The cyber-production mechanization control

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Abstract. This article pays your attention to the cyber-production mechanized equipment control problem. There is a scheme proposed of automatic cyber-production segment control, mechanized technological aggregates and multi-chain manipulation systems. The control system is made in a multi-loop mode with a sensor measuring part to correct production automatics functionality errors. Within the technological aggregates there is a physical processes regulation loop in the machine working volume and one for the assembly units being manufactured material tide. There is a control loop in the manipulation system to move the rail chassis base movement and positioning loop of force and momentum regulation with a multi-chain grip. To control the cyber-production segment mechanization they propose a global loop to engage in the company virtual environment the equipment reference models and digital model (twin) of the product being manufactured.

1. Introduction

The technological processes control with cyber-systems is the production basic option, which are actual for the Industry 4.0 innovations [1]. The industry modernizing current strategy requires to solve production tasks of new difficulty level category, which require to create scaled technological objects and to control the cyber-machines agglomeration. The autonomously configurable machines with a lot of unique settings is a new advanced class of automatic equipment to provide the mass production complex mechanization [2, 3].

The production relations new structure base, which is the Industry 4.0 concept in practice is the inter-penetrating unification cyber-technologies, which is a single solution for industrial robots and an artificial intelligence made with a program [4, 5]. The finishing form to grasp the technological innovations is to invest an attractive mono-plant to support the entire automatic production capabilities range. The basic principles system and the mono-plant functioning rules means only to process semantically the production information algorithms and to synthesize the product material tides as cyber-objects, which are to be synchronized using the Internet net [6, 7].

The cyber-objects net interaction logics provides a mono-plant with all business processes full integration, which are tied closely with the company market competence strategy and the smart
production modern specifics equipped with different types technological aggregates [8, 9]. The cyber-production complex mechanization is an economic growth source, which let company maintain and increase their presence percent in the global industry segments.

To develop the Industry 4.0 concept with automatizing focus they require a material plane where the technological aggregates smooth interaction option position using a relation system is formalized in cloud environment [10]. The industry complex automatizing pragmatic and eristic solutions, which are to stimulate a search of new quality cyber-production working technologies and tools means only to create the mono-plant basic infrastructure, which unite [11, 12]:

- in the physical workshop level they are mechanized technological aggregates, which are capable to assemble a multi-option product and to provide minimal volume of non-finished production;
- in the cable level and Wi-Fi telecommunication net it is an informative bridge connected to IP (Internet Protocol)-addresses the industrial Internet of Things electronic users, which is a number of machine brands and data protocol transmission interfaces in variety;
- in the workshop virtual environment level they are technological aggregates models, product digital twins and assembly units material tides movement models integrated as a program code placed in a remote server.

The cyber-production process main element from the global mono-plant construction experience is a distributed control system, which directly engages a parallel regulation of all telecommunication net connected technological aggregates. The regulation subject general connectivity makes the production chains robotizing easier and provides monitoring and controllability of an industrial object being re-configured in the required business structure level [13]. The Industry 4.0 cyber-production mechanization control problem is far today from the full enlightenment by specialists and that why some auxiliary researches are vital, which are to develop the mono-plant composition with a multi-tact discrete regulation different in technological aggregates parameters [14, 15].

2. Micro- and macro-levels of cyber-production control
The cyber-production inner product and transport tides monitoring is done with the company virtual environment control system, which is the modern industry IT (Information Technology)-node. The virtual environment information supports a close connection and coordination of technological aggregates functionality with discrete regulation methods based on continuously being acquired from the equipment data. The company digital model deployed in the cyber-production control platform is the regulator main chain with a direct influence over the industrial infrastructure mechanized objects.

The cyber-production mechanization control principle means to transfer messages with commands and parameters registered on the technological aggregates net through an electronic mail, which may automatically regulate physical processes in the equipment industrial work volume. The coordination unit (the information collection and processing net center) to provides complex company automatizing (in a macro-level) with different technological combinations, which is a unified control cyber-system, which adapts aggregate behavior up to the complicated items robotized assembly production cycle settings. The company automatizing micro-level is the technological processes multi-coordination regulation inside the aggregate work volume compensating the being controlled parameters deviation, which are out of the accepted limits.

The intellectual technological aggregates real time control is based on virtual and physical objects information submersion into the cyber-production dimension space. The robot sensor systems control the technological aggregates work organs movement and translate the process parameters into the macro-level control system to form the regulator integral awareness of the industrial object condition. The joint information processing may prognosticate the multi-sections kinematics chain joint positions for the aggregates being controlled and provides the command control of equipment groups into start and stop mode.
The cyber-production control mechanism micro-level is a special Industry 4.0 sub-technology to improve technological aggregates functioning with regulation methods implemented into the physical device virtual analogue. The technological aggregate digital control system made as a reference model and deployed in a cloud is the item processing quality increasing standard tools alternative, which cannot be reached with the Industry 3.0 means. The mechanical and electronic robot movement acts reference samples formed in a digital twin are compared in a micro-controller with real executive organs movements and aggregate special devices, after which the received dissonances are re-calculated into control signals, which with high precision compensate the space and force and momentum deviations. The super precision control is reached through the error values defined in the physical device automatic system and in its virtual regulation model (reference).

