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RESEARCH ARTICLE

PROBLEMS OF INTRODUCTION OF INNOVATIVE TECHNOLOGIES 3D-PRINTING IN KAZAKHSTAN

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ABSTRACT

The article reveals the main Factors that require research of implementation and operation of the a new additive technology of the Republic of Kazakhstan. The main problems of studying and implementing new technologies have been developed. Within the study there was used the structural-functional model of the introduction of innovative technology was used. Exactly technology in the broad sense - the presence or the absence of them - determines the position of national economy in the world, its strategic position. Available of technologies provides scientist or designer with powerful tools for implementation of new ideas. Lack of technology limits creativity of scientists and engineers, forcing them to apply technical solutions that are in their possession, rather than those that are required to achieve goals. Therefore, technology itself is a major part of innovation.

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INTRODUCTION

Additive technologies (Additive Manufacturing, AM) - a term that is currently logged into use almost in all sectors and spheres of human activity. Heavy industry and dentistry, foundry and cooking, light industry and construction. Successfully conducting research in the field of 3D-printing in tissue engineering to create artificial human organs. The basic principle of the technological direction of additive technologies is a layering of material build-up. The concept of "rapid prototyping" or Rapid Prototyping (RP) was spread among industrialists and engineers. Today when searching for information you can use terms prototyping, three-dimensional printing, additive technologies, layered synthesis and others. There is evidence that the prototyping technology has been known in the defense industry laboratories in the middle of the 20th century. After the destruction of the military-industrial complex in Germany and impossibility to support the patent the general idea and description of the process of creating layered parts become open and accessible to the masses. Depending on the method of connecting the layers, methods of material coating, different variants of technologies can be identified.

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It should be noted that there is no a classic and well-defined classification of additive technology. Depending on the country and the manufacturer its own definition and separation of technologies can be given. It is possible to identify the main technologies that are the base for a wide variety of currently existing methods of layer build-up. Their representations are listed in Table 1. Additive manufacturing, also known as 3D-printing, is a process of creating object according to 3D model. . A range of different metals, plastics and composite materials may be used. Depending on the method of layers connection, the method of material deposition there are different types of technologies. The most widespread types of the developed additive technologies are the following: stereolithography (SL) - curing a photo-reactive resin with a ultraviolet laser or another similar power source; PolyJet technology- layer-spraying of a photopolymer with the following curing of each layer, MIT- layer-gluing of powder material particles, 3DP-inkjet deposition of liquid binder on powder. These technologies were used in military-space production and precision engineering, and were declassified after the expiration of the patent on the above mentioned SLS technology [1]. FDM is the cheapest method of printing, it provides a high popularity. Currently, on this technology some Russian printers is already created such as PICASO 3D Designer and Kazakh 3DLAB Prusa.

Table 1. The story of the three-dimensional printing

Company	Country	Technology	Founded	Date of release of the first products on the market
3D Systems	USA	SLA	1986	1988
EOS	Germany	SLS	1989	1990
Stratasys	USA	FDM	1989	1992
Z Corp	USA	MIT	1991	1996

In 2017 in the Petropavlovs, at the factory named after Kirov, the first Kazakhstani three-dimensional printer was made. It should be noted that the classification of the equipment for the additive technologies is not clearly formulated and interpreted depending on producing country. Presently the usage of 3D printing is significantly increasing. FDM technology, used in 3D printing, is an extruding of fused plastic filament. The usage rate of the equipment is explained by the expiration of the patent which led to the lower prices twofold since the time it was developed by Scott Crump, a founder of Stratasys, Ltd.. Today, the market of three-dimensional equipment has a wide range of different types and kinds of prototyping machines, three- dimensional printers and scanners, herewith. The key factor in the growth of any economy is to organize an effective system of technology transfer and its further improvement. Additive technologies are technologies of the future and according to foreign experts seven years will be sufficient for the technologies to be widely spread and used [2].

