AN EFFICIENCY MODEL OF MULTISTAGE ELECTROMECHANICAL MACHINES

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Abstract: This paper presents an efficiency model of multistage electromechanical machines design. The aim of design and redesign can be got by analyzing the rhythm of work with the model.

Key words: efficiency model; multistage; electromechanical machines.

1. INTRODUCTION

With the development of science and technology, multistage electromechanical machines become more and more favorite in market. How to harmonize these machines' working rhythm and optimize the structure becomes the focus of the design. This paper presents an efficiency model and put it into practice.

2. SYSTEM BALANCE & OPERATION CYCLE

2.1 One-piece Flow Production Theory

Supposing an equipment is composed of n sub-components which contain one or several operation cycles for each one, and make an part needs time: Time; the theory time is Ti of every sub-component. The efficiency model:

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$$\text{Time}=\sum_{i=1}^{n} k_i T_i c_i^{-\lambda_i}$$

$$\begin{cases} 0 < k_i \le 1; \\ c_i > 1; \\ \lambda_i = \begin{cases} 0(\mathit{improved}) \\ 1(\mathit{unimproved}) \end{cases} \end{cases} \tag{1}$$

The k_i is rhythm parameter and stand for the harmony of sub-components' operation cycle; λ_i is the developing parameter of sub-department; c_i is the developed sub-component efficiency parameter, which shows performance of the sub-component.

There are two ways to raise the working efficiency of a machine according to the model: 1. Developing k_i. We can optimize the rhyme basing on the old machine, which is seldom happen in practice, or developing one or several sub-components' structure. 2. Parameter c_i. This parameter can be raised by redesign the sub-components. Parameter k_i cares of the macroscopical development of machine, while c_i pay attention to some sub-component's development. We use k_i to develop a machine as soon as c_i will show the changing tendency, which can direct our redesign. The value of c_i should be tested by k_i, and make sure whether it is appropriate. All of these will affect the machine development. The two parameters have a close relationship, and have a influence on the other, which lead to the optimization of the system.

3. APPLICATION

"Fully Automatic Crimping Machine" is used to process wire, just as picture 1 shows. The description of process can be subscribed: crimping the both ends exodermis of wire, then stamping the both ends. According to this process and the other situations, the machine should include 7 sub-components: Neatened Component, Sending Wire Component, Tool Post, Stamping Component (2), Back Crimping Component, and Taking Products Component. Every one of them has about one or several operation cycle but Neatened Component. The picture 2 shows the machine's operation cycle. The rhythm of these operation cycles is key factor of successful design, which is the main mission of redesign. The paper will analyze parameter k_i

at first in order to get preliminary optimizing the system; then computer parameter c_i, At last, we can get the aim of this design and redesign.

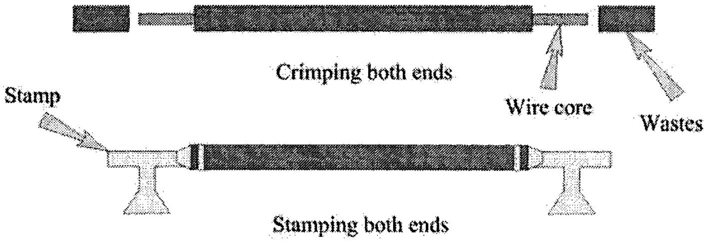

Figure 1. processed wire

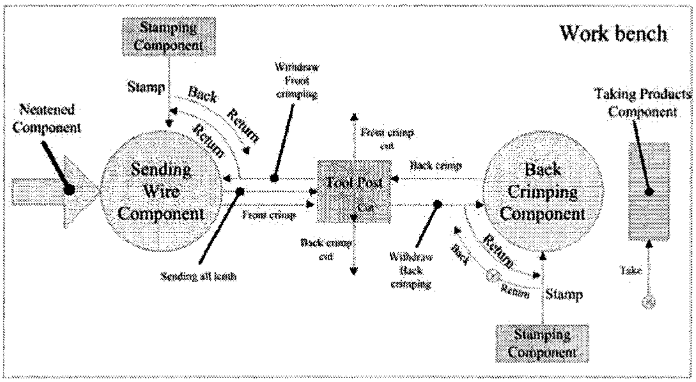

Figure 2. the old Fully Automatic Crimping Machine's operation cycles

3.1 k_i in products' optimization

Picture 2 shows the machine's operation cycle. This machine can be seen as front and back parts according to its' structure and the wire processed. The picture 3 shows the synthetical rhythm that can be got after analyzing the machine's operation cycle. It's clear that processing the first wire end time (this process happens in Sending Wire Component, for short: FC, Front Crimping) is overlap with the second wire's top (this process happens in Back Crimping Component, for short: BC, Back Crimping), and the end must wait for the top for a while form the picture. The Sending Wire Component has lots of potential to use after analyzing it's work ability. This problem can be easily resolved if crimping the first wire's end and crimping the second wire's top are done at the same time. So we should study the Tool

Post and try to give it a development. If the Tool Post contains three tools, other than one, this situation will happen and the Tool Post running ability has not a raise. The machine's rhythm just as picture 4 and the development is cycled by long and two short dash line now. The description of developed operation cycles in detail: the old Tool Post's top crimping and end crimping can be processed by one operation cycle; the sending operation of Sending Wire Component and Back Crimping Component can be completed at the same time (this operation cycle is named Sending wire); the draw back wire operation cycles of Sending Wire Component and Back Crimping Component happen simultaneously (named as: Withdrawing wire). The synthetize of operation cycles is showed in picture 5. Now the running burthen of Sending Wire Component is same as Back Crimping Component, which optimizes the machine's process rhythm and leads to efficiency rising.

