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Conceptual Fixture Design Method Based On Petri Net

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ABSTRACT*: Fixture conceptual design is based on the analysis of the required functions and requirements, on the basis of establishing the function of the fixture structure model, then carries on the function decomposition and allocation, to generate the design constraints of fixture layout and structure, finally it is concluded that reasonable fixture function structure diagram output. Fixture conceptual design is the whole fixture design automatically decide the key stage of technical and economic benefits in the process. This paper based on Petri net model and simulation method study, and put it into the fixture conceptual design. With a brace of fixture design methods as an example, at the same time, using the Petri net .model simulation software CPNtools on the technical process model and simulation of fixture design, Eventually effective method prove that Petri net has worked well in the fixture conceptual design.*

Keywords: *conceptual design; fixture; Petri net;*

I. INTRODUCTION

Scientific, reasonable and machining of fixture design can effectively guarantee the quality, improve the production efficiency, reduce the workpiece production cost. Once a fixture conceptual design, the designer should be more clear design task, determine the fixture structure scheme, determine the dimensional tolerance and technical requirements related to the fixture and drawing fixture assembly drawing and part drawing, improve the quality of fixture design, guarantee the quality of the workpiece. But now in conceptual design theory research is less.

Now mainly in Guangdong university of technology Lili Jiang [1] Fixture conceptual design based on polychromatic sets theory research. By using polychromatic sets theory fixture conceptual design model and generate a polychromatic graph. Use the fixture conceptual design polychromatic graph and the algorithm of polychromatic sets, find out all satisfy the constraint conditions of path and possible design scheme. Guangdong university of technology Hangjun Chen[2] use the Analytic Hierarchy Process (AHP) method in fixture conceptual design. it is concluded that accords with index to optimize the best solution On the basis of a series of optimization index, from multiple feasibility scheme optimization one. Harbin industrial university, Gaoliang Peng[3]was proposed based on rule reasoning (RBR) and case-based reasoning (CBR) method for processing and fixture design, the method of integration system based on VR. In this method, combining RBR and fuzzy comprehensive evaluation method is put forward reasoning appropriate positioning scheme and positioning function. According to the result of reasoning CBR method and machining fixture design.

This paper put the Petri net .model and simulation of a fixture conceptual design method. Petri net is a kind of distributed system .model analysis tools, particularly suited to describe the order between each process in the system or components, concurrency, conflict and synchronous structure relations. It can not only describe the structure of the system, but also can be used to simulate the dynamic behavior of the system. It has become a powerful graphics oriented .model language, at the same time has a strong ability of dynamic analysis, is an ideal model for process .model tool, so the Petri net working process of the fixture system model is established for the guidance of fixture conceptual design to provide efficient and reliable.

II. THE PROCESS ANALYSIS OF BRACE

2.1 The analysis of brace's structure

The brace (Fig 1)is a complex irregular part and made from an aluminum alloy casting, which includes the head, neck and lower. The head is a circular flat stepped surface layer and the neck is truncated cone and the lower is triangular prism. The center of the three part are paralleled. The head connects the lower through the neck, which is positioned above the edge of the lower. The section of the neck is segments and the straight edge flush with the bottom. The other side of the head protrudes the neck and there are two outwardly projecting rounded ribs between the projections and the bottom surface side of the neck. The other two corners of the lower paralleled to the centerline, which outwardly projecting a cylinder. The outer edge toward the cylinder bore opening through the long grooves, which makes the middle of the through hole can connect with the outside. By the support frame on the bottom surface to the outer projecting rounded oblique cut at the lower edges of the head just below the cut surface triangles. The brace as shown in Fig 1.

