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Construction Methods for Discrete Production Systems Based on Model of Simulation and Optimization

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Abstract: F Based on the elaboration of the characteristics of discrete production system, this thesis introduces some computer optimization techniques and proposes some ways to build a production system by simulation methods, to combine the optimal production function with the expanded random networks and then establishes the discrete production system. Finally, it uses the simulation and optimization system to model a production system and analyzes the running status of the production system, which provides the basis for the feasibility study of system construction scheme.

Key words: Simulation and optimization, discrete production systems, petri net,bottleneck

INTRODUCTION

Under the multispecies productive conditions, the production workshop is composed of multiple production units (or section) and each unit with several connections such as the material transfer, personnel collection, information transmission and so on. The optimal solution is currently found by heuristic methods and computer search algorithms. The planar adjacent diagram method, proposed by Leung (1992), is a heuristic method. This method uses a graphical way to represent each department with node and the two adjacent sectors can be connected by an arc. Then, using the heuristic method to seek program with the biggest logistics quantity on the arc connecting with the adjacent units. Heuristics can only handle relatively simple layout problems and its optimization is relatively poor. Recent years, many scholars used the intelligent optimization algorithms in computer optimization search process (Meller and Bozer, 1996; Tam, 1992), which effectively improved the facilities layout optimization results. Computer aided facility layout system is easily to result irregular shaped layout program, for which the literature adopts the ratio of the side length and area as the area of the shape constraints (Meller and Bozer, 1997), which may prevent irregular area programs to some extent. This essay is mainly discussing establishing discrete event system mode by using extended stochastic senior judge Petri nets and improving the production system construction by combining with the simulation approach, in order to help the enterprises to shorten the trial period and improve the efficiency of production and operation to obtain greater economic benefits.

PROBLEM DEFINITION

In the operation process of the production system, the material transport costs accounted for 20 to 50% of the production costs (except for the raw material cost), while the rational production system layout can reduce production operating costs by 10 to 30%. The rationality of production system layout has a great significance on reducing the product cost per unit, the effective use of manpower, equipment, space and energy and so on. The main task of the workshop layout is to identify the reasonable location of each unit and the shape of area, so that each unit can be closely connected and to reduce the workload of the material handling during the operation process and to achieve high efficiency, low occupancy and low cast of the operation process (Zhang *et al*., 2004). In the process of the system construction, we need to follow a number of principles, shorten the handling capacity, reduce equipment investment, increase turnover rate of the articles being processed and make full use of the existing space. At the same time, the system must provide the adjustability of the switch. Among the above principles, some cannot be implemented before the system running, which can only complete the construction rely on the designers' experience; however, the uncertainty of the system brings some hidden troubles for the subsequent productions, which will easily cause uneven equipment utilization, reduce the production efficiency. The simulation software can help decorate personnel effectively complete the system layout design and save the operation time and resources.

In equipment layout, according to simulation approaches to ensure the quality for the designs, we have

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considered the followed project schemes. Scheme A: considering more about the products, which adopts assembly line layout to the equipment; Scheme B: considering more about the processing, which adopts machine group layout to the equipment; Scheme C: consider more about the group layout, which adopts mixed group layout to the equipment.

Before constructing the model system, we need to make assumptions according to the reality, which are: (1) The constructed model mainly takes mechanical processing, not including other processing operations.(2) Assembly ability is sufficient or have other storage measures, no retention of components. (3) the workers are enough for every process, so production halts will not happen because of the lack of no worker operation; in reality, the workers are in demand; Raw material supply is adequate, so work will not hold up for lack of material; in the producing process, raw material supply is affected by market fluctuations;

Scheme expositions: The objective function of the spatial arrangement of the production system with many forms, the commonly used are: logistics transportation cost minimization and comprehensive index optimization. The constraints included in: workshop area and its shape, size and shape requirements of the production units and the production units with special requirements on location. The adjacent unit material transportation cost maximization, is essentially a simplified form of the objective function of the total transportation cost minimization. Such an objective function ignores the impact of logistics between non-adjacent arranged units on the transportation costs, thus the optimizing results have some limitations (Zhang *et al*., 2004).

The constraints on logistics transportation cost minimization included in: logistics volume between units $lv_{i,j}$; transportation costs between units $tc_{i,j}$; distance between units $td_{i,j}$. The objective function model about material transport costs to maximize between units are:

$$\max \sum_{i=1}^{m} \sum_{j=1}^{n} lc_{i,j} tc_{i,j} x_{i,j} \quad (1)$$

The objective function model about total material transportation cost minimization are:

$$\min \sum_{i=1}^{m} \sum_{j=1}^{n} lc_{i,j} tc_{i,j} td_{i,j} \quad (2)$$

Material transportation cost objective function of the model considers the workshop internal transportation workload, without considering the material from the shop entrance to the outlet of the fixed transportation work, so the actual optimization effect affected (Zhang and Liu, 1999).

