, maritime, environment, behind facilities, zone utilization, initial developing cost, developing passibility condition, and so on.

The constraints consist of depth of sea area, maritime traffic congestion, initial development cost, waves, sea zone utilization. The basic assumption of linear programming is positive property of variables. The 0 and 1 represent whether a specific candidate is selected or not. If a candidate is selected, the selected variable conceive 1, otherwise 0. Lastly, 0-1 model among linear programming by combining object and constraint function to choose optimal marina's establishment location is completed.

2. The marina's establishment construction location selection procedure

2.1 The situation grasp of construction candidates

We performed the optimal spiral analysis procedure on the marina's establishment in the order in the follow chart as shown in Fig. 2. The factors which influence marina's establishment are drew out in principal factor extraction step. In the weight analysis, weight of factors is graded in proportion to influence degree. The disadvantage and advantage of extracted factors in the before step for marina's establishment location candidates are analyzed synthetically. The extracted factors are rated factor's advantage from zero, which is no advantage to 10, which is most advantage. The condition analysis of location candidates is performed such as depth, wave, marine traffic

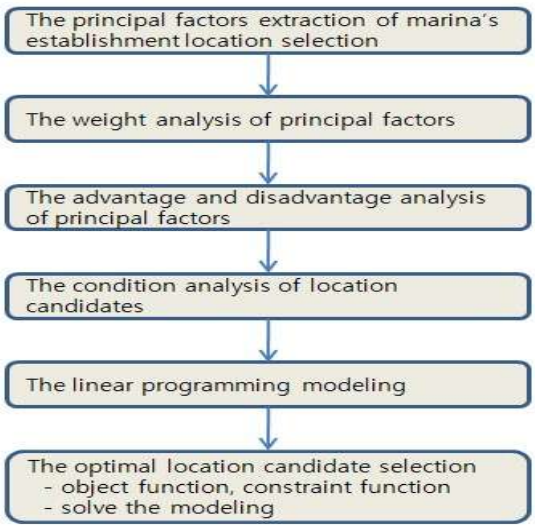

Fig. 2. System flowchart to determine the optimal marina construction location.

congestion, initial development cost, and sea zone utilization constraint condition. In the linear programming modeling, the detail model for finding solution is completed using the object function and the constraint equations. Lastly, the optimal location among 4 candidates is selected using integer linear programming with object function and constraint equations.

2.2 The marina's establishment development circumstance analysis

To analyze development circumstance, natural and social environment are considered. The former consists of atmospheric phenomena and marine stipulation. The datum such as wind, precipitation, temperature, relative humidity, fog days, precipitation days, typhoon days which have an effect on the water surface leisure activity influence are analyzed. The month variation of wind velocity annual average(2003-2007) is represented in following Fig. 3. As annual average wind velocity in the Mokpo area is about 3.7 ~4.7 m/s, it is appropriate condition of marine leisure activity(Park, 2009).

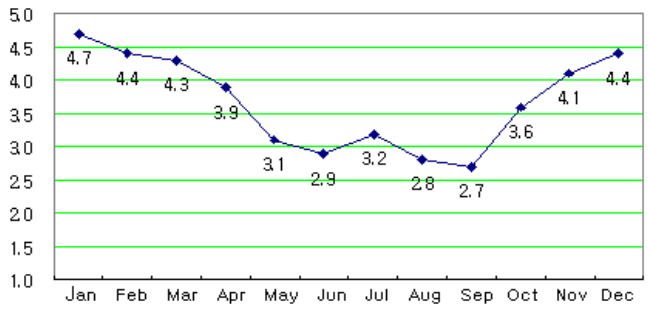

Fig. 3 Month variation of wind velocity.

Generally, the rainfall distribution of our country has steadily decreasing trend from the south to the north according to latitude, can be classified copious rainfall region around the coast and semiarid rainfall region around inland. The superabundance precipitation and localized heavy rain are not only a drawback in marina's establishment maintenance but also disadvantage influence because of limited view in recreational ship navigation. Since the annual precipitation of the Mokpo area is 1304.76 mm, less than other south areas with annual 1400 mm~1800 mm which are copious rainfall region, the Mokpo area is considered as moderate position of marina's establishment location.

