Flexible technologies of the reconfigurable automatic plants

A V Gurjanov¹, A V Shukalov², D A Zakoldaev² and I O Zharinov²

¹ Stock Company «Experimental Design Bureau «Electroavtomatika» named after P A Yefimov, 40, Marshala Govorova St., Saint Petersburg, 198095, Russia
² Faculty of Information Security and Computer Technologies, ITMO University, 49, Kronverksky Av., Saint Petersburg, 197101, Russia

E-mail: igor_rabota@pisem.net

Abstract. The scientific problem is to analyze and to synthesize modern plants resource, which manufacture the devices in engineering. There is an analysis and scheme of plants resources in the existing enterprises, which use the flexible technologies of computer numerical control as a base for devices manufacturing. Obviously that computer numerical control robotic cell potential today has run out its possibility. There is an analysis and some ready theoretical solutions (scheme) in the subject area of the new paradigm reconfigurable manufacturing resource. Obviously that synthesis of new reconfigurable plant is based on flexible assembly technologies, which have some application for the industrial reconfigurable manufacturing systems. Reconfigurable manufacturing infrastructure elements of the existing enterprises and the modern plant are defined as well as new robots specialized for the reconfigurable automation plant.

1. Introduction

Existing today approaches to develop sustainable reconfigurable plant being applied in practice are based on device manufacturing processes some resources [1, 2]: machine and theoretical solution, which use computer numerical control (CNC). CNC machines are used in scientific design bureau and may significantly automatize a number of manufacturing operations. But the potential of further technologies and machine development, which use the CNC, today has run out its possibilities significantly [3, 4].

The agenda has the new type companies’ projection task, which will complete the full cycle of the device manufacturing automatically using autonomous reconfigurable manufacturing systems (RMS) [5, 6]. Deep industrial automatizing is a modern approach trend to create self-reconfigurable manufacturing plant based on the novel methodology (Industry 4.0) [7, 8].

New methods and means of RMS, new flexible assembly technologies defined today the primary directions of the plant automatizing in the subject area of the RMS designing, engineering and other [9]. The rejection of paper sets of design (DD), software (SD) and other documentations in a reconfigurable factory in the favor of new device description electronic forms will allow to project the scalability plant in the formats of fully automatic factories, which manufacture the multi-material device [10, 11].

Base resource of reconfigurable plant [12, 13] in the new paradigm factories becomes RMS in the cyber-physical systems family, which support flexible technologies, which almost completely exclude humans from the methodology of device manufacturing [14, 15]. Reconfigurable plant designer key project problem in this case can be rounded down to justify the interoperability RMS selection and flexible technologies [16, 17].
2. Flexible technologies of the existing plants

The flexible technologies of existing plants are a machine with software numeric control. A CNC machine is a machine and software combination, which has:

- a chamber, within which device manufacturing are completed (with «subtractive» flexible technologies);
- a system of sensors to measure the parameters of the CNC being completed;
- an electromechanical actuator;
- a controller to provide controlling commands for the actuator with the sensors measurement results;
- a functional software being executed by the controller;
- a test software to control CNC machine;
- operational system.

The functional scheme of the existing plants resource is shown in figure 1.

The CNC machine exploitation and maintenance is done by the humane. CNC machine exploitation technical means are kept in the warehouse and include:

- means of metrology quality control of the device;
- instrument being installed in the actuator;
- accessories and other.

CNC machine brainware includes the following thing placed in the archive:

- sets of manufacturing standards;
- sets of DD, SD and others documentations;
- sets of manual for the CNC machine and other

One of existing plants section may include several multifunctional CNC machines.

3. Flexible technologies of the reconfigurable plants

The reconfigurable plants are a digital twin-based manufacturing companies, which functions with advanced and flexible technologies. Reconfigurable plant equipment primary unit is a RMS. A
reconfigurable manufacturing system is a hardware and software combination, which has [18]:

- a chamber, within which device manufacturing;
- a system of sensors to measure RMS functioning parameters;
- an electromechanical actuator;
- a controller to provide controlling commands for the actuator with the sensors measurement results;
- a functional software;
- a testing software to control of RMS;
- operational system (OS).

The functional scheme of the reconfigurable plants resource is shown in figure 2.

In the reconfigurable plant reconfigurable manufacturing system servicing is done by the humane in the periods when RMS is not engaged. All processes of RMS interaction with other analogue robotic workcell is done through the sub-system of parts reception and transition, which interacts with mobile manufacturing system. The mobile RMS transmits to the multifunctional RMS input from the warehouse or output the previous RMS a detail to complete some flexible additive operations. After they are finished the detail will be extracted from the output RMS. The device manufacturing algorithm prescribes the detail transition sequence among RMSs in a reconfigurable robotic plant.

Reconfigurable robotic plant RMS software consists of the several manufacturing cloud resources and includes:

- sets of manufacturing standards;
- sets of RMS and manufactured device digital twins;
- sets of manuals for the RMS.

![Figure 2. The functional scheme of the reconfigurable plant's components.](image-url)
4. Conclusion
The existing plants and the reconfigurable plants manufacturing resource has some substantial components in common, include:

- computer machine controlled with a software, which use the principles of automation software control;
- electronic formats of device representation, which will be manufactured in RMS;
- humane high qualification, which run the CNC, RMS and make running in the subject area of works to organize a scalability plant and other.

New types of automatic reconfigurable resources, which are particular for the self-reconfigurable plants are:

- reconfigurable manufacturing system to make the full cycle of device manufacturing operations;
- flexible and advanced technologies, which provides the RMSs self-reconfigurable principles using artificial intelligence methods;
- virtual sensors of reconfigurable manufacturing systems and the reconfigurable plant in general placed in the factory cloud environment.

The reconfigurable plants resource main advantages are the greater role of automatization in completion of manufacturing operations, which helps to develop of RMSs.

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