As the selected production system is of a certain scale, the annual output can be forecasted and determined in terms of the market demand; From the foregoing assumptions, the system will not appear low utilization rate of equipment caused by non-arrangement factors; Therefore, when choosing equipment, the general ones are given priority and can be used coordinated with special equipment.

Before carrying on the system building, we need to draw up the process route and determine the cutting parameter first in terms of the specific accuracy requirement of the components. Then calculate every norm of working hour in every working procedure and the quantities after summarizing various kinds of working procedures in combination with the selected equipment required. Other auxiliary parameters should be referred to related standards.

PARAMETER CALCULATION

Confirming the equipment number: The number can be calculated from the formula. It is clear that the key data is the machining time for one piece. Before calculating the machining time for one piece, we have to confirm the parts processing technology and the cutting data.

The symbolic meaning in the process of calculation shown in Table 1.

The cutting data calculation for the rough machining:

- The end-surface 1 cutting: $a_p = 3.0$ mm, $f = 0.35{\sim}0.65$ mm r^{-1}, take $f = 0.5$ mm r^{-1} and get $v = 80{\sim}100$ m min^{-1}; take $v = 80$ m min^{-1}, $n = 1000v\ \pi d^{-1} = 90.43$ r/min;according to the machine tool standard speed, we choose $n = 100$ r min^{-1};so $v = \pi dn/1000 = 95.65$ m min^{-1}

The basic time T_j can be chosen for the formula according to different machining route such as the basic

Table 1: Two symbolic meaning

Nomenclature	
a_p	Depth of a cut
f	Feed
V	Cutting speed
T_d	Single job processing time
T_f	Auxiliary processing time
T_{fw1}	Work location technology business hours
T_{fw2}	Work location organization business hours
Tx	Rest time
T_j	Basic processing time
T_d	$T_d = T_j+T_f+T_{fw1}+T_{fw2}+T_x$

Table 2: Collection of equipment number and shifts

Size	No.	Shifts	Adjusted no.
CDE6140	42	2	21
CJ0625	7	1	7
C6140A	24	3	8
X5036B	16	2	8
B6066	4	1	4
Z35	4	1	4
ZQ3040	4	1	4
MYS250	16	2	8
XH7132	6	2	3

time of turning $T_j = (L/f^*n)^*i$ and other auxiliary times can be taken by the rete base on the basic time. After collecting all the production time for each piece,the required number of the equipment will be calculated. Table 2 shows the final calculation and the result after adjustment of the shifts.

Analysis of the layout: Here are the layout characteristics for the three above-mentioned layout schemes.

- **Scheme A:** In layout process, on the basis of the craft principle, arrange the similar equipment and personnel intensively, such as lathe, milling machine, which is helpful to adjust the equipment and personnel and increase the flexibility of the system
- **Scheme B:** In arrangement process, based on its shape and the craft similarity, code and group the work pieces in processing --- process the components in the same group by similar technology, arrange the equipment into group and divide the whole system into several groups of manufacturing unit, which can improve the utilization rate of equipment, reduce logistics quantity and the processing time
- **Scheme C:** In layout process, based mainly on the product principle, set up different assembly line of different functional components respectively and configure the required equipment, personnel and material in terms of the order of the processing in order to meet the requirements of the product on time and space to the greatest extent

The production line on research has a complex structure. It is a complete artificial system of logistics, processing, dispatching, which is dynamic and complex. From the point of view of the dynamism, this system belongs to discrete event dynamic system, which has certain uncertainty. The main determiner on the behavior of this system process is a group of discrete events. In general, the discrete event system can be modeled according to the ordinary Petri net, which usually makes the model very large. Therefore, this essay chooses the E-N modeling.

MODEL BUILDING

Definition of E-N: The major advantages of E-N are:

- In order to make the tokens convenient for users to observe and do performance analysis and convenient for FMS scheduling simulation as well, we defined dual token and dual identity into E-N
- Dispatch principle is brought in E-N to improve its reasoning and decision making. Here is the definition, E-N can be defined as a 16 tuple:

$$EN = \{LC, T; A, C, CM_0, DI, F, I, K, M_0, I_-, I_+\}$$

Establishing E-N model: To model the existing production line, we need to express all the state changes of the machines, but most machines have similar state change. Due to the limited length of this essay, we only give only present E-N model between three equipment, E-N models between other equipment are just its expansion cascading. Fig. 1 is the E-N relation model of machines.