The temperature will have to be considered from the point of view of water leisure activity, the higher temperature done the better for water leisure activity. A temperature of 10 ℃ or above is impertinent for general race and sailing, a long distance race and cruising boat are not influenced. The vicinity of the Mokpo city can be a great place for marina's activity since the average of annual temperature is above 10 ℃ except winter 4 months as shown Fig. 4.

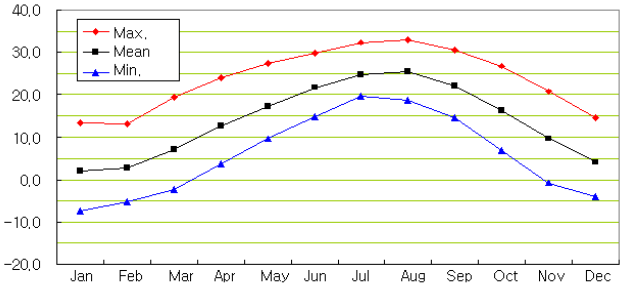

Fig. 4 Month variation of temperature.

The boat with limited view in leisure activity waters is gonna be cause a marine accident such as collision, and stranding since a nautical mark recognition and movement observation of other boats is affected. However, the average of mist days in the Mokpo area are 23.4 days as shown Fig. 5, which are the lower than different localities of the Korea west coast.

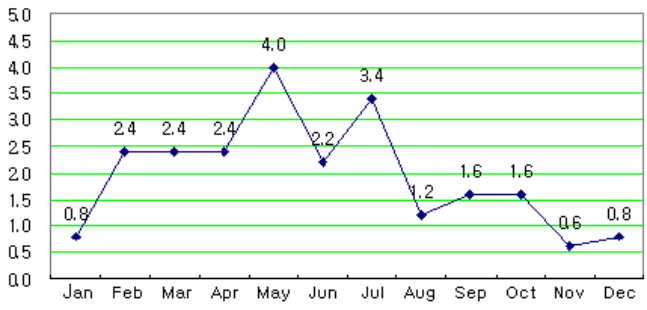

Fig. 5 Month variation of mist days.

The marine stipulation factors consist of tide, tide height, waves, the depth of water, disemboguement. Since the tidal range of the Mokpo port area according to characteristic of the Korea west area is far bigger than other regions, the analysis of tidal characteristic is required. Since the tidal range of the Mokpo port is 3 m~4 m, the plan of mooring system to consider it's characteristic is required. The closeness sea area of the Mokpo port which is a part of the Aegean Sea has complicated tide, the flow velocity of ebb current prevails against it of flood current. The flood current of the Mokpo port is the northeast and the southeast current,

ebb current is northwest and southwest, the velocity of moving fluid is very irregular as shown Fig. 6 and Fig. 7(Park, 2009). The Mokpo port which the many Aegean Seas take role of a breakwater keeps on calm sea area since wind and waves don't reach directly. Therefore, the establishment of marina's facilities is possible without breakwater which requires the hundred of billions.

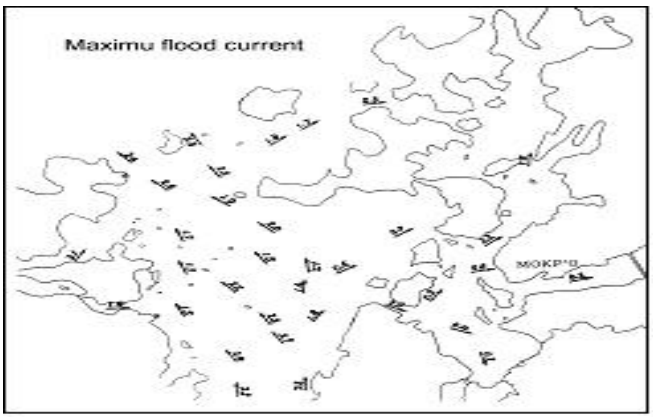

Fig. 6. Maximum flood current distribution of the Mokpo sea area.

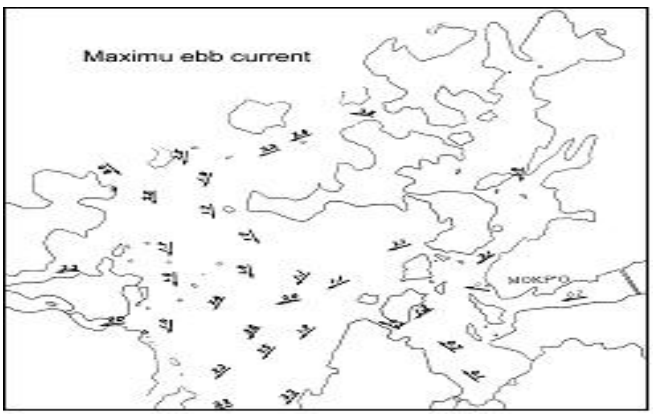

Fig. 7. Maximum ebb current distribution of the Mokpo sea area.

