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Optimization of control of automatic assembly process of parts with cylindrical shape

Abstract

Supervisory devices reduce losses of time and material losses in the automatic assembly equipment. Rationally chosen control system raises economic efficiency of the equipment work. In given article it is shown that to increase of reliability of work automatic assembly equipment should be used some special actions concerning both designs of automatic assembly equipment knots and technological process of assemblage.

Keywords: assembly process, automation, orientation, search

Introduction

At present various systems and devices have been developed that increase the probability of assembled parts. Ensuring of accurate of relative position of parts on the position of the assembly can be realized by four methods:

1. Orientation of one part by another one;
2. "Blind" search;
3. Directed search;
4. Electromagnetic control of the assembly process.

Orientation of the one part by another one is the brining of part axis into the zone of allowable tolerance by using the technological elements, self-alignment assembly devices or preliminary bending the axes of the connected parts.
In applying the method of "blind" search - parts, before their assembling, move relative to each other on a certain trajectory until match the mating surfaces, which allows without difficulty join two parts[1].
Method of directed search requires special control devices that determine the relative position of parts on the position of the assembly and acting on the control element, which leads connected parts into the necessary position.
Highly efficient is the system for the connection parts with electromagnetic control of the assembly process.

Application of vibrations for ensuring of parts' assembly

During the creation of methods and tools for automated search of zone of allowable deviation the following demands have to be taken into account:

- the trajectory of the search must to be the maximally simple so as not to be required the use of complex mechanisms for its realization;
- the moving size should be sufficient for reliable a centre of a platen end hit in a zone of a maximum deviation δ_0;
- a detail displacement speed in searching process should be big enough so it wouldn't increase cyclic time,
- search mechanism should have elastic links or links backlashes.

Many vibrating devices, including applied in automatic rotormachines, conform to such requirements.
The use scheme of sinusoidal trajectory is presented in Fig.1. The fluctuations amplitude should be $A \geq \delta_{\Sigma Y}$ ($\delta_{\Sigma Y}$ – a dispersion field of details deviations in a direction of vibrations).
Sinusoidal and them approximated trajectories on automatic rotormachines are created due to linear speeds difference of details that move in common with assembly rotors (Fig.2).

$$V_y = V_1 - V_2 = 2\delta_0 v, \tag{1}$$

where δ_0 – a maximum deviation,
v – frequency of vibrator fluctuations.

Speed of detail vibrating movement is:

$$V_{x(\max)} = A_x \cdot \omega, \tag{2}$$

where A_x - amplitude of fluctuations,

ω - angular frequency.

Speed of detail vibrating movement is practically limited to weight of a detail, the form of edges and a relative orientation error.

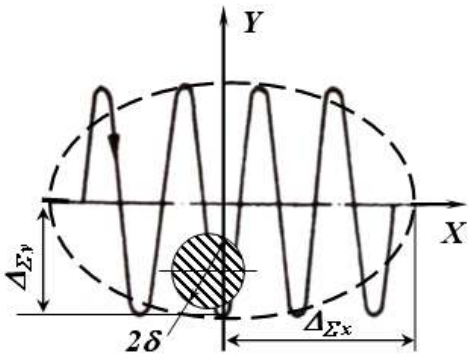

Fig. 1. The scheme of a sinusoidal trajectory.

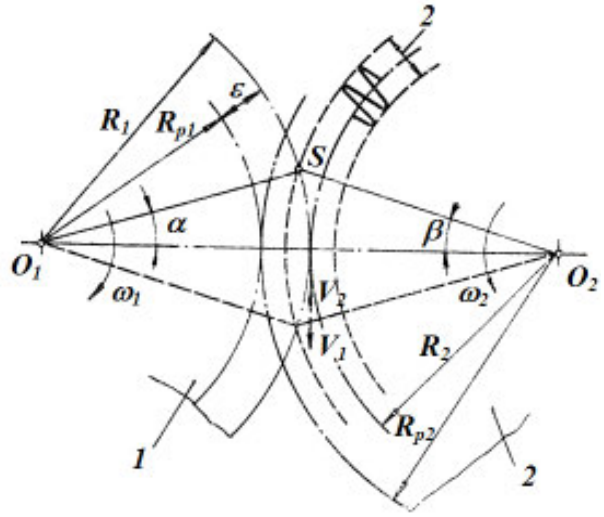

Fig. 2. Details on rotors.

The device with a rotating holder and a pusher

A detail 1 movement is considered in two stages in this device (Fig.3): the detail leans on an edge of an aperture of a detail 2 in a point *w* at the first stage, and in point *U* in the second stage. The starting position of a detail 1 takes place between the first and the second stages [2].

