Workstations Industry 4.0 for instrument manufacturing

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Abstract. The actual task is to project the structure of operator automatic work place in the Industry 4.0 smart factory. The Industry 4.0 smart factory is a new type of production company. Smart factories are oriented to manufacture item designing components in automatic mode. The key technologies of humanless and paperless production are cloud technologies, industrial Internet of things, sensors technologies and others. A principle is given how to construct automatizing work place in existing production companies of the Industry 3.0. There is a functional scheme of the Industry 3.0 production company automatized work place. It is clear that implementation of new informative technologies influence significantly the structure of an operator automatized work place in production. The proposed functional scheme of the automatized work place is for the Industry 4.0 smart factory.

1. Introduction

The organization of item designing components production in the Industry 4.0 company is based [1, 2] on implementation into technological processes the cyber and physical systems and technologies of humanless production. Cyber and physical systems [3, 4] is a new type of production machines with two primary components:

- physical component which is the hardware itself to produce a limited number of technological operations inside the work chamber;
- virtual (cyber and physical) component placed into company cloud environment to support informatively the item manufacturing technological processes.

The technologies of humanless production applied in the Industry 4.0 [5, 6] require the implementation of the following components into technological processes of item manufacturing [7, 8]:

- electronic documents of construction (CD), program (PD), and technological (TD) documentation based on the net informative technologies;
- production machines which are cyber and physical systems of industrial purpose which are capable to complete production tasks automatically;
- self-organization algorithms of cyber and physical systems placed into industrial company cloud environment to ensure the completion of technological processes of item designing component manufacturing without humans and other.

The division of company production resources into physical and virtual components is a stage [9] of the Industry 3.0 company development where the base for item manufacturing are physical components [10, 11]. To project innovative productions of the Industry 4.0 must be done in special automatized work places of operators oriented to use the progressive industrial technologies.

2. Automatized work places to produce item designing components in the Industry 3.0 company

Central component of the automatized work place (AWP) to produce the item designing components in the Industry 3.0 company is the technical support which include:
- instrument PC (Personal Computer) with installed system, net and application software to check, make settings and adjustments of the items being manufactured automatically (with human participation);
- peripheral printing equipment which make documents of the completed technological operations being done on the item by the manufacturer;
- technological models of unity to interact with instrument PC interface through cable connection and check remote control for the item being manufactured.

The item designing components manufacturer AWP functional scheme of the Industry 3.0 company is given in figure 1.

![Diagram](image)

**Figure 1.** Item designing components manufacturing AWP functional scheme of the Industry 3.0 company.

Manufacturer (operator) with application software tells the instrument PC the volume of item check which depends on the number of program algorithms. Item check modes could be of software or hardware means. Machine means to program item check modes are remote control organs which is a part of AWP technical means. System, net and application components are a part of AWP software means.

The application software helps the operator in the Industry 3.0 production to do the following:
- correctness control of the item being manufactured which is done by internal or external hardware and software means;
- setting of the item being manufactured being done by the operator automatically to make sure that item functional and accuracy properties as they should be and relevant for the exploitation;
- item faults diagnosis manufactured in production, in exploitation to find out the reasons of faults (defects) after which the item has broken and other.

Item manufacturing technological operations completion results in the Industry 3.0 companies are documented by the operator with the forms of report documents (test protocols, fault analysis acts, entering control acts, fault acts and other.). The report documents forms are according to the company standards or to branch (state) standards. The company operator may find all necessary reporting document forms into company electronic archive.
Production company operator access to the electronica company resources is done through the net software interface installed in instrument PC. All instrument PCs which are part of AWP united in the Industry 3.0 company into local bus where also electronic archive is connected. Along with report documents forms and norm documents (state standards) company electronic archive also has CD, PD, TD of the item being manufactured and accessories (technical accessories) which are necessary for manufacturing. CD, PD, TD give the operator informative support of his activity processes in the company to produce the item designing component of high quality.

3. **Automatized work places to produce item designing components in the Industry 4.0 company**

Automatized work place of the item designing component manufacturer central component in the Industry 4.0 company is a cyber and physical system. The cyber and physical system (CPS) hardware include:

- work chamber to complete technological process (for example, 3D-printing of parts from powder material);
- a set of CPS condition detectors and detectors of technological manufacturing processes completion quality control into the work chamber;
- a controller which with special software may form digital commands which influence the gear to reach the necessary modes of the technological operations completion;
- a actor (electric and mechanical unit) which does the commands from controller to maintain the necessary instrument movements trajectories inside the work chamber (for example, a nozzle of 3D-printer).

Each CPS may complete in production a limited number of technological operations. Unification of CPSs in their acceptability for production process into clusters may create special sections (workshops) with necessary functional capabilities. CPS informative interactions united into technological sections is done in communication environment of industrial company.

Communication environment of the Industry 4.0 is a channel of wireless high speed connection functioning in multi-agent access mode for the specialist and CPSs. CPS hardware provide the information exchange in communication environment with program and software means of controller. Specialist (tester) of the Industry 4.0 production company may access to the communication environment resources through the interaction interface available in mobile devices (tablet, phone, communicator, computer and other.). Communication environment of the Industry 4.0 industrial company support the standards of information exchange with protocols of Internet of Things (IoT).

Company informative resources placed into cloud environment include the following components:
- norm documentation (a set of state and branch standards oriented to production processes being done into digital economy conditions);
- CD, PD, TD of the item being manufactured represented as item digital models;
- algorithm libraries of CPS self-organization which helps CPS to interact with multi-agent technologies;
- methods and forms of test protocols being conducted on the item being manufactured to prove the item quality and other.

The item designing components manufacturing AWP functional scheme of the Industry 4.0 company is given in figure 2.

The Industry 4.0 AWP helps the operator in production to do the following technological operations:
- production processes completion with humanless and paperless technologies automatically;
- conduct physical tests with manufactured item in automatized (automatic) mode;
- remote creation of electronic protocols about manufactured item physical tests results;
- manufactured item digital certification with standards of digital economy.
4. Conclusion

To project a production division of the Industry 4.0 with highly-productive CPSs and innovative technologies is a relevant direction of modern industry development. The main options how to create a smart factory could be realized in the following ways:

- by modernization of production capabilities and existing science and research institutes and item designing bureaus of the Industry 3.0;
- by construction of new plants equipped with cyber and physical systems and which have qualified personnel trained to work with CPSs.

If we are to modernize the existing capabilities of the Industry 3.0 companies we must stage by stage renew the technical equipment and company software with the components functioning in the digital space. Also they need professional re-training of personnel in special educative organizations accredited to prepare the personnel with new industrial occupations.

Educative programs to prepare the specialists of the Industry 4.0 must have material and technical support which is adequate to the progressive industrial technologies (cloud calculations, Internet of...
Things, security of cyber and physical systems, big amount of data analysis, sensors and other.) which are being applied today in item and machine designing.

If we are to construct new plants (smart factories) we must assess the company economic criteria and also how rentable a high-tech production with high added value is and which is the most suitable option to develop the item designing industry within the Industry 4.0.

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