The industrial equipment net communication capabilities dynamics define the hold-up parameters in the being regulated values transmission through the Internet of Things among the controlling automatic loops for micro- and macro-levels. The discrete control mechanisms engage the extrapolators in such loops to calculate the expecting (missed because of asynchronous industrial net properties) values of being regulated parameters, which are translated to technological aggregates as messages.

3. The cyber-production mechanized segment control system

The intensification of inter-branch competence led to the industrial production innovative transformations, which implement the technological processes automatic mechanization means. The aggregate cyber-components are a base to create a process factory to make projects interesting for different industry branches. Applying the automatizing systems the technological lines modernization is done in a classical scheme, which include the complicated industrial objects general control laws.

To control the cyber-production mechanization is an Industry 4.0 sub-technology to provide assembly units material tides movement among technological aggregates. The tide machines specialty, which includes the manipulation system and technological aggregates is the technical parts movement with a fixed trajectory. The parts loading and unloading in the manipulator position space and within the technological aggregate is based on a row of organization control principle, which are used as the industrial assembly robots interaction group technology as for electronic devices.

The cyber-production mechanization is based on a transport via (chassis) as a monorail design, which controls automatically the manipulation system movement. The manipulator space position regulation is calculated keeping in mind the controlling influences including the given momentum over a step engine, which are necessary for:

- to provide a transportation with the movable manipulator base changing step for a given distance received from the control center as some navigation coordinates in the cyber-production space;
- axis and angle movements of the manipulator shoulder mechanism with a part gripping function under a control signal of latitude and pulse modulation;
- the control commands compliance accuracy with given trajectories, which excludes the robots pair joint blocking and to provide maneuvering when the robot moving parts incoming movements are detected and other.

The manipulation system executive mechanisms remote control is done with a limited number of automatics elements and connections, which connect the special regulators to the control object. The controller and object communication is done with an industrial net to provide message transportation service into the upper level control system.

The requirement signal to complete a technological operation is given to the message stack (the production tasks limited queue) and is received to be executed by a particular aggregate or a group of aggregates. The manipulation system actions and aggregates actions are synchronized up to the production cycle dynamics and passing through capability of low and high speed control values transmission buses. Technological systems aggregation with periodic control parameters engaging
reflects the discrete control sense, which is sufficient to realize all cyber-production functions with industrial equipment groups.

The upper level control system collects the industrial controllers data into an event registration journal and synchronizes the peripheral cyber-production equipment functionality. The upper level control system forms a required structure of assembly units material tides, which manufacturing is done with regulation methods, which is individual intellect of each technological aggregate. The technological processes measuring adaptation requires corrections of the cyber-production mechanization control laws or their parameter settings. The cyber-production mechanized segment automatic control system scheme is given in figure 1.

**Figure 1.** The cyber-production mechanized segment automatic control system scheme (IMS – informative and measuring system, IoT – Internet of Things).

The available technologies and potencies base containing cyber-production resources limitation may view technological aggregates independently from each other in their control level with general or several centers, which makes easier the equipment compatibility problem and how to select typical means to solve the production tasks. The aggregates functioning in the upper control level (automatics case) is made with an abstract resource representation with its digital twin (reference model) to support information connection with technological parameters with peripheral or higher level production equipment.
4. Conclusion
The industrial robots and manipulation systems are the cyber-production machine pool base. The Industry 4.0 automatizing dominating trend is to build a mono-plant where one border of which is to change the industrial equipment computerized control paradigm. The first production mechanization of cyber-control is an actual robotic and technical task adapted to the new industry digital technology.

The mechanized equipment control algorithm where discrete processes are presented is based on machine learning technology where a pre-calibrating is required and the technological aggregates behavior is to be adapted to the cyber-environment conditions. The tool permissible trajectories deviations evaluation method working-out from the required values (before a real technological operation is completed) must be done with neutral positions connection accepted in coordinates with each machine workspace volume.

The technological aggregates executive organs planned movement correspondence control to the real tool movement is done in the cyber-production virtual environment, which is the mono-plant special competence to implement the Industry 4.0 technologies. The cloud environment developed informative system let unite autonomous control aggregate models and provide technological and transport machines ordered interaction (manipulation system) synchronized in object changing position for the being regulated influence. The high precision regulation parameters and position movement macro-level accordance is done with informative system tools, which has the cyber-production control task finished representation and its separate technological segments.

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