Combination of collected details doesn't occur if the detail 1 loses contact to a holder in a point *q* at the second stage of movement. In that case the detail 1 passes the first stage of movement again, a starting position, and then the second stage of movement, that is the cycle repeats.

Details relative starting position, characterized by an angle of slope, is one of the major factors defining movement of a detail at the first stage. Therefore, researching the first stage of a detail 1 movement, the problem has been put to define, whether a detail 1 bottom end displaces at this stage of movement, that is whether the corner changes from a cycle to a cycle. And for this purpose the differential equation of a detail 1 accelerated movement has been solved (by the approached method) and detail movement in the established mode has been reviewed.

Influence of separate parameters of the device and collected details has been researched on the assumption of the second stage of a detail 1 movement, and the initial relative position of details, in which contact with a holder in a point q is preserved, has been investigated.

Results show that the bottom end of detail 1 moves at the first stage of movement that is search of the collected details position most favorable to assemblage is carried out. However, contact loss in a point *q* is possible at high value of a sliding friction of collected details edges at the second stage of a detail 1 movement, that is combination of details is impossible. Contact in a point *q* remains at a small friction and the detail slips into a detail 2 aperture in point *U*. Withal there is the component of speed directed to the center of an aperture, that is a detail 1 gradually slides in an aperture.

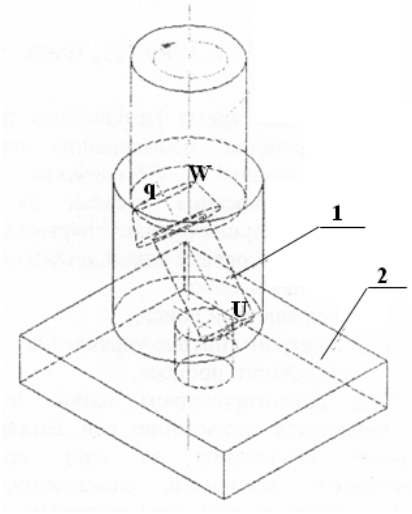

Fig. 3 Details assemblage device

Electromagnetic management of assembly process

Electromagnetic details displacements at their assemblage are possible only if details are metal (Fig.4). Spatial moving of details using electromagnetic field can be made by means of the symmetrically located electromagnets [3]. It is possible to position details, to give them connecting movement, search movement and assembly effort using an electromagnetic field in management of details composition. Accuracy of the equipment work depends on the given equipment details producing accuracy.

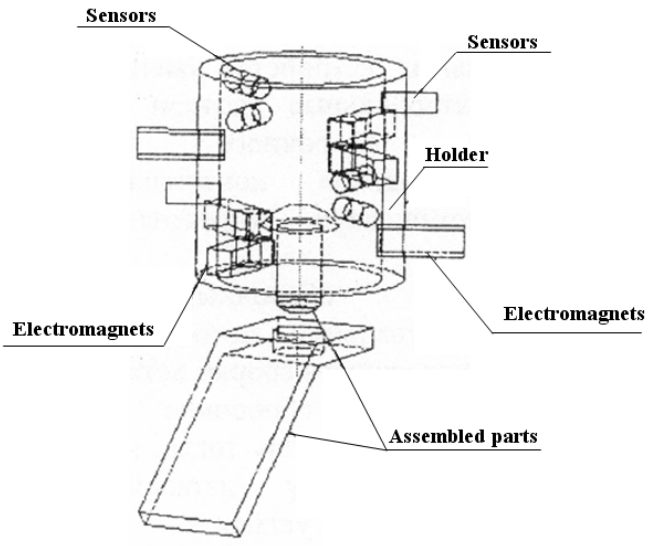

Fig. 4. Electromagnetic management of assembly process

Theoretically it is possible to connect almost unlimited quantity of details of the unlimited sizes by means of an electromagnetic field, but the electromagnetic field is more often applied to details of the small size and in situations when one of collected details is fixed motionlessly, and another joins to the first with one dimensional movement.

Application of the given equipment allows to increase flexibility of manufacture because it is possible to use one equipment to assemblage different, but the same type details. If it is necessary to change collected details than changes are brought only at software level. It allows to avoid deterioration of mechanisms executive elements and the loss of accuracy connected with it.

Assembly process sensor systems

Sensors are used directly in assembly process for definition of collected details position and location. Frequently there are used magnetic, inductive and photo sensors, videos sensors are used very occasionally. Magnetic sensors are used only to assemble metal details.
It is enough to use two sensors, which operate by a triangulation principle, to definite a detail position on a plane. It is necessary to have at least three sensors to define position of object in space. It is necessary to have the whole system of sensors which are symmetrically located in two planes (three sensors in each plane) to define coordinates and also the detail position. The mentioned sensors should be analog action, because they should define detail presence and also detail's dimensional characteristics.
Use of video sensors allows to apply a small amount of sensors; withal there is possibility to define a location and a position of details. Use of video sensors lay down very high demands to the software. Video sensor can be located in considerable removal from an assemblage zone.
Photos sensors can be used to definite details presence and photos sensors can give the information of a location and a position of a detail at matrix use. As a rule, sensor matrix use is applicable only for photo sensors.