The depth of water is most essential factor to moor a boat. A motorboat requires 3 m~4 m depth of water, a sailing yacht to be considered keel needs 5m. The average depth of water keeps 10m over except several area such as the Koha Island around, the North port neighborhood, the South port in the Mokpo port area.

The water velocity of main anchorages in the inner Mokpo port while the Yeongsan, the Youngam, and the Kumho lake are disembogueing water into the sea separately or simultaneously is increased about 30 % ~ -20 %, 290 % ~ -21 % in the Daebul quay, and 15 % ~ 34 % in the Mokpo port compared with non disemboguement. The Fig. 8 and Fig. 9 represent the flowing place accoring to disemboguement or not.

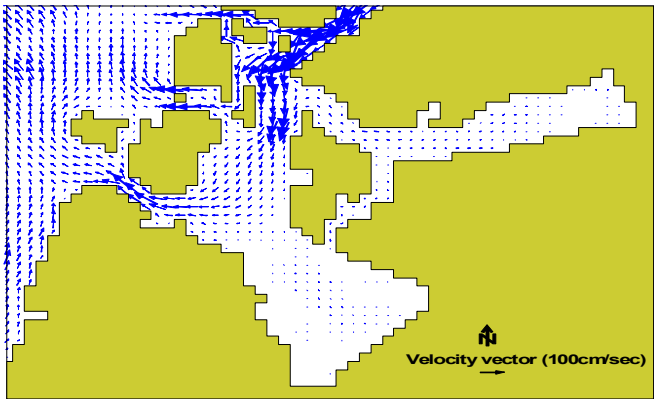

Fig. 8. Flowing place at non disemboguemen.

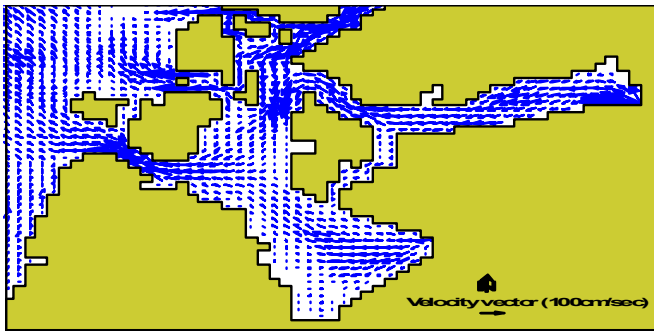

Fig. 9. Flowing place at disemboguemen concurrently in the Yeongsan and the Kumho lake.

3. Optimum spiral method

3.1 The weight analysis

To select the most optimal candidate among 4 marina's establishment candidates, the object function and constraint equations of this model must be extracted. The object function consists of 21 factors such as atmospheric phenomena, tide, tide heights, waves, disemboguement, marine traffic, maritime traffic congestion, the depth of water, topography, the spectacle of background, an ocean ecosystem, water pollution, available land of background, lodging facilities, traffic system, parking space, a short period development, a long term development, initial investment cost, sea zone utilization, and fishery rights. These factors are classified with 4 weighted grades. The weight of factors which influence marina's establishment is represented in Table 1.

The constraint equations consist of waves, the depth of water, maritime traffic congestion, and initial development cost, and sea zone utilization. 0-1 model among integer programming model is introduced by combining object function and constraint equations to select the most optimal

candidate location. The short period development possibility and initial investment cost has higher weight than other factors to reflect inferior municipal government financial affairs.

Table 1. Consideration factors weighted in marina's construction candidate selection.