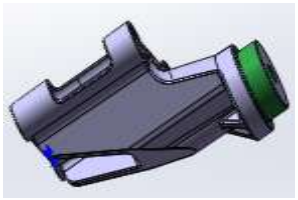


Fig 1 The brace parts

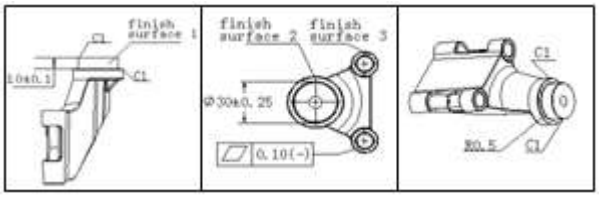


Fig 2 Analysis of the brace parts

2.2 The processing requirements of brace

In the actual production, the requirements of this piece not only quick and easy clamping position in machining centers, but also in the process strictly to ensure both its size and shape precision. Quick and easy clamping positioning means positioning with two holes to strengthen the positioning ribs at the head ,which can quickly locate their position in the alignment fixture above, to enhance efficiency and reduce costs. The surface to be machined expertly including the diameter of the head machined surface (surface 1) of the brace machined surface(surface 2) of the brace's top vertical distance as shown in Fig 1. Shape precision including a round table chamfer piece of the head, and the transition arc junction (R0.5) between the machined surface (surface 1) and the machined surface (surface 2) and the flatness of the machined surface (surface 3). Ensure accuracy of content, which can make its assembly parts with higher reliability and stability[4]. Specifically as shown in FIG 2.

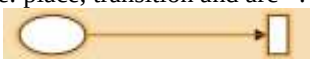
III. PETRI NET THEORY

3.1 The introduction of Petri nets

In 1962, The first time to put forward a kind of used to describe the physical process and the combination of the physical system network model said "Petri net" in "Kommunikationmit Automaten" by German scientists CarlAdnalPetri. In the early 1970 s, Petri net has its unique feature, gradually got the attention of European and American scholars, and many scholars studied it ever since. Currently Petri net has expanded into a variety of forms, such as basic Petri net, time Petri net, Colour Petri net, Fuzzy Petri net, Hierarchical Petri net, its expression ability is becoming more and more strong, Petri net has become a powerful graphics oriented .model language, at the same time it has a strong ability of dynamic analysis, and it is the preferred .model tool for process .model, This paper adopts Petri net and extension Petri net as the product development process .model and analysis tools, This chapter in Petri net and its extension and classic work inside do a simple introduction, they are used in subsequent chapters, Petri net and the foundation of the workflow.

3.2 The basic knowledge of Petri nets

A Petri net structure elements include: place, transition and arc[5].



Place arc transition

The place is also calls the position, but the position is abstract, not the resources property. It is to describe the system may be local state. Transition is used to describe the changing system events, it represents a kind of resource interaction relations of events. Arc is said resource consumption and production, is used to describe state transitions between the local state of development to the event. The most simple net is Fig 3. Right is another concept ,it describe the need resource of transitions Fig 4.

Token in this paper with inside the circle and numbers, is another concept in Petri net model, it beside with the place in circle, it indicates that the place is the amount of resources, is an attribute of the place. In the place of the dynamic changes between different states of the system, the dynamic behavior of Petri net model is refers to the rights problems, Fig 5 describe it has the occur right, Fig 6 describe it can't occur.

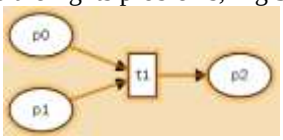


Fig 3 The simple net

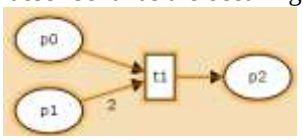


Fig 4 The net with right

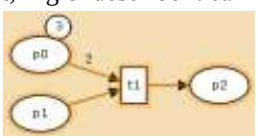


Fig 5 The net can occur

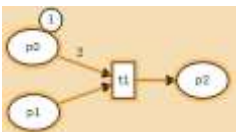


Fig 6 The net can't occur

3.3 The basic concept of Petri net definition

3.3.1 Definition: directed net[6]

Directed net of triples N = (P, T, F); if the following meet three conditions is called a directed Petri net, referred to as P is a Place, T is a transition, F is the net flow relation.

$$P \cup T \neq \emptyset \wedge P \cap T = \emptyset. \quad (1); \quad F \subseteq P \times T \cup T \times S. \quad (2); \quad dom(F) \cup cod(F) = P \cup T. \quad (3)$$

where " × " means Cartesian product. $dom(F) = \{x|\exists y : (x,y) \in F\}$; $cod(F) = \{y|\exists x : (x,y) \in F\}$. (1) P and T is the collection of don't want to joint. (2) means the arc only found in place and transition, there is no arc between any two places or transitions.