Review of the Relevant Literature

The results of data analysis from the Internet shows that there is a sufficient number of three-dimensional modeling laboratories, but it is mostly commercial service companies in the field of three-dimensional printing. Analysis of the various literary sources revealed that the existing data on additive technologies is only controversial proposals without any appropriate scientific and engineering work. It is obvious that research of the basic parameters which influence the quality of parts produced by the additive technologies are conducted but no research papers are found in the Internet. Much information of the widespread equipment tells that it is relevant to bring new knowledge on additive technologies to enter the market of the new technical production. Process complexity, absence of a mathematical model which would have helped to estimate the equipment characteristics accurately, particularly shrinkage, deformation, force, contact pressure, etc., shows that the additive technologies are not sufficiently investigated.

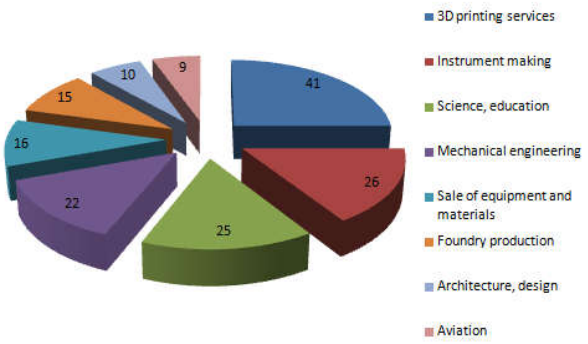

Fig. 1. Sector structure of survey participants

Poll at the conference 3D Print Expo 2017 from 5 to 21 September 2017 in Moscow, gave the following indicators. Of all who know about 3D printing, only 49% specialists, for the rest it is a hobby.

There are foreign magazines on additive technologies, but in Russia and Kazakhstan there are no textbooks with fundamental knowledge. The most famous publications are a manual for engineers, author M.A. Zlenko [3]. Also K. Kazemchuk and B. Dovbysh from St. Petersburg. According to the results of the survey, which was mentioned earlier, it is possible to draw the conclusion, which is shown in Fig. 1. Analysis of the situation regarding the implementation of additive technologies has shown that as weaknesses for development new technologies in Kazakhstan may be key factors:

- Absence of clear understanding of equipment purpose of and its inefficient use;
- Unprofessional service;
- Lack of technical support.

No quality advice due to the lack of highly qualified specialists. The main threat to transfer new technology in Kazakhstan is human potential.

METHODS

In a study structural and functional modeling under the Cause and Effect Diagram (also called: Ishikawa Diagram) was used to develop the contextual model new product with the aid of the additive technology. Branches are the causes that affect the receipt of a new product; this is shown in Fig. 2.

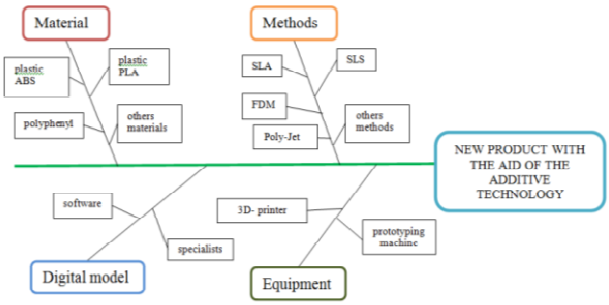

Fig. 2. Structural-functional model of obtaining new product with the aid of the additive technology

The overall forecast of the 3D printing market will reach $ 40 billion by 2027 - this is the forecast of Dr. John Harrow [4].The introduction of new technology is necessary in Kazakhstan very quickly.FDM (Fused deposition modeling) - modeling method by layering fusing of sequential layers coating material, which repeats the contours of the digital model. Usually, thermoplastics supplied in the form of of rods or coils of strands serves as materials for printing. The plastic strand is fed into an extruder where it is heated and molten material is welded through the nozzle to the building model. As a rule, the upper part of the nozzle is cooled by a fan to create a temperature gradient required to ensure a smooth supply of material. Extruder head is moved in two coordinates, synthesizing a certain layer of the model. Then, the platform is lowered, the next layer is created, and so on. The product, or "model" formed by layers, which frozen immediately after extruding. As FDM advantages can be noted: ease of adjustment from one material to another, non-toxic, low cost and relatively high productivity, low temperature processing, and minimum operator intervention in the functioning of the equipment.