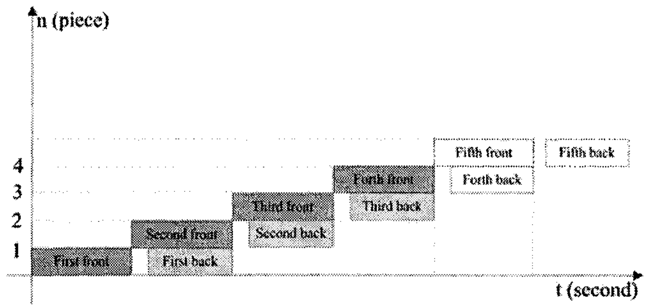

Figure 3. the preliminary synthetical rhythm

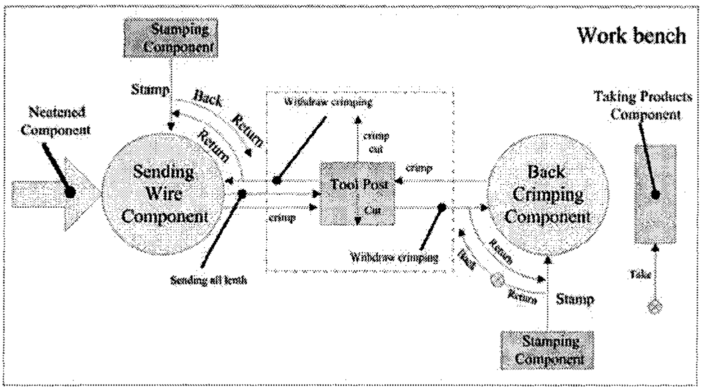

Figure 4. the developed Fully Automatic Crimping Machine's operation cycles

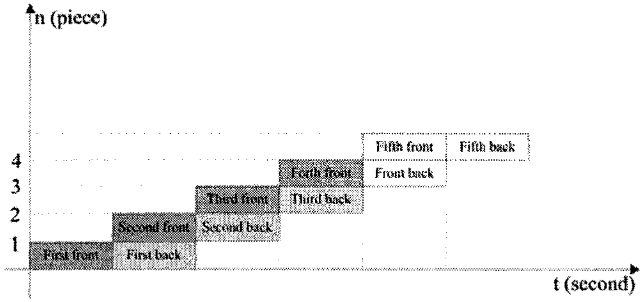

Figure 5. the developed synthetical rhythm

3.2 Parameter c_i analyzing

Analyzing the performances of every sub-components, we can get their detail stage-time bar, bar 6(Note: ① the same color belongs to the same component; ② Stamping Component and Tool Post's half operation cycle is useful to process). Based on Sending Wire Component, study the Stamping Component and Tool Post's operation cycles, and compare their relation with the system.

Stamping Component:

Process ability of theory:

$$2T_1=2/3s/cycle$$

The other sub-components' time:

$$t=0.010+0.286+0.015+0.045+0.015+0.045+0.010=0.426s$$

Compare:

$$2T_1>t$$

Tool Post:

Process ability of theory:

$$2T_2=0.027s/cycle$$

The other sub-components' time:

$$t1=0.045s;$$

$$t2=0.045+0.010+0.335+0.010+0.286=0.686s$$

Compare:

$$2T_2<t1, \ t2$$

It can be get that Stamping Component affect the machine's process efficiency from the above result. So the next step: developing Stamping Component, increasing parameter c_i, and optimize parameter k_i again, in order to harmony system's process rhythm.

Every parameter of the Model has a close relationship between them, which shows in the above study. When one parameter changes, the other parameters will show their trends of changing, that gets the design better.

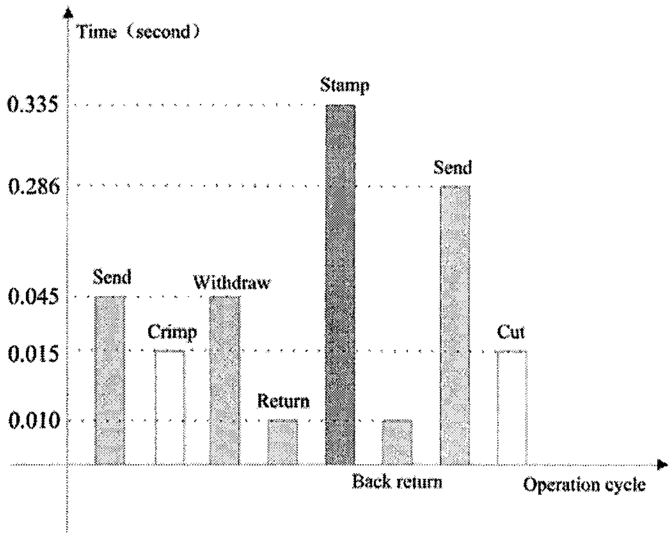

Figure 6. the detail stage-time bar Case Study

4. CONCLUSION

The project of Fully Automatic Crimping Machine Design has been completed by using this Efficiency Model, which direct this design and redesign.

5. REFERENCES

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