Management of assembly process

The software of operating computers and controllers plays the important role in management of automatic assembly process. It is necessary to have possibility to reprogram and/or readjust the assembly equipment without the big expenses of time and means.
There is a possibility of sensors association with executive elements–electromagnets using electromagnetic and sensor management of assembly process. It gives the chance to simplify mechanical parts of the assembly equipment and signal-power installation.

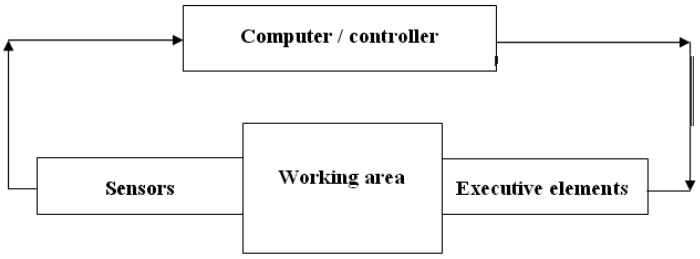

Fig.5. The management scheme of assembly process.

The information from sensors arrives on program – operating block which gives an operating signal to executive elements at a usual configuration of elements when sensors and executive elements are divided (are not united) (Fig.5).

The monitoring system of an automatic assembly equipment work continuity

The automatic assembly equipment, like other machines, isn't absolutely reliable device. There are refusals at its work. Refusals serve as a reason of the losses expressed both in releases of rejected production and in idle times.
There are control devices which detect refusals in a control system. This control devices signal about separate working positions disoperation or check the validity of the collected product (assembly unit).
Refusals have various characters in the assembly equipment. The first group consists of refusals that do not make major defect to work. In such situation only one product appears incomplete or incorrectly collected. The given refusal doesn't repeat in a forthcoming cycle, that is it withdraws. As a

rule, these refusals are matchless; two refusals very seldom follow one after another. For example, if one detail sticks in a tray, the detail following it can strike the first and push it further. As a result refusal is eliminated without intervention of the serviceman. Thus, refusals of the first group are casual and intermittent at the same time.
The second group refusals are not intermittent. They are caused by such reasons as deterioration, breakage, dissonance, more serious jamming of details and so on. The serviceman intervention is necessary for their elimination. The automatic assembly equipment will collect the rejected products at occurrence of such refusal until the cause of a failure will be revealed and eliminated. But emergency refusal doesn't necessarily lead to breakage of the equipment details (for example, detail jamming in the submitting device).
Each refusal reduces time of useful work, reduces productivity and economic efficiency. The losses of time caused by refusal and the material losses connected with damage of collected details depend on reaction of supervisory -operating system. Its complexity is usually in direct dependence on quantity and complexity of operations and cost of collected details. So, as a rule, a control system of one item pressing–assembly automatic machine that collect inexpensive details has no control devices of the collected object validity. Also supervisory devices are absent in more difficult assembly equipment if its work is steady, refusals are extremely rare and caused losses aren't considerable. Inconvenience in this case consists only in necessity to cull poor-quality products that is quite often carried out manually.

Conclusions

Supervisory devices reduce losses of time and material losses in the automatic assembly equipment (AAE). Rationally chosen control system raises economic efficiency of the equipment work.
Assembly process management is based on creation of methods and devices which increase reliability of details composition.
AAE works reliably only when quality of details that arrive on assemblage completely corresponds to specifications.
Increase of reliability of work AAE can be reached also by some special actions concerning both designs of AAE knots and technological process of assemblage. Application of vibrations, an electromagnetic field for details orientation and use of supervisory – operating systems to move collected details before assemblage can be these actions.

References

[1] MOZGA N.: Optimization of technological process for assembly on rotary assembly machines. Promotion work. Riga, Latvia. 2004.
[2] СТАЛИДЗАН А.А., МУЦЕНЕК К Я.: Условия сборки деталей в устройстве с вращающимися обоймой и толкателем. В кн. Автоматизация производственных процессов в машиностроении и приборостроении, вып.8. – Рига, Зинатне, 1972.(in Russian)
[3] ИОФФЕ Б.А., КАЛНИНЬ Р.К. Ориентирование деталей электромагнитным полем. – Рига, Зинатне, 1972. (in Russian).