3.3.2 Definition: subnet

Suppose N1 = (P1, T1, F1), N2 = (P2, T2; F2) are two nets, N1 are subnet if and only if $N1 \subseteq N2$, $T1 \subseteq T2$ and $F1= F2\cap((P1\times T1)\cup(T1 \times P1))$.

3.3.3 Definition: the input set and the output set.

For N = (P, T, F) as the directed net, $X= P\cup T$ called the Net element set . For any $x \in \in X$, $*x= \{ y| y\in X \wedge (y, x)\in F\}$called the input set of x, $x^*= \{ y| y\in X\wedge (x, y)\in F\}$ called the input set of x. For $x\in T$, then $*x\cup x^*$ called the extension of x.

3.3.4 Definition: Petri net system.

Make Σ = (P, T, F, K, W, M0) for net system, M is the logo of (P, T, F) , $t \in T$. N = (P, T, F) a directed net , called Σ base net . K is N the capacity of the function. W is the weight function on the N. M is capacity function allows identifier, called the initial identification.

1) where t have occur right in M: $\forall P\in {}^*t$; $M(P) \geq W(P, t) \wedge \forall P \in t^* : M(p) +W(t, p) \leq K(p)$.
2) it has the right to occur in the M can occur and will instead of M of M,' M '$\forall P \in (P)$ is given by type, namely:

$$M'(P) = \begin{cases} \{M(p) - W(p,t), P \in {}^*t - t^*\} \\ \{M(p) + W(t,p), P \in {}^*t - t^*\} \\ \{M(p) - W(p,t) + W(t,p), p \in {}^*t \cap t^*\} \\ M(p), p \notin {}^*t \cup t^* \end{cases}$$

3.4 The important property of Petri net

3.4.1 Order relationship: Event e1 e2 in modal c conditions with order relation is $c[e>c' \wedge c'[e2>\wedge \neg c[e2>$, that is, e1 in c have right and e2 have no right , but after the occurrence of e2 , e1 occurred subsequent modal c ' rights . As follows: Fig 7.

3.4.2 Concurrent relationship: Event e1 and e2 in modal c concurrent conditions are e1 and e2 independent each other, and are in c have rights, that is $(*e1 \cup e1*)\cap(*e2 \cup e2*) =\emptyset \wedge c[e1>\wedge c[e2>$. As follows: Fig 8.

3.4.3 Conflict relationship: Event e and e ' in the modal c conflicts (conflicts) is the condition of e and e' in c both have occur right, but not {e, e} 'c and released, $c[e>\wedge c[e'>\neg c[\{e, e' \}>$. As follows: Fig 9.

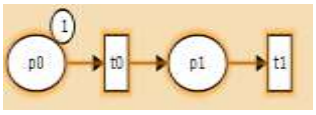


Fig 7 Order relationship

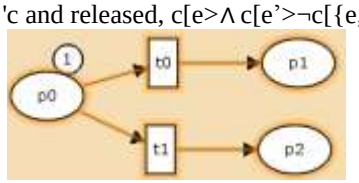


Fig 8 Concurrent relationship

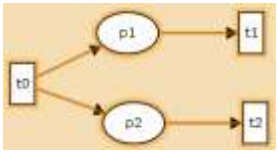


Fig 9 Conflict relationship

IV. PETRI NET MODEL

Now put the brace of Fig 1 as an example, the method based on Petri net to start conceptual fixture design (Fig 10). According to the fixture design process procedures, Clamping workpiece process procedures and processing unit of the clamping process procedures, and using Petri net .model method, on the basis of CPNtools software, to start .model the net. CPN Tools is a tool for editing, simulating, and analyzing Colored Petri nets. Its operation is unique and easy . .model as shown:

