STRUCTURES OF FLEXIBLE ASSEMBLY CELLS

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Abstract: The development of new technique and technology make the dependence on machines and technological devices by human work. The human work developed by the development of new technology in the production area to such degree that individual production operations could run without human work cooperation. The human work state in this type of production is changed into planning, control and inspection work functions. This partial human work elimination out of production process verifies one of main requirement for automated production.

Key words: assembly cell, structure of assembly cells, flexible assembly system FAS, supply

1. INTRODUCTION

System - a set of interacting or interdependent entities, real or abstract, forming an integrated whole. The flexible assembly systems include the set of technical devices and parts that are connected by functional, material, information, energy and secondary unions in its structure. The systems provide and realize the assembly process (Fig. 1).

![Fig. 1 Individual levels of assembly system](image-url)
Cooperation between levels of FAC has to provide the synchronize production of some products. The production changing is realized automatic with minimal or no human work. The using of technical parts and devices has to start of optimal solution by technological, technical and economic aspect. The flexible assembly cell (FAC) is one of structural element by realization of flexible assembly lines (FAL) and flexible assembly systems (FAS).

2. STRUCTURES OF FLEXIBLE ASSEMBLY CELLS

The structure of flexible assembly cell is understood as set of production technique in typical space place. In FAC is realized the most quantity technological operations on production objects with minimal manipulation with them. Then it is achieved high degree of flexibility and it is enabled the integration between objects with co-operation manipulation in higher control level.

The robotized cell is able to include:
- Station with one or two co-operated industrial robots
- A number of stations that are disposed into line – robotized assembly line

Co-operation between robots can be organized by several methods:
- The robots practice several functions. The practices are designed to achievement of substitute the task of co-operated robot. This co-operation between industrial robots increases the reliability of assembly process. The co-operated robot substitute the second failed.
- Co-operated robots can operate in one set. The total cycle time of realization is shortening.
- One of the robots can realize complete assembly process and finish the product assembly or divide assembly process into co-operate robots process. This organization shorted requested workplaces, time cycle shortening and quantity of less required assembly devices (jaws, pneumatic or electric screwdrivers e.g.)

Typical operations need co-operation of two industrial robots. For example: the assembly part is shaping and dimensional complicated, the assembly process is more difficult. There are eventually used two industrial robots. The advantage of this system is using of two type of robots with different attribute and capability. One of them is more quickly in low price and the accuracy is standard. This type is able to manipulate with heavier products. The second one is realized as very accurate but less speedy and more expensive.

FAC with two co-operated industrial robots is more flexible but the realization of control and coordination is more difficult.

Robotized assembly cell can be organized and disposed by 3 basic types:
- Assembly cells with one industrial robot situated in the centre of cell (Fig. 2),
- Assembly cells with industrial robots situated in line on after another (Fig. 3),
- Assembly cells with mobile industrial robot (Fig. 4).
Fig. 2 Assembly cells with one industrial robot situated in the centre of cell

Fig. 3 Assembly cells with industrial robots situated in line on after another

Fig. 4 Assembly cells with mobile industrial robot
The kinematics of industrial robots represented the shape of work place FAC. The industrial robots with serial kinematics are popular and it can be funded in different modifications with concrete work places:[27]

- TTT – 3 translation kinematics pairs – block (rectangular, Cartesian work place),
- RTT – 1 rotary and 2 translation kinematics pairs – cylinder,
- RRT – 2 rotary and 1 translation kinematics pairs – sphere,
- RRR – 3 rotary kinematics pairs – torus.

2.1 FAC STRUCTURE BY MATERIAL FLOW

The structure of FAC depends on type of distribution and delivery. Type of delivery depends on dimensional, shape, material and weight parameters of assembly products. Dimensional small and simply shaped elements with simply orientation that are usually used in FAC utilize stationary storages with position equipment. This structure of FAC (Fig. 5a) is able to often changing in production line and mass. The disadvantage of this FAC structure is in its limited flexibility. The production and assembly is more effectively in this case.

