Production Planning and Measuring Method for Non Patterned Production System Using Stock Cutting Model

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Abstract—The simple methods used to plan and measure non patterned production system are developed from the basic definition of working efficiency. Processing time is assigned as the variable and used to write the equation of production efficiency. Consequently, such equation is extensively used to develop the planning method for production of interest using one-dimensional stock cutting problem. The application of the developed method shows that production efficiency and production planning can be determined effectively.

Keywords—Production Planning, Parallel Machine, Production Measurement, Cutting and Packing.

I. INTRODUCTION

Cutting and packing problems appear under various names, such as cutting stock problem, bin packing problem, pallet container loading problem, knapsack problem, etc. [1]. It can be classified using four characteristics; 1) Dimension start with the simplest, one-dimensional model [2], [3] to the complicated multiple-dimensional model, 2) Assignment of large objects and selection of small items or a selection of large objects and small items, 3) Assortment of large objects having one large object, many identical large objects, few group of identical large object and different large object, and 4) Assortment of small objects having few item of different dimensions, many items of many different dimensions, many item of relatively few dimensions and many identical items [4], [5].

This is an applied research focusing on non patterned production system especially in garment industrials, the small and medium enterprises (SME’s) in Thailand. Their products are made to order, which have arbitrary styles and are changed with the customer satisfaction, the fashion and the season. They also have to face with two important problems of (1) lacking of man power during rice growing season and (2) changing of due date as customer request. These raise the problem in their production planning resulting in the problem of delayed production and late delivery to the customer, consequently. With the nature of such industrial, it is an identical parallel machine system [6], [7]. One worker operates one machine. The work could be planned via the assignment of process to each machine. Such manner could imply the conditions that (1) the whole processes are cut off and assigned to each machine, according to cutting problem [8]-[14] and (2) the processes are packed in the machine, according to bin packing problem [1]. The latter problem is mostly used to determine the minimum number or the maximum capacity of bin. Therefore, this work will apply the stock cutting model to develop the planning method which provides the maximum efficiency for each machine. Such plan should be simple and flexible in order to overcome the limitation of garment industrial such as investment, man power and their potential, customer dependent order, etc. The dimension of the problem of interest will be determined using the definition of working efficiency. Consequently, the simple planning model can be developed from such definition and solved by the stock cutting problem.

II. MODEL DEVELOPMENT

A. Determination of Dimension

If the stock is determined from the whole processes, the complexity will be the difference in stock length since the number of process and order number are different. If the stock is determined from daily maximum working time of machine, this case can be viewed as how to cut the daily maximum or available working time of each machine by assigning the processing time for it. Therefore, processing time will be used as the variable for cutting off or selecting the work for each machine. In this case, theory of one-dimensional [2], [3], [15], [16] cutting [1], [4] and packing [17] problems are applied in planning model.

B. Data Preparation

As the style of product of interest is always changed, the processing time might not be suitable variable. With the nature of industrial of interest, there will be a number of processes used to complete one product but the method of all processes are the same, sewing method. Therefore, by applying the comparative working time determination technique which is the same the working detail, the same the time consumed will be [18], such difficulty is solved. In this case, working data are needed to suitably prepare in the form.
of processing time data structure (the standard process and its processing time). The whole processes used for all products are clearly declared at first, then, the processing time of each process is collected and prepared as the data file. This file will be used as an input of processes required for each product during production planning calculation.

C. Model Development

As discuss previously, maximum or available time of machine can be determined as stock length. Such time is one working day interval which is constant and equal for each machine. In this case, the selection of processing time is suitable since the planning model can be formulated in a simple form.

The maximum the efficiency, the maximum the available time have to be cut off or replaced by assigned processing time. On the other hand, this means that the processing time have to be cut off or replaced by assigned processing time. In this case, the selection of processing time is suitable since the planning model can be formulated in a simple form.

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IV. MODEL VALIDATION AND APPLICATION

A. Validation and Application

The computed plan in Table I was assigned to the production of interest. The number of work in process from each process was counted for the end of working day. It was found that such plan was effective as the production efficiency was achieved at 99%, approximately. The results are shown in Table III. From the table, since the product style is always changed, therefore; the comparison have to be performed between the most similar style and the closed order number. It is found that the production following the plan constructed by model does not only improve the production efficiency, but the number of machine required is also smaller even though an order number is larger. This could provide more benefit as production resources are more utilized.

In reality, the enterprise will have more than one order and more than one customer at a time. From the model, the number of machine required completing each model and the production plan with the best efficiency is determined individually for each one. Applying the total number of machine that the enterprise have and the order due date, the production plan of all order can also be simply determined. In case of the problem of man power changed, the plan is still effective. The enterprise knows the maximum machined used for a specific day and a due date, in this case they can relocate the operator to finish each order whereas all orders can be finished in time as required by customer. The flexible plan can solve the problem of lacking of man power.

B. Production Measurement

Furthermore, the nature of this production is that there will be no finished good at the early stage of production. On the other hand, work in process (WIP) is only presented. In this case, it will be difficult to measure daily working condition comparing to the standardized production system. It is very easy to implement and to understand, flexibly used and cheap to invest. The larger the size of enterprise, the larger the order number and the more the product style will be. The complexity of planning will be increased definitely. The variable might be the same as in this research but the difference among each condition, the difference the constraint will be. This could challenge the future research.