Estimating factors	Peace square	South port	Daeban-dong area	North port
Atmospheric phenomena	10	10	10	10
Tide	10	10	8	6
Tide height	6	6	6	6
Waves	10	8	4	6
Disemboguement	4	4	4	10
Marine traffic	10	8	6	6
Maritime traffic congestion	10	8	6	6
Depth of water	10	8	10	4
Topography	10	10	10	10
Spectacle of background	8	8	10	10
Ocean ecosystem	10	10	10	10
Water pollution	10	10	10	10
Available background land	4	10	8	6
Lodging facilities	10	4	4	8
Traffic system	8	6	8	10
Parking space	6	4	6	6
Short period development	13	8	8	10
Long term development	4	10	10	10
Initial investment cost	15	9	9	12
Sea zone utilization	10	8	4	4
Fishery rights	10	10	10	10

3.2 The modeling

The definition of variable to model the selection of optimal marina's establishment candidate location is as following.

i : The marina's establishment candidates of the Mokpo port neighborhood(the North port, the South port, the Daebandong area, the Peace Square sea area)

j : The selection factors' weight of marina's establishment candidates(Atmospheric phenomena, tide, tide heights, waves, disemboguement, marine traffic, maritime traffic congestion, the depth of water, topography, the spectacle of background, an ocean ecosystem, water pollution, available land of background, lodging facilities, traffic system, parking space, a short period development, a long term development, initial investment cost, sea zone utilization, fishery rights)

$$X_i : \begin{cases} 1 & \text{if } marina's\ establishment candidate\ i\ is selected \\ 0 & \text{if } marina's\ establishment candidate\ i\ isnt selected \end{cases}$$

B_k : The restricted value of cost and considered factors

0-1 integer modeling which is considered cost, weighted factors is as following.

The object function

$$Max \quad \sum_{i=1}^{4}\sum_{j=1}^{21} X_i\ W_{ij} \tag{1}$$

The constraint equations

$$\sum_{i=1}^{4} X_i\, W_i \quad \leq \quad B_k, \qquad k=1, ..., 4 \tag{2}$$

$$\sum_{i=1}^{10} X_i \quad = \quad 1 \tag{3}$$

$$all \quad X_i = 0 \quad \text{or} \quad 1 \tag{4}$$

In the 0-1 integer model, the equation (1) which is object function is used to select the most optimal candidate among 4 candidates such as the North port, the South port, the Daebandong area, and the Peace Square sea area. The equation (2) which represents satisfying condition at certain level such as waves, the depth of water, maritime traffic congestion, initial development cost, and sea zone utilization consists of 4 equations. The equation (3) means to select only one candidate. Lastly, equation (4) represents that every variables are 0 or 1.

4. Model application and analysis

The purpose of drawing up model is that finds optimal candidate which satisfies constraints, maximizes weight of object function such as the North port, the South port, the Daebandong, and the Peace Square sea area. The factors weighted for 4 candidates are shown in Table 1.

The concrete case based on previous constructed modeling to determine marina's establishment location is as following.

The object function
Max 189.0x1 + 164.0x2 + 160.0x3 + 170.0x4

The constraint equations
10.0x1 + 8.0x2 + 10.0x3 + 4.0x4 >= 8.0
(The depth condition)
10.0x1 + 8.0x2 + 4.0x3 + 6.0x4 >= 6.0
(The wave condition)
10.0x1 + 8.0x2 + 6.0x3 + 7.0x4 >= 7.0
(The marine traffic congestion condition)
15.0x1 + 9.0x2 + 9.0x3 + 12.0x4 >= 10.0
(The initial development cost condition)
10.0x1 + 8.0x2 + 4.0x3 + 4.0x4 >= 6.0
(The sea zone utilization condition)
x1 + x2 + x3 + x4 = 1
x1, x2, x3, x4 = 0 or 1

Generally, Lindo package is used to obtain linear programming solution. In Lindo, the object function and the constraint equations are entered, then come up with solution. The result of proposed model using Lindo is represented in Fig. 10. In Fig. 10, the optimal candidate which satisfies constraints, maximizes weight of object function among 4 candidates is the Peace Square sea area. The object value which is represented by weight is 189 as shown in Fig. 10.

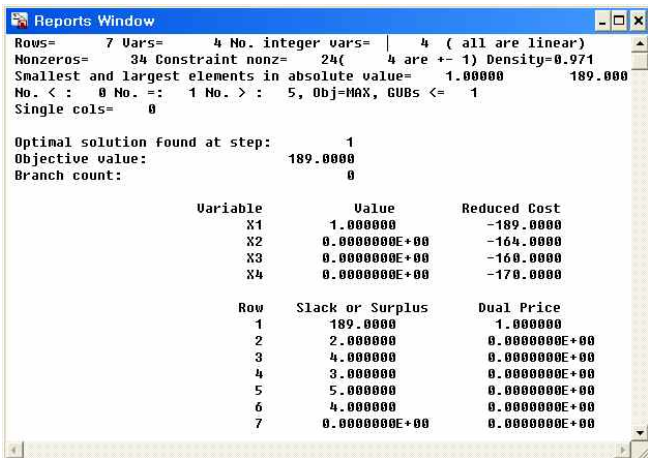

Fig. 10 Lindo package application result.