SIMULATION STUDY

Establishment of the simulation model: For discrete manufacturing system, the common influencing factors include: component arrival time, component setup time, component processing time, average trouble-free working time and the average repairing time.

Arrive time: In the actual production process, materials for processing during the flow production line depend on the inventory. From the foregoing assumptions, in the process of the simulation, it will not be affected by inventory. To be consistent with the actual to meet its mode, arrive time is defined to obey the exponential distribution of 180 second parameter in the model.

Setup time: The setup time of the components is greatly influenced by the workers' fatigue strength and operating proficiency. Therefore, in this model, a definite value 45 sec is set up based on the actual production estimates, which simplifies the difficulty of building the model to a certain extent, but increases certain errors.

MTBF and MTTR: Both MTBF and MTTR happen randomly. Through collecting data to establish a reasonable analysis interval, frequency and cumulative frequency, etc., similar probability distribution fitting can be found. It is supposed that the parameter conforms to the common normal distribution in the essay.

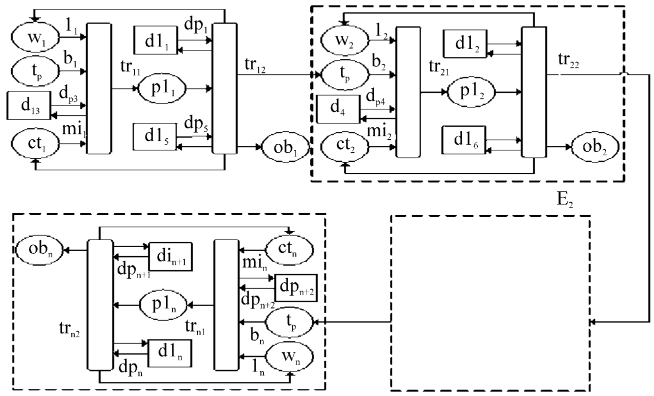

Fig. 1: Relation model of E-N

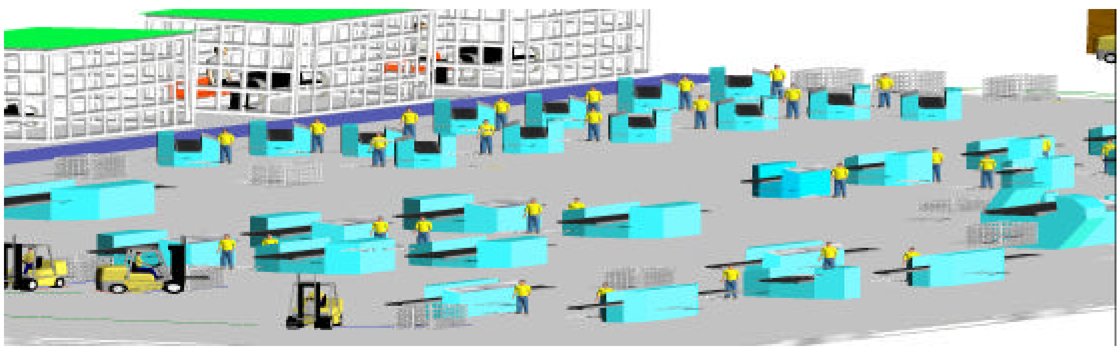

Fig. 2: 3D simulation gram

In terms of the above conditions, build the models of three different schemes respectively, the No. 2 3D simulation gram is shown in Fig. 2.

Scheme selection and analysis of system running status: After running 105000 unit of time, we checked the running status of equipment one by one and analysis the comprehensive running status of the system, Scheme B had the highest and optimal system integrated index. When we checked the running status of Scheme C, we found most of the equipment utilization rate achieved an acceptable level, a small number of equipment utilization rate was low and even caused production bottlenecks, for instance.

In summary, the three abnormal states in the initial program, haven't affected the current production plan and they are acceptable. Considering from an economic aspect, the number of ZQ3040 equipment can be reduced. Considering from the aspects of the system flexibility, the status can be maintained or increasing the number of the corresponding equipment in the downstream of blocking device.

CONCLUSION

In this essay, we mainly solved the following problems: (1) Established a discrete manufacturing system E-N model. (2) Presented the method for the comprehensive utilization through simulation approach to measure the production system; (3) Employed simulation system tools on the basis of real examples, to analyze the system running state, which provided the basis for feasibility study of the system construction scheme and it will also provide decision support for the construction of the production system.

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