Also the positive is the possibility of printing different colors of the same type of plastic to create a single model. The main problem can be considered the need of support for creating overhanging surfaces. It is possible to print a model of a single material with printing towers from another of a readily soluble material that will allow you remove the support elements easily after finish of the printing process. Furthermore, when printing FDM some welds formed between layers, possible reason can be bundle of temperature fluctuations during the processing cycle, and thus the quality of the surfaces can not be high, if one layer capacity model is 0.25 mm, so four-layer parts are placed on 1 mm. If part has an angled wall, which is not perpendicular but inclined table, then stages will be visible on it every 0.25 mm. Among the used plastic materials ABS and PLA, polyphenyl, polycarbonate and polyetherimide. These materials are valued for their heat resistance. Some embodiments of polyetherimide, in particular, have a high fire resistance, which makes them suitable for use in the aerospace industry [5]. If we talk about different technologies, then this is clearly seen in Fig. 3.

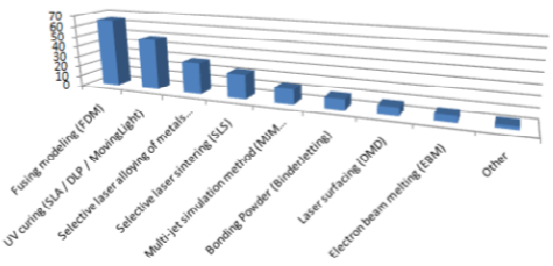

Fig. 3 Types of technologies that are common in Russia [6]

In general, we can talk about the division of additive technologies in inkjet and non ink-jet. This classification gives an idea of connection layers and allows you to immediately plan the quality of the model surface. In the case of inkjet technology either construction material or connection material can be supplied. In any case, the thickness of supplying material (strands diameter or adhesive volume) will affect on the quality of the surface because it determines the roughness parameter. An important parameter in determining the quality of surface in three-dimensional printing is the quality of the original three-dimensional CAD-model. Known definition of the technology is production method or combination of methods, processes and materials for specific products. For the consumer when choosing product the main characteristic is its value and quality.

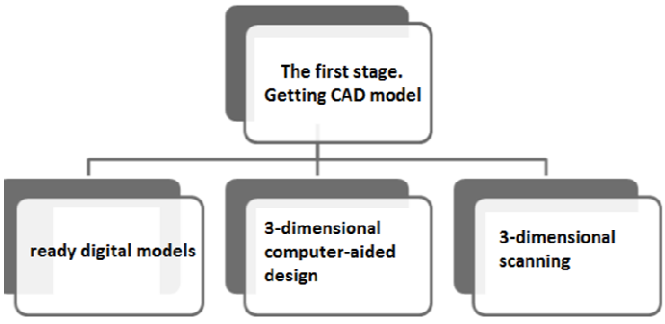

Fig. 4 Production CAD-model

The main advantage of the additive technologies is maximum realization of requirements and possibility of obtaining exclusive products at minimal expenses. Exclusivity of productsis created on the first step of new technology at design stage. You must accurately present the subject of production and have it digitized three-dimensional model. Existence of three-dimensional electronic model is sine qua for additive technologies. Now you can be offered three options for obtaining CAD-model: from the Internet using existing databases; 3-D computer-aided design and 3-D scanning. From the above it can be concluded that using of computer solid modeling provides a rapid expansion of additive technology and a its market price will be decreased. The cost of printed product will depend on uniqueness and quality of three-dimensional digital model much more than on material and equipment. All of this suggests that technologies and systems of 3d printing will occupy an increasingly large place in our lives.

