Infrastructure as a service for a digital factory, smart factory and virtual factory of the Industry 4.0

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Abstract. The task is to create an infrastructure cloud service to support informatively the completion of project and production tasks in the Industry 4.0 companies. Infrastructure digital factory service has some program components which are necessary to create digital twins of items and cyber and physical systems. Infrastructure smart factory service has some components which are necessary for completion manufacturing of technological operations of the item in automatic mode with cyber and physical equipment. Infrastructure virtual factory service has some components which are necessary to control the item during its remote exploitation by personnel. There is a scheme how to organize cloud infrastructure which is the same for smart and digital factories which are the parts of the Industry 4.0 virtual factory.

1. Introduction

Digitalizing of the economy industrial sector is a vector of the national technological initiative in the specialty «advanced production technologies» [1-3]. The national technological initiative is a set of technical and economic measures, which is a route map to create a digital project and production environment oriented to manufacturing of high-tech items with additional costs. This approach is the fourth industrial revolution today [4, 5], in some ways known as the Industry 4.0.

The route map of this national initiative means that personnel with some special competences [6-8] undergoes precise development and implements new technological solutions at the all stages of the high-tech item life cycle to be used in the industry as progressive informative technologies. The expected results of this route map are [9, 10]:

- new companies (companies of the Industry 4.0) equipped with robotized cyber and physical technological equipment which works automatically in paperless and unmanned ways;
- new high-tech items in the market with high additional costs manufactured in the companies of the Industry 4.0.

The Industry 4.0 companies are the base for automobile, railroad, maritime, aviation, rockets and space and other industries which have a lot of machine designing and item designing. The Industry 4.0 companies are about to provide the full life cycle coverage of the items being manufactured or projected including market research, production, exploitation, repair, elimination, etc. The base of the Industry 4.0 companies is developed today technologies, which will be better in the future [11, 12]:

- the technology of industrial Internet of Thing (IoT);
- cloud technologies;
• additive technologies (3D-printing);
• sensors technologies;
• technologies of cyber and physical safety;
• the technologies of BigData to process the vast amount of project and production data;
• the technologies of Machine-to-Machine, Systems-to-Systems, Humane-to-Machine.

Implementation of advanced informative technologies is done with a single infrastructure placed in a cloud [13-15] with the general components for digital factory, smart factory and virtual factory of the Industry 4.0.

2. Classification of the Industry 4.0 companies
The organization of industrial production of unmanned and paperless technologies based on the companies is of three types:
• digital factory;
• smart factory;
• virtual factory.

They initiate the production of high-tech items with additional costs. Such high-tech items could be the item and machine designing components.

The Industry 4.0 digital factory is a company for projecting the item and industrial technologies digital twins. A digital twin is an item description (technology) which is a set of construction (CD), program (PD) and technological documentation which is created as mathematical models. The designers create technical documentation in their PCs (Personal Computer) and automatic work places. An Industry 4.0 digital factory is a more advanced form of project activity which is today known as an experimental design bureau (EDB) and science and research institutes (SRI) of the Industry 3.0 (see figure 1). The main difference between a digital factory and an EDB or a SRI is:
• new technologies in project activity (internet of things, cloud calculations and other);
• new form of results (digital twin) after project activity.

A smart factory of the Industry 4.0 is used for manufacturing processes in items with cyber and physical equipment and test equipment. Items are being manufactured according to technical documentation issued by a digital factory. The production cycle in a smart factory is for the following technologies:
• 3D-printer, PCB (Printed Circuit Board) components placer;
• robotized transport system and others.

They are united in a workshop at the virtual level. The smart factory virtual level is in a cloud and has components which are necessary to support informatively, the production cycle with imitation modelling. The Industry 4.0 smart factory is a more advanced form of a production company which in the Industry 3.0 is a serial plant to manufacture the items. The main difference between a smart factory and a serial plant is:
• new technologies used in production (additive 3D-printing, cyber and physical systems, Systems-to-Systems, artificial intelligence and other);
• when the item manufacturing routes are being done without humans (automatic production with electronic item documentation).

The virtual factory of the Industry 4.0 is a set of companies united to realize the exploitation of the item life cycle. Each company in a virtual factory is for one of the following stages:
• maintenance and repair;
• transport and storage and others.

They are a part of the item life cycle. The economic effect of a virtual factory for a user is the reduced costs of item exploitation in its life cycle. The virtual factory is a more advanced form of traditional corporations and concerns of the Industry 3.0.
Figure 1. Infrastructure scheme of cloud service for digital factory, smart factory and virtual factory of the Industry 4.0.
3. Cloud infrastructure service in the Industry 4.0

Cloud service supports informatively the activity of the Industry 4.0 company; there is a set of program means, which is a virtual infrastructure.

The service virtual infrastructure of the Industry 4.0 is a set of components with the following types of services (see figure 1):

- program as a service is a cloud automatic production mean of mathematical modelling and others, which gives the user a finished instrument for basic actions of project and production activity (preparation of technical documentation for the item);
- platform as a service is a cloud environment which gives the user a finished instrument to create new applications (3D modelling and cyber and physical equipment visualization) which is for projection and production of a particular item nomenclature;
- calculation machine as a service which is an imitator of the calculation machine which is a part of the cyber and physical system (cyber and physical production control system) and which is used for calculation and modelling functions in projection or production of items;
- communication as a service which is a set of virtual instruments (routers, communicators and other) for net interaction of machine type services united for solutions of project and production tasks in calculation clusters;
- technical support as a service which unites imitators of calculation machines as unified cloud components;
- data as a service which is informative resources such as separate documents (state and branch standards, company standards and others) or documents united in SQL (Structured Query Language) data base.

The Industry 4.0 company activity specialty means that the infrastructure can be a private cloud, society cloud or hybrid cloud. The cloud deployment type is the cloud access system for the company personnel for the services and components of technical documentation (information) for the item or for the factory itself. The user access the cloud services done with the standards of industrial internet of things of wireless data transferring protocols of project and production data.

4. Conclusion

The implementation of cyber and physical equipment and new informative technologies (additive technologies, internet of things, cloud technologies and other) projects and manufactures the complicated technical items, created new types of occupations which do not exist today. To prepare this personnel for the industrial sector of digital economy is an important element of modern machine designing and item designing industries.

The specialist of the Industry 4.0 companies must have some narrow knowledge and skills (competences) in some fields of machine and item designing and some knowledge of modern informative technologies. To prepare such specialist with such narrow knowledge, the Industry 4.0 must be done in parallel with projection and construction of the companies itself and the components of their project and production activity.

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