The simple method used to plan and to measure the production of small and medium garment enterprise are developed and used effectively. The application of this work dissolves the problem of late production. Even though it is a singular computed plan but this planning model can provide the most advantage used for SME’s having non patterned production system. It is very easy to implement and to understand, flexibly used and cheap to invest. The application of this work on small and medium garment enterprise are developed and used effectively. The simple method used to plan and to measure the production of small and medium garment enterprise are developed and used effectively. The application of this work dissolves the problem of late production. Even though it is a singular computed plan but this planning model can provide the most advantage used for SME’s having non patterned production system. It is very easy to implement and to understand, flexibly used and cheap to invest. The larger the size of enterprise, the larger the order number and the more the product style will be. The complexity of planning will be increased definitely. The variable might be the same as in this research but the difference among each condition, the difference the constraint will be. This could challenge the future research.

\[ \text{Daily completion time} = \sum_{i}^{n} \sum_{k}^{K} x_{ik} \cdot t_{k} \]  

(9)

Total required time (TOT) for an order can be calculated from an order number and the cycle time of product.

\[ \text{TOT} = \sum_{k}^{K} t_{k} \cdot N \]  

(10)

Then, production condition can be measured thru the work completion using (11).

\[ \text{%completion} = \frac{\sum_{i}^{n} \sum_{k}^{K} x_{ik} \cdot t_{k} \times 100}{\left( \sum_{k}^{K} t_{k} \cdot N \right)} \]  

(11)
### Table II

**Example of Production Planning for Sequential Constraint (Sequence 4 Before 5)**

<table>
<thead>
<tr>
<th>Machine Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Times (sec.)</td>
<td>2789.5</td>
<td>2784.6</td>
<td>2783.4</td>
<td>2781.6</td>
<td>2781.3</td>
<td>2787.8</td>
<td>2786.5</td>
<td>2786.1</td>
<td>2787.7</td>
<td>2788.0</td>
</tr>
</tbody>
</table>

**Average**

- Cmax = 28799.52 sec.

**Figures**

- **Fig. 1(a)** Production Time for Non-Sequential Production
  - Production times (sec.): 28774.95, 28795.68, 28780.2, 28791.68, 28711.97, 28799.2, 28781.2 |

- **Fig. 1(b)** Production Efficiency for Non-Sequential Production
  - Production times (sec.): 28775.57, 28779.93, 28794.86, 28791.25, 28796.1 |

- **Fig. 2(a)** Planning of Production time for sequential constraint
  - Production times (sec.): 28780.78, 28799.52, 28779.93, 28794.86, 28791.25, 28796.1 |

- **Fig. 2(b)** Production Efficiency for Sequential Constraint
  - Production times (sec.): 28780.78, 28799.52, 28779.93, 28794.86, 28791.25, 28796.1 |
ACKNOWLEDGMENT

The authors would like to thank Department of Industrial Engineering, Faculty of engineering, and Thammasat University for their financial and academic support in conducting this research. Finally, this research goal could not be achieved without the help from our case of studies, small and medium size of garment enterprise in Thailand, who would like not to be specifically mentioned here.

REFERENCES


APPENDIX

The processing time (seconds) are: $t_i = 102.9, 63.5, 57.9, 68.34, 74.16, 67.19, 35.84, 125, 66.66, 55.41, 77.5, 150.84, 187.91, 298.34, 21.25, 12.09 52.2, 148.34, 76.25, 49.59, 42.91, 198.75, 107.09, 162.09

TABLE III

<table>
<thead>
<tr>
<th>Condition</th>
<th>Product*</th>
<th>Average efficiency</th>
<th>No. of machines used</th>
</tr>
</thead>
<tbody>
<tr>
<td>current plan</td>
<td>1 order = 120</td>
<td>65.3%</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>2 order = 720</td>
<td>60.7%</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>3 order = 305</td>
<td>80.3</td>
<td>29</td>
</tr>
<tr>
<td>Model plan</td>
<td>1 order = 125</td>
<td>99.94%</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>2 order = 334</td>
<td>99.94%</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>3 order = 305</td>
<td>99.98%</td>
<td>22</td>
</tr>
</tbody>
</table>

TABLE IV

<table>
<thead>
<tr>
<th>Process</th>
<th>ACCUMULATIVE NUMBER OF WIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>DAY1</td>
</tr>
<tr>
<td>1</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>65</td>
</tr>
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<td>5</td>
<td>3</td>
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<tr>
<td>6</td>
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<td>7</td>
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<tr>
<td>8</td>
<td>32</td>
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<tr>
<td>9</td>
<td>125</td>
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<tr>
<td>10</td>
<td>33</td>
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<tr>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>125</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>125</td>
</tr>
<tr>
<td>18</td>
<td>85</td>
</tr>
<tr>
<td>19</td>
<td>125</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>21</td>
<td>125</td>
</tr>
<tr>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>23</td>
<td>125</td>
</tr>
<tr>
<td>24</td>
<td>0</td>
</tr>
</tbody>
</table>

%Completion | 37.19 | 37.19 | 100 |

The authors would like not to be specifically mentioned here.