There are a lot of 3D modeling software such as COMPASS, 3D Max, AutoCad and many others. This allows to project an object of any shape and size, so possibilities of Additive manufacturing are limitless. Highly precise micro parts can be printed now. As for Kazakhstan, we can assume that the most widespread software package for creating three-dimensional models is KOMPAS-3D, company Ascon. ASCON - Russia's largest developer of engineering software and integrator in the field of automation of design and manufacturing activities. In company's products are implemented achievements of the Soviet school of mathematics, 26 years experience in creating CAD and perfect expertise of data in the design and management in engineering and construction. ASCON software used by more than 9,000 industrial enterprises and design organizations in Russia and abroad. 3D-print today is no longer innovation it turns into usual business and KOMPAS-3D becomes habitual tool for many users.

The main advantages of software are:

- Russian, very simple interface that gives you a clear advantage over foreign design systems, it contributes to the rapid training of working in the program, even who first sat down at the computer;

- Ease of use;
- The availability of teaching materials and methodological literature that is available and distributed free of charge;
- A two-level training (freeware version for non-commercial home computers and licensed version);
- Universality (for machine-building, instrument-making, construction and other fields.).

Three-dimensional modeling system KOMPAS-3D is widespread in Kazakhstan through Asconofficial dealers in Karaganda and Ust-Kamenogorsk and successfully used at the leading enterprises. Opportunity for universities to purchase KOMPAS licenses has allowed tens of educational institutions of Kazakhstan to open the program course in the educational process. Drawing schoolbook for grade 9 is approved by the Ministry of Education and Science, it contains a section about computer graphics in KOMPAS-3D system . Annual competitions and contests carried out by Ascon allow to determine the level of younger generation's interest in new possibilities of three-dimensional modeling [7]ю

RESULTS

Knowledge of new technology should be based on scientific research and after the main provisions and the basic sciences will be formulated.

To create layered details need to know all the about the material how to set the equipment on effective modes of operation, accuracy and quality of the process parameters. Skills in new technologies is possible to obtain under the direction of specialists who know these skills. To acquire high-quality skills are neededequipped workshops and advanced equipment. You can make the conclusion about the need to introduce a new educational program or as it was called in the last century, a new specialty - additive technology. This is shown in Fig. 5.

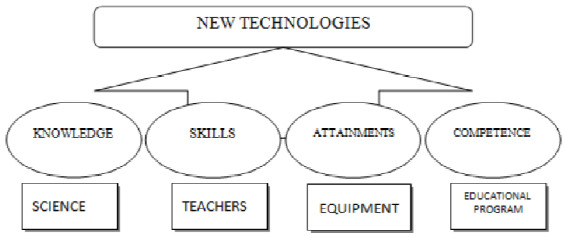

Fig. 5. The Basics of existence and development of new technologies [8]

As for Kazakhstan, we must take into account the Russian experience and move on our own directions. The Decree of the President of the Republic of Kazakhstan dated June 4, 2013 № 579, said: "We need to focus resources to meet the requirements of engineering and technical personnel with the relevant expertise of international level…" [8]. For the proposed scheme, as a confirmatory factor can give an example of the Swiss Federal Institute of Technology Zurich (ETH Zürich).An investment of financial resources in technology of 3D-printinginstitute guide explains the brewing needs to improve educational programs of the engineering direction.The acquisition of a number of 3D printers will improve the level of teaching, including courses from CAD systems and engineering graphics. Thus, the European Institute of ETH Zurich, promotes rapprochement between educational institutions and industry, and focused on the European Employers who need specialists in the three-dimensional printing.

The result was the release of the main tasks for the near future on the development of additive technology in the Russian Federation:

- organization of working group on the creation of the design industry, the definition of the main participants, sources of financing, range of consumers of developed products;
- create a new model of introduction of perspective technologies in the additive industry by organizing a consortium of different sectors of the industry, as part of which can be represented as manufacturers and consumers of technological solutions, including large companies with state participation;
- The establishment within the Foundation of perspective researches (FPR) for the organization of the laboratory breakthrough research;
- Creation of a unified coordination mechanism - a single center of competence on additive technologies;
- preparations for the new academic year, proposals on development of the system through the training of specialists in the field bases of intellectual and information technology, computer simulation, robotics and additive technologies;
- Creation of a system of national standards for additive manufacturing, including:
- general and special qualification of materials (source and synthetic);
- standardization of designs, technologies and equipment;
- The development and certification of quality control methods and properties of synthesized materials and products;
- rules of applying additive manufacturing products (assessment of safety, forecasting term).