For FAC delivery with dimensional larger and shape complicated components are used technological pallets. It applies to FAC delivery with components as are: groups, subgroups, sets, aggregates. Inputted and outputted assembled components on technological pallets in FAC are in three types of shape:

- Non-oriented and non-positioned - components are free stored
- Oriented and non-positioned – components are right oriented and free positioned
- Oriented and positioned – components are right oriented and positioned by clamping

The assembly fixtures positioned on technological pallet are divided into two categories:

- Assembly fixtures to position and orientation provision with clamping. Clamping and positioning of assembly components in flexible automated assembly is only realized and belongs to basic assembly element. Clamping and positioning elements can’t beside prevent to assembly process. This type of assembly fixture is only used in this case when the basic assembly component stays on technologic pallet in all assembly time.

- Assembly fixtures to position and orientation provision without clamping. This type of assembly fixture is used for delivery of FAC by components (parts, groups, subgroups, sets, aggregates e.g.). Components have to be right oriented in assembly process. This type of assembly fixture without clamping are also used for basic assembly parts but the basic assembly part is taken away out of technological pallet and is inserted in workplace of FAC.

FAC delivery of components located on technological pallets is able to two types:

- The first method rests in logistic method JIT (Just in Time). This logistic method is very complicated. Against FMC is the material flow in FAC more difficult thanks to more quantity of assembled parts. It follows that this logistic method is used in smaller FAC. For this purpose is able to use FAC showed on Fig. 5b. This type has more input and output places

- The second method rest in use of interoperate receivers that optimized the material flow in complex system (Fig. 5c).
3. THE ASSEMBLY CELL EQUIPMENT

The work place is defined as place where are realized all assembly, advanced and helping operations. Elements of work place in FAC are:

- The assembly operation equipment:
  - Tools – are used by assembly operations (screwing, pressing, riveting e.g.),
  - Fingers – are used by manipulation and picking of parts or tools,
  - Fixture clamps with changing jaws.
- Specific devices used for secondary assembly operations,
- FAC includes delivery devices – controlled devices as are: rotary tables, storages for standard assembly parts. The delivery devices are not movable except technological pallets imputed to FAC,
- Input or output FAC devices,
- Storage work places for assembled components, failed components, tools, fingers, clamping and position devices of fixture (jaws e.g.).

4. SENSOR DEVICES IN FAC

The important element of flexible assembly cell is sensor equipment that is applied in assembly systems. It is divided into three basic groups:

- Tactile sensors – used in industrial robots with required tactile touch with manipulated and assembled object. Sensors are used for object existence checking, clamping force identification, monitoring, assembly tools position checking e.g. In the present tactile sensors are used for measuring of force and pressure. Output signals are modified to electrical signal for control system,
- Proximity switches sensors – used for non contact with assembled component. It can be integrated to sensing values; basic dimensions, colors of components, parts distance measurement e.g.,
- Visual sensors – the using is more extensive, basic area of using is part orientation identification, type of object, ridge detection e.g.

5. CONCLUSION

In previous chapters are described structures of FAC. On the ground of this information is realized the FAC structure in the laboratory at Institute of production systems and applied mechanics, MTF STU Trnava (Fig. 6). This FAC is realized in project VEGA.
1/3193/06 „Multifunctional production - assembly cell“. The next project VEGA 1/0206/09 „Intelligent assembly cell“ is opened after finish of this project. Flexible assembly cell (FAC) is designed similar to intelligent assembly cell (IAC) in structure. FAC that use “intelligent” technical devices cannot name as IAC. Difference between FAC and IAC is based on planning, control, inspection functions. The functions are realized partly automatic in FAC by new software and new technologies. The human planning, control and inspection functions in production will be partial changed with using of artificial intelligence elements in IAC.

It is generated new generation of flexible automated assembly with implementation of artificial intelligence elements in automated assembly. The important question is: are these technical – economic difficult assembly systems responded to realize? The economic return of “simple” FAC begins in some years after activation of this system. Intensity of system increases on the basic of flexibility complexity. In the system it can find more information if is the system more difficult and expansive. The control system processes the quantity of data and information and realization of control is more difficult. It is created the minimal problem of realization and level increasing of IAC in this case.

6. REFERENCES