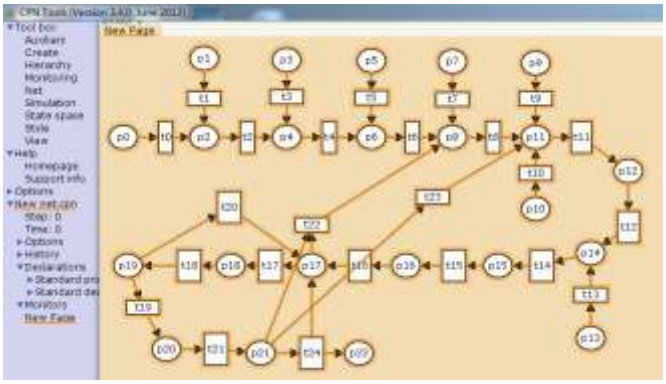


Fig 10 Petri net model

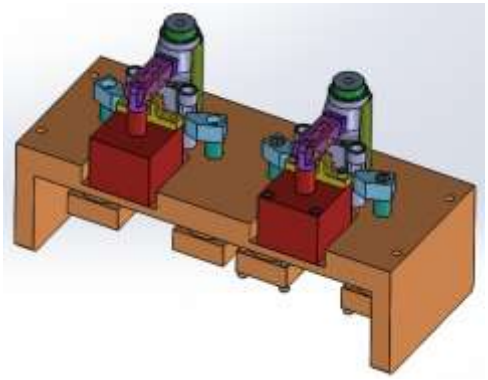


Fig 11 The fixture 3D model

symbol	instruction	symbol	instruction
P0	the part information	P12	Fixture parts layout
P1	parts of tolerance analysis	P13	The cutting tool library
P2	The characteristics of the tolerance relation group	P14	The selected cutting tool
P3	Manufacturing resources capacity model	P15	Processing order to determine
P4	The characteristics of the manufacturing resources ability groups	P16	Check machine capacity
P5	Preference constraint knowledge base	P17	NC code
P6	Locating datum	P18	The cutting tool path generation
P7	Machine tool library	P19	Determine whether to eliminate interference
P8	The selected machine tool	P20	Cycle time calculation
P9	The fixture library	P21	Determine whether the time is in line with expectations
P10	Fixture parts design	P22	End of the design
P11	Fixture holder		

Table 1 The symbol and instruction

Based on the above analysis and the Table 1 , the workpiece clamping P0 technical process of input and output information in P1, through the analysis of the parts of tolerance to build relations between the P2 tolerance feature set. Then according to the computer aid fixture design ability of manufacturing resource model group P4 P3 to build manufacturing resource capacity characteristics, using computer aided fixture optimization constraints libraries P5, P6 for locating datum design. According to the machine tools library P7 selected P8. Then go to the step of the fixture library to do two things, first, According to the analysis of the above selected P10 fixture parts, inside the fixture base to select good P11 fixture holder. In view of the above selected parts to optimize the layout of the parts P12, Next is the selected cutting tool, the appropriate cutting tool in cutting tool library P13 chosen P14. Behind the P15, determine the processing order to calibrate the ability of NC machine tools P16, Next is for NC code P17, considered in cutting tool path generation P18. In view of the above various selected, judge whether there is interference P19, calculate the cycle time of P20, if in line with expectations P21 ,P22 is ended, if not in line with expectations modify P8 selected, machine tool fixture parts and the selection of base P11 to further optimize and eventually meet fixture model in order to achieve the aim.

To show visual positioning components, design and operation of specific parameters rationality, using the software Solidworks to build 3D model of the brace of fixture[7, 8, 9], then find out the design is not reasonable place in the .model , according to the design process and then feedback to the design process[10]. To optimize the unreasonable places. Ensure that actual production fixture with high precision, high efficiency, good maneuverability features. As shown: Fig 11.

V. CONCLUSIONS AND SIGNIFICANCE

Fixture manufacturing high-precision mass production in our country plays an important role, fixture conceptual design using Petri nets design development process model is presented in this paper. it described a complex product design and development process and simple graphics with image column. If given a positive integer to each change in t time d (d said change requires constant time), the model also became a delay Petri net model. It can be seen from the Petri net model and the simulation results:

1)the product development process model is established based on Petri net ,It can not only describe the connection of product development input, output relationship but also can describe the product development input, output, so build a more comprehensive description of the product development process;

2) The product development process model is established based on Petri net ,At the same time, it can use Petri nets quantitative simulation performance, such as time, cost of the product development process quantitatively analysis;

3) It can build synchronization with product development level of the product development process model, so as to realize a dynamic description of the product development process and dynamic quantitative analysis.

For different complex curved surface parts should be further development and promotion, through the parts of fixture design, according to the results of calculation and practice verification, the design of fixture satisfies the requirement of workpiece machining accuracy. Implemented two parts processing at the same time, in the case of guarantee accuracy and save the cost and improves the efficiency for similar complex surface more products processing has a certain reference value.

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