Based on the above we can suggest that the successful development of new technologies requires the support of the state.

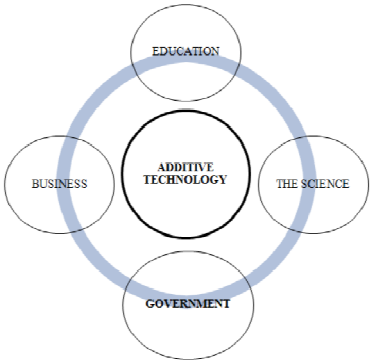

Fig.6 The State should become a participant of the process of introducing new technologies

Finally, the degree of use of AM-technologies in material production is correct indicator of real industrial power of state, indicator of its innovative development.

Thus, in accordance with the the foregoing for implementation of additive technologies are necessary:

- Fundamental knowledge based on scientific principles;
- Specialists teachers to transfer skills;
- Equipped workshops and laboratories for the acquisition of skills;
- A new specialty in high school.

And most importantly, based on the above we can suggest that the successful development of new technologies requires the support of the state. The possibility of qualitative development and implementation in production, and most importantly in the educational process of new additive technologies will help to boost industrial-innovative development of Kazakhstan, and will enable young professionals feel more confident in the international market [10].

DISCUSSION

Thus, the perspective direction for 3D printing in the industry is printing with metal powder and laser sintering. but there are two problems: technological; normative. First, additive technologies do not guarantee that detail will immediately go into production, as we would like. Concerning details for the industry, similar projects should be certified, similar to inspection of details for responsible units. For this, you need to have standards that you can target. For this, it is necessary to have standards that serve as an example.

We can talk about two significant defects, appearance of pores in the model - the powder is fused non-uniformly, small voids are obtained.. If there are many voids, they will weaken the part. And cracks that are inevitable as a result of uneven sintering. If we talk about metal powders, then everything here is also ambiguous. It is widely believed that they should be spherical. This is due to technology: the powder is scattered over the surface by a layer from 20 to 40 microns and then a laser is sent to it. Sphericity, close to ideal, is needed for the material to spread evenly over the surface without delays, otherwise the particles will cling to each other. Now this new technology is beginning to spread - the powder is fed to the place where the beam falls. You can serve not only balls, although balls are easier to move. Not sphericity is important, but the size is from 10 to 100 microns. Too large fraction is sintered unevenly, and fine - flows and mixes. That is, the requirements for powders vary with the change in technological processes.

Now the situation is that many domestic enterprises purchased 3D printers and were dependent on producers of imported powders. These powders are very expensive, and raw materials from other supplier are not recommend to use in their 3D printers. Therefore, the first task of our science is to learn how to make a quality powder for 3D printer. The second step will be the creation of own equipment. In the three-dimensional printing activities are regularly exposed Russian production printers PICASO 3D, differing worthy relation "quality-price". However, in view the fact that now on the market of equipment appeared not only Russian, but also Kazakh producers, solution of the problem of implementation in the educational process and the study of new technologies, require a speedy solution.

Conclusion

Nowadays, when profits of enterprises depend on the speed of response to market needs, necessary using of new technologies that provides updating its range of products in short terms. For successful business development you need to respond quickly to growing and changing demands of consumers, this means greatly simplify, accelerate and reduce expenses of manufacture. Kazakhstan needs new technologies for machine building, need three-dimensional printing. Technologies discussed in present work are not only modern and highly effective, but innovative in its essence, because they make possible to generate new technologies, carry a new quality. Besides obvious advantages in speed and often in manufacturing cost of products, these technologies have important advantage in terms of environmental protection, and in particular, greenhouse gas emissions and "thermal" pollution. Additive technologies have great potential in reducing energy costs for the creation of a wide variety of products.But without specialists of this technology will not be in Kazakhstan.

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