

The Research of Variable Production Line Into the Cell-line

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ABSTRACT

In order to explore an effective way to reduce the number of tardiness by means of variable production line to the cell-lines, without any increase in cost of equipment and human resources are studied under the premise of through the variable production line to cell-line to reduce the number of tardiness, and improve production efficiency. Proposed tardiness quantity as objective function, equipment cost and manpower cost as constraint of single objective model. In view of variable production line to the cell-line transformation is a NP hard problem, according to the characteristics of the model, small problem of the branch and bound method is proposed. Is verified by a lot of calculating examples, variable production line to cell line can be under the premise of effectively reduce the number of tardiness, and on the basis of experimental results shows how to make the structure of the product unit in order to reduce the number of tardiness.¹

INTRODUCTION

The traditional production model represented by assembly line provides an efficient way for mass production. However, in the face of current production requirements such as short life cycle, unfixed types, mass batches, and small quantity for each batch, a train of issues has emerged for the traditional assembly line due to its low flexibility and large investment. For example, there are extra working stations for the assembly line; the requirements for floor space are high; there is low rate of equipment utilization due to short production period, frequent exchange, and long setup time; the efficiency of operators is low; and there is poor adaptivity to production changes for each production period.

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MATHEMATIC MODEL

Assumptions

- (1) There are I types of production and L batches. Each batch corresponds to one and only product. Also, the size of batches is restricted.
- (2) One batch should be finished in no more than one multichannel. Splitting is not considered here.
- (3) The construction of multichannel is fixed in the whole production process.

Objective Function

$$f = \min \sum_{T'=1}^T \sum_{k=1}^K \sum_{i=1}^I [D_{iT'} - \sum_{s=1}^{T'} (P_{iks} - D_{is})] \quad (1)$$

s.t.

$$\sum_{t=1}^L (ZB_t + TG_t + KS_t) \leq TI_t \quad \forall t, k \quad (2)$$

$$\sum_{w=1}^W Y_{wk} \geq 1 \quad \forall k \quad (3)$$

$$\bullet \sum_{v=1}^V \sum_{k=1}^K X_{vjk} \leq SC_j \quad \forall j \quad 4$$

$$\sum_{w=1}^W \sum_{k=1}^K Y_{wk} = RC \quad (5)$$

$$\sum_{k=1}^K \sum_{q=1}^Q \sum_{t=1}^T Z_{iktq} \geq 1 \quad \forall i \quad 6$$

The minimum tardiness lies in the objective function in equation (1). Equation (2) denotes the constraint for labor time, that is the sum of setup time, passing time, and startup time should not exceed the lead time at the current period. Equation (3) denotes the constraint for the number of operators in k production lines, which means that there should be at least one manipulator at each cell line. Equation (4) denotes the value range of the total number of equipment at the same workplace for each of the cell line, which is no more than the number of equipment at the same workplace in variable production line. Equation (5) denotes the value range of manipulator. Equation (6) denotes the constraint for production distribution in cell line. In equation (1), k is unknown. The decision of objective function is directly related to the decision of X_{vjk} , Y_{wk} and Z_{iktq} . The initial issue is divided into X_{vjk} . Y_{wk} is

called as the issue of multichannel construction (ACL), while Z_{lktq} is called as the issue of multichannel loading (ACF).

ALGORITHM

In the design of production units, assigned to each production unit of product varieties, needs the same amount of manipulator, so, in the whole process, there will be no phenomenon of robot hand didn't work. Transform the input collection of a variable production line into a set of the same beat and different mechanical hands. The above set according to each product the required minimum number of manipulator is decomposed into multiple small collection, namely in every small collection, product have the same number of minimum manipulator is required for each product.

Step 1: we call the collection of the same products for the minimum number of robots required for each product.

Step 2: set the equivalent mechanical hand, within the scope of application program, the following model respectively take the operator number is equal to the number of subsets of manipulator's double, twice, three times, etc., corresponding to beat for the smallest manipulator of the each product number corresponding to the beat of a times, 1/2 times, third times, etc., on the premise of known beats, strives for the objective function, until to 0, remember all kinds of manipulator and the corresponding number of beats and the objective function value. If the number of the manipulator is equal to the number of mechanical hands on the upper level, after merging with the previous layer, execute step 4.

Step 3: put the manipulator for the minimum number of subsets of the manipulator in accordance with the ratio in turn increase respectively with the same number to other subsets of manipulator, the same number of merging equivalent operator set as a new equivalent manipulator. Follow the steps 2, 3. Until synthesize a large set.

Step 4: compare each objective function value to maximize value.

$$f = \begin{cases} 0 & D_{ii} \leq (D_{(t-1)i} - P_{ik(t-1)} - P_{ik,t}) \\ \sum_{t=1}^T \sum_{k=1}^K \sum_{i=1}^I (D_{ii} - P_{ik,t}) + (D_{(t-1)i} - P_{ik(t-1)}) & D_{ii} > (D_{(t-1)i} - P_{ik(t-1)} - P_{ik,t}) \end{cases} \quad (7)$$

The target function is the number of delays. Consists of two paragraph number for this cycle without the delivery of the goods, the second for the number of cycles without delivery in positive represents the production quantity is less than the number of delivery, negative number on behalf of the large number of production and delivery. During the whole process, the number of production is less than the number of delays, and the target function is 0. The quantity of production is greater

than the number of delays, and the target function is positive. The target function is not going to be negative.

$$0 \leq \sum_{i=1}^I P_{kti} * cp_{ik} * Z_{ik} + (Y_k * (Z_{ik} - 1) * T * C \leq TI_t \quad \forall t, k \quad 8$$

The production time of each production line is less than the cycle time.

$$\begin{cases} \lceil SJ_{ij} / cp_{ik} \rceil \leq X_{jk} & \forall i, j, k & Z_{ik} > 0 \\ 0 & & Z_{ik} = 0 \end{cases} \quad 9$$

K production line j work place quantity constraints.

$$\begin{cases} \sum_{j=1}^J \lceil SJ_{ij} / cp_{ik} \rceil \leq Y_k & \forall i, k & Z_{ik} > 0 \\ 0 & & Z_{ik} = 0 \end{cases} \quad 10$$

Operator of K production line.

$$cp_{ik} \geq CM_i \quad \forall i, k \quad 11$$

K production line of the beat constraint.

