OPTIONS FOR SYNCHRONIZING BUNKER DEVICES OF DIFFERENT TYPES, FLEXIBLE SUPPLY ASSEMBLY CENTRES

Ivan Shopov

Summary: *An important trend in the development of tools for the automation of assembly processes is a study of the principles and relationships to design the assembly centres. Since in the assembly centres concentration and combining different assembly operations are used it is necessary hopper feeders with different principle of action (as vibration and mechanical) to operate synchronously. The task is placed and a solution to the problem of synchronization of vibration bunker feeder (BF) and mechanical (Gate) feeder was found.*

Keywords: synchronization , bunker feeders , assembly centres

Introduction

Automation and comprehensive mechanization of assembly processes are the most backward in comparison with other phases of production processes in mechanical engineering. Labor intensity of the assembly processes in the country is on average of 25-40 % of the total labor intensity of the manufacturing process , and its duration occupies 40-60 % of the overall productivity of the process. (1)

An important trend in the development of tools for the automation of assembly processes is a study of the principles and relationships to design the assembly centres.

Assembly centres are means of wide versatility, with a large degree of concentration and reconciliation of the operations. Assembly centres also allow to be carried out the assembly of units, consisting of a large number of parts, wherein the nomenclature and their sizes may be changed. (2)

By means of an assembly centre different operations may be performed automatically - handling details, connecting by different methods, orientation.

A particularly important feature is the orientation of the details, because the ability to build a system to automate the flow of parts depends on it. Since concentration and combining different assembly operations are used in the assembly centres, it is necessary bunker feeders with different principle of action (as vibration and mechanical) operate synchronously.

The problem of synchronization of bunker feeders with different operating principle has not been studied and described in the literature for automatic assembly. The refore that is of a special interest.

Place of the feeders in the structure of assembly centres and requirements to them

In the assembly centres are included various devices such as feeders, transport systems, shops, valves, basing devices, industrial robots, assembly devices (tools) systems for changing the catchers and the tools.

There are different ways of organizing robotic assembly centres. Here they are classified in terms of the presence and the position of the feeders.

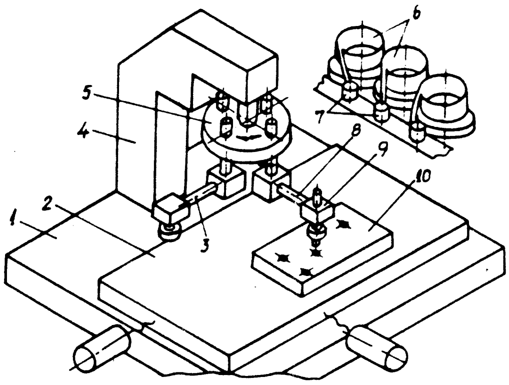

Fig.1 *Assembly centre containing a group of orienting devices*

Figure 1 (2) shows an assembly centre containing a group of orienting devices. It consists of a table with two coordinates and a based part 10 positioned on it. Assembling tools are in the tool shop 5 attached to the stand 4. The role of operating mechanisms is played by the mechanical hands 3 and 8. The transfer of the parts to the work item is done by manipulators. The orientation of the parts occurs in a group of bunker devices 6, in the outputs of which valves 7 are placed.

The feeders of the bunker type sometimes complicate the structure of assembly centres. When composing products with a large number of parts, the many feeders increase the volume of the centre, and the vibrations caused by the working movements can worsen the conditions for carrying out the assembly process. In this case, a group of shops is positioned in the assembly centre and the feeders are put outside the structure of the assembly centre and are a separate complex cassette unit.

Figure 2 shows a centre of the company Fuji (Japan) for mounting electronic components on print circuit boards. The pivot has a rotating faceplate with 8 working heads that consistently grip the elements and fit them into the print circuit board on the place given by the program. The circuit boards are 25 and are arranged horizontally in stores and they are passed to the workbench . The elements are arranged in bands in the rotor shop. It is provided automatic search for the required element , extracting of the item from the band , forming his ends and transferring to assembly mechanism where it is implemented in the circuit board (3).

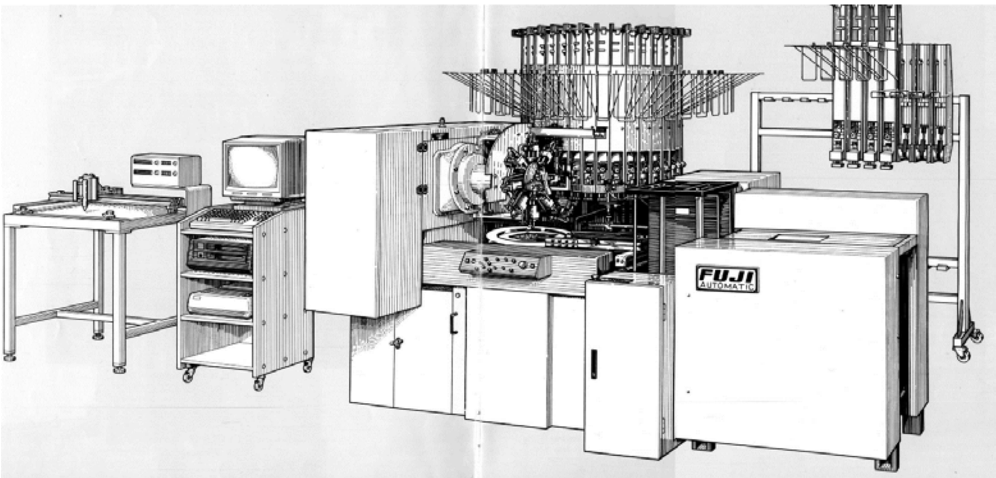

Fig. 2 *Assembly centre of Fuji (Japan) for the establishment of electronic components with axial leads*