5. Conclusion

In this paper, to extract the optimal marina's candidate location among the North port, the South port, the Daebandong, and the Peace Square sea area, the mathematical model using optimum spiral method(0-1 integer programming) of the linear programming methods is proposed.

The object function of proposed model in this paper consists of atmospheric phenomena, tide, tide heights, waves, disemboguement, marine traffic, maritime traffic congestion, the depth of water, topography, the spectacle of background, an ocean ecosystem, water pollution, available land of background, lodging facilities, traffic system, parking space, a short period development, a long term development, initial investment cost, sea zone utilization, and fishery rights. Also, the proposed constraint consist of depth of sea area, maritime traffic congestion, initial development cost, waves, sea zone utilization.

This proposed mathematical model is applied to select the optimal marina's establishment location in the Mokpo sea area, the optimal alternative solution which satisfies constraints, gets maximum weight is obtained.

In the future research subject, the allocation problem which the object function and constraints is transformed into cost function will be researched. The mathematical model proposed in this paper will be applied to the marina's establishment candidate selection problem in other places.

References

[1] Agha, S. R.(2006), Use of goal programming and integer programming for water quality management A case study of Gaza Strip, European journal of operational research, Vol. 174, No. 3, pp. 1991-1998.

[2] Byun, S. J(1992), Knowledge based Integration of Process Planning and Scheduling, KAIST. pp. 23-36.

[3] Hwang, J. H., C. H. Park, Y. H. Lee and K. R. Ryu(2002), Crew Schedule Optimization by Integrating Integer Programming and Heuristic Search, Journal of Computing Science and Engineering, Vol. 8, No. 2, pp. 195-205.

[4] Hwang, J. H. and K. R. Rgu(2004), A Hybrid of Neighborhood Search and Integer Programming for Crew Scheduling Optimization, Journal of Computing Science and Engineering, Vol. 31, No. 6, pp. 829-839.

[5] Lee, Y. D., S. K. Kim, J. H. Kim and J. H. Kim(2003), a Multiple objective Mixed Integer Programming Model for Sewer Rehabilitation Planning, Journal of the Korean Operation Research and Management Science Society, Vol. 12, No. 1, pp. 660-667.

[6] Soland, R. M.(1987), Minimum cost Mixtures of Area and Point Defense Assuming Simultaneous Attack, Naval Research Logistics, vol. 34, pp. 337-363.

[7] Yong, S. L., T. N. Cho and S. H. Lee(2000), Design of public-key Cryptographic Algorithm based on Integer Programming, Journal of Computing Science and Engineering, Vol. 27, No. 9, pp. 785-792.

[8] Yoo, B. C. and M. W. Yi(1996), Development of Scheduling by 0-1 Integer Programming, Journal of Industrial Engineering, Vol. 19, No. 38, pp. 269- 276.

[9] Won H. K., H. H. Kim, S. K. Cheng and J. C. Woo(2006), A Forest Management Planning Method based on Integer programming, Journal of Korean Forst Society, Vol. 95, No. 6, pp. 729-734.

[10] Zhang, Y. F., N. Saravanan and J. Y. H. Fuh(2002), A back-propagation approach to the integration of process planning and scheduling for batch manufacturing, International Conference on Control and Automation(ICCA), pp. 164-165.

[11] Zhao, Fuqing, Hong Yi, Yu Dongmei and Yang Yahong(2004),

A genetic algorithm based approach for integration of process planning and production scheduling, Proc. of International Conference on Intelligent Mechatronics and Automation, pp. 484-488.

[12] Park, S. H.(2009), A study on development of maritime transport route for activation of marine leisure tourism in western area of Korea. pp. 2-9.

[13] Yu, H. S.(1982), Introduction of marine Physics. pp. 3-20.

원고접수일 : 2011년 09월 28일
원고수정일 : 2011년 11월 22일 (1차)
2011년 12월 07일 (2차)
게재확정일 : 2011년 12월 26일