NUMERICAL EXAMPLE

The paper adopts MATLAB2012 to construct production cells. All the experiments are executed in Microsoft Windows XP with 2GB ROM and Pentium®Dual-Core CPU E5500@2.8GHz.

The specific parameters and number of examples are shown in table 1 and table 2

According to the minimum number of operators required for each product in table 4, according to the above steps, the first step is to divide 10 products into three equivalent manipulator sets. The first equivalent manipulator set consists of cp1, cp2, cp3, cp4, and the minimum number of manipulator required is 4. The second equivalent manipulator set consists of cp5, cp6, cp8, cp9, and the minimum number of manipulator required is 2. The third equivalent manipulator set consists of cp7, cp10, and the minimum number of manipulator required is 1. The optimal solution is solved by the equivalent set of three manipulator. The result is the first line in the table below.

TABLE 1. TEN PRODUCT SEQUENCE DIAGRAMMT.

		<i>QJ1</i>	<i>QJ</i> ₂	<i>QJ</i> ₃	<i>QJ</i> ₄	<i>QJ</i> ₅	<i>QJ6</i>	<i>QJ7</i>	<i>QJ</i> ₈	<i>QJ</i> ₉	<i>QJ10</i>
<i>P1</i>	<i>SJ</i> _{ij}		430	180			480		190	425	
<i>P2</i>	<i>SJ</i> _{ij}						480	666	184	425	
<i>P3</i>	<i>SJ</i> _{ij}	430			424		480			425	
<i>P4</i>	<i>SJ</i> _{ij}	425				240		664		425	
<i>P5</i>	<i>SJ</i> _{ij}		320	315		325				360	
<i>P6</i>	<i>SJ</i> _{ij}		320	530		325					360
<i>P7</i>	<i>SJ</i> _{ij}		450								480
<i>P8</i>	<i>SJ</i> _{ij}			214	215				100		360
<i>P9</i>	<i>SJ</i> _{ij}			230					214		480
<i>P10</i>	<i>SJ</i> _{ij}	460									480
		4	8	8	4	4	6	6	4	4	8

TABLE 2. ORDER OF TEN PRODUCTS IN TWELVE STAGES.

	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T4</i>	<i>T5</i>	<i>T6</i>	<i>T7</i>	<i>T8</i>	<i>T9</i>	<i>T10</i>	<i>T11</i>	<i>T12</i>
<i>P1</i>			330	350	180	180	180	180	180	180		
<i>P2</i>		180	180	180	180	180	180	180				
<i>P3</i>	330	160	160	160	160	160	160	160	350	350	350	350
<i>P4</i>			160	160	160	160	160	160	350	350	350	350
<i>P5</i>	180	180	180	180	180	180	180	180	180	180	180	180
<i>P6</i>	260	260	260	260	260	260	260	260	280	280	280	280
<i>P7</i>			350	220	160	160	160	160	160	160		
<i>P8</i>		120	180	180	180	180	180	180	320	320	340	340
<i>P9</i>	330	320	160	160	160	160	160	160	120	120		
<i>P10</i>	180	180	180	180	180	180	220	220	340	340		

TABLE 3. THE RESULTS OBTAINED.

X_{kj}	f	Y_i	P_{ij}
2 2 1 0 0 2 0 1 2 0	0	4	358 358 180 180 198 198 180 108 0 0 0 0 0 0 178 178 160 160 178 250 358 358 358 182
2 0 0 0 2 2 3 0 2 0	0	4	0 180 180 180 180 180 180 180 0 0 0 0 358 178 178 178 178 178 178 178 358 358 358 172
0 2 2 0 2 0 0 0 2 2	0	4	197 197 197 197 197 197 197 197 197 197 197 190 260 260 260 260 260 260 260 260 280 280 280 273
0 1 1 0 0 0 0 1 0 1	712	2	364 214 184 184 184 184 184 184 184 154 26 0 0 0 0 108 108 108 108 108 108 148 158 302 224
0 2 2 0 0 0 0 0 0 2	0	2	350 220 160 160 160 160 160 160 0 0 0 0 0 120 180 180 180 180 180 180 320 320 340 340

CONCLUSIONS

In this section, we study how to reduce the number of towing by changing the flow line to the product unit without extending the delivery time and the number of manipulator. The contributions of this paper are as follows:

Establish a model with the number of delays as the objective function, and the number of delivery periods and the number of manipulators.

Aiming at the problem of the transformation of the variable assembly line of electronic product assembly line to the product unit, the algorithm is proposed to solve the large-scale case.

Based on a large number of examples, it is proved that the transformation of the variable pipeline to the product unit can reduce the number of delays in the guarantee of the delivery time. The paper gives some Suggestions on how to reduce cost and improve efficiency of unit construction. There are also many issues regarding variable production line conversion, such as the transformation of a variable production line into a multi-channel production line.

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