Development of the Optimized Algorithm for Quay Wall Assignment Problem in Shipbuilding

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Abstract

In this paper, the optimized scheduling algorithm for quay wall assignment problem was studied. A heuristic algorithm deciding an optimized schedule to assign ships is proposed for improving efficiency and productivity of the quay walls. The result of the proposed algorithm provides reasonable solution for quay wall assignment.

Keywords: quay wall, assignment problem, heuristic algorithm
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I. Introduction

- Quay wall process

  - Launching ~ Sea Trial
    - installing machines/pipelines/electric equipment
    - inspecting whole functions of ship

WC: Work Commence
KL: Keel Laying
LC: Launching
DL: Delivery
I. Introduction

• Importance of quay wall process

- Lead time of quay wall process is increased for new type ship
  - drillship, LNG, FSRU
  - 3 ~ 4 times longer than lead time of general type ship (CNTR)

- Proportion of new type ship in ship production is increased
  - 4 times larger than the past proportion of ship production

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>General Type</th>
<th>New Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead Time of Quay Wall Process</td>
<td>Standard value (X days)</td>
<td>$3 \times X \sim 4 \times X$</td>
</tr>
</tbody>
</table>

LNG : Liquefied Natural Gas
FSRU : Floating Storage Regasification Unit
CNTR : Container ship

- General Type
- New Type
II. Analysis

- Constraints of quay wall process
  - Restriction of quay wall length
    - $\sum$ length of ships $\leq$ $\sum$ length of quay walls
  - Restriction of parallel assignments
    - some ship types DO NOT permit parallel assignments
    - combinations of ship types assigning ONLY themselves in parallel

Develop algorithm for scheduling ship assignment
III. Design

- Two steps of algorithm
  - **Heuristic**:
    - assigning ships to quay walls **DAY BY DAY**
    - applying priority rules for assignment
      : Min. movements of ships
  - **Metaheuristic**:
    - applying **TABU search** method
    - **MIN. non-assigning days**

<table>
<thead>
<tr>
<th>Quays</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
</tr>
<tr>
<td>Quay 1</td>
<td>![Ship]</td>
</tr>
<tr>
<td>:</td>
<td>![Ship]</td>
</tr>
<tr>
<td>Quay m</td>
<td>![Ship]</td>
</tr>
<tr>
<td>Non-assigning ships</td>
<td>![Ship]</td>
</tr>
</tbody>
</table>
III. Design

Metaheuristic algorithm (TABU search)

- Minimize non-assigning days (ships)

![Diagram of the metaheuristic algorithm (TABU search)]
III. Design

Decisions

- Searching neighbor solution set
  - reflecting quay walls that non-assigning ships can be assigned

- Determining size of TABU list and stopping rules
  - by various experiments (instances)

\[ \sum \text{non-assigning days} \]

Applying this value to the algorithm

Size of TABU list/stopping rule
IV. Result

- **Heuristic vs Metaheuristic**
  - movements of ships & non-assignment days are **MINIMIZED**
  - Relatively not so much runtime is spent (10% difference)

<table>
<thead>
<tr>
<th>Schedules</th>
<th>Average movements of ships</th>
<th>Average non-assigning days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heuristic</td>
<td>Standard value (a times)</td>
<td>Standard value (b days)</td>
</tr>
<tr>
<td>Heuristic + Metaheuristic</td>
<td>21.6% reduced</td>
<td>15.1% reduced</td>
</tr>
</tbody>
</table>

**Performance of metaheuristic is effective!!**
V. Conclusion

● **Achievements**
  - Define ship types and priority of quay walls
  - Develop *algorithm*/system with assigning ships to quay walls

● **Effects of study**
  - Productivity of quay wall process is improved
    - make/modify advanced schedule easily
  - Deal with various situations of quay wall process
    - work delay of ships, temporary stops of work process
  - Make efficient operation strategies
    - to manage movements of ships
    & determine the investment of facilities in advance