Regardless of whether the feeders are located in the center of the assembly or in a separate module , there is a common requirement towards them: their productivity must be equal to or bigger than that of the centre about 10 - 20%. Furthermore, a basic requirement is to have a supply of non-oriented parts, sufficient to supply the centre for a certain period of time , as well as the volume and arrangement of the bunker devices to provide convenient transporting of the parts to the position of the assembly . At the same time the feeders must be isolated from the mounting position so that the vibrations of their work do not affect the assembly .

The problem is that, when the feeders are of a different type (for instance mechanical and vibration) due to the fundamental difference in the nature of the movements of the gripping-orientating devices and of the parts as well as the dependence of the probability factors determining the number of driven parts, it is difficult to achieve synchronization in providing the productivity.

The reasons why you need to use bunker feeders of different types can be varied: the appropriate form of the feeder as a unit to be built into the design of the assembly assembly centre, the kind of the part and the availability of reliable and affordable supplying solution for it, suitable productivity, close to that of the assembly centre and more.

Analytical solution of the problem for synchronizing of bunker feeders of different types

Upon getting of the analytical solution for synchronization of bunker feeders of different type it is started from the equality of the analytical expressions for the productivity of these devices. It will be considered a variant of synchronization of a vibratory feeder with gate mechanical feeder , as such a task was solved by the author in the design of assembly center for the production of cartridges for locks .

So it is necessary :

$$Q_C \leq Q_{MF} \approx Q_{VF} \quad (1)$$

where, $\mathbf{Q_C}$ is the productivity of the assembly centre, $\mathbf{Q_{MF}}$ is the productivity of the mechanical feeder, and $\mathbf{Q_{VF}}$ is the productivity of the vibration feeder.

$$Q_{VF} = \frac{60 v_{AV}}{l} \quad (2)$$

There are expressions for the productivity of the vibration and mechanical feeders /4/:

where, $\mathbf{v_{AV}}$ is the average velocity of transporting the parts, and l is the length of the oriented parts.

$$Q_{MF} = n.m.z \quad (3)$$

where: **n** is the number of the double motions of the shutter in min^{-1}, **z** – the number of the shutters, **m** – the maximum number of simultaneously oriented parts by one shutter.

From (1) follows:

$$\frac{60 v_{AV}}{l} = nmz \quad (4)$$

However, **m** is a probability value, which depends on the number of the double motions per unit of time. There is a number of double motions that **m** has a maximum value and the increase of this number of double motions worsens the probability of entry of parts on the gate and their orientation. Therefore, it is better to select a gate feeder with optimal **n** and suitable productivity slightly greater than that of the assembly centre and to be researched the possibility of regulating the vibration feeder so as to obtain the required synchronization . Then:

$$v_{AV} = \frac{nmzl}{60} \quad (5)$$

Approximate size of the transport velocity of the parts in the vibration feeder can be determined as part of the amplitude value of the speed V of the runway according to the formula (5):

$$V_g = V\cos(\alpha - \beta).K_v = 2\pi\nu A\cos(\alpha - \beta).K_v \quad (6)$$

where: **Kv** is a coefficient, taking into account the reduction of the average velocity of the with respect to V. It is assumed that Vav is equal to Vg. A is the amplitude of the oscillations, cos (α-β) - angle of ejection of the part, **ν** - frequency of the oscillations of the vibration feeder. Approximately K_v can be defined by the following formulas for different values of R_0 – a coefficient characterizing the motion of the parts in the runway:

$$R_0 \leq 1 \quad K_v = (0{,}18 - 0{,}2)\; R_0\left(1 - \frac{tg\beta}{f}\right);$$

$$1 \leq R_0 \leq 1{,}16 \quad K_v = (0{,}18 - 0{,}2) R_0\left(1 - \frac{tg\beta}{f}\right) \cdot \left[1 + \left(1 - \frac{1}{R_o}\right)\right];$$

$$1{,}16 \leq R_0 \leq 3{,}3 \quad K_v = K_c\left[1 - \frac{1}{R_o^2}\right]\left(1 - \frac{tg\beta}{f}\right) R_o^2 .$$

$$K_c \approx 1 - \frac{K_в}{2}$$

Where, K_c is a coefficient of speed recovery at impact, depending on the part material and the runway of the vibration bunker and f - a coefficient of friction between the part and the runway.

Consequently, when a mechanical bunker is pre-selected having productivity slightly greater than that required for the operation of the assembly centre, it is possible to find a vibration bunker feeder, whose speed of movement of the parts in the runway can be selected so that the vibration and mechanical feeders can be synchronized.

Conclusions:

1. The task about synchronization of different types of feeders working in an assembly center was set.
2. A solution to the problem of synchronization of bunker vibration feeder and mechanical (Gate) feeder is obtained.

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