Improvement of Fabrication Efficiency of Complex Shaped Parts in Engineering

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***Abstract*: At present numerous efforts of engineering industry are aimed at optimization of expenses, improvement of fabrication efficiency of parts, and competitiveness of fabrication of complex shaped parts. Parts are fabricated using casting into sand molds. While searching for new solutions, it was required to consider a new method of fabrication of complex shaped parts. Two fabrication methods of complex shaped parts were compared. Additive technologies were proposed as an alternative fabrication of submersible pump impellers. Impeller is the major part of pump, thus, fabrication of this complex shaped item is especially important. Necessity and efficiency of fabrication of complex shaped part using additive technologies has been proven. Layer-by-layer synthesis for fabrication of impeller of submersible pumps has been considered.**

***Index Terms*: petroleum engineering, machine building enterprises, additive technologies, submersible pumps, impeller, foundry equipment.**

I. INTRODUCTION

Pump engineering is one of the most important branches of engineering industry. Numerous industries are based on application of pumps. Engineering industry also includes metal machining. Engineering industry manufactures machinery and equipment, apparatuses and instruments, various mechanisms for material sphere, science, cultural sector and services. Metal machining fabricates metal items, repairs machinery and equipment. At present engineering industry in Russia is comprised of numerous independent industries including more than 350 branches and productions [1]. Engineering industry fabricates working tools: machinery and equipment, instruments and computers, transfer units, means of transportation for all industries of national economy [2].

Analysis of state and trends in global oil and gas industry reveals that at present the rate of oil production increases both in Russia and abroad. In Russia the main oil production is carried out using electric submersible pumping systems (ESPS) competitive with foreign analogs.

Main participants of Russian market of pump equipment can be conventionally subdivided into oil and gas companies, the main consumers of the products, companies ordering diversified products, and foreign companies involved in oil exploration, drilling, and production [3].

At present the pump engineering industry is on rise. During the recent two–three years the pump production became steady and even increased. Manufacturers have significantly upgraded the list of their products, standards are reviewed and coordinated. As a consequence, the requirements of internal market for numerous pump models are satisfied by Russian manufacturers [4].

The Russian market of pumping equipment is very challenging. Its development can be attributed to oil and gas sector, since the high demand for domestic pumps is formed mainly by oil companies.

At present the main amount of oil is produced using ESPS. These assemblies make it possible to pump stratum fluid at the rate of 10 – 2500 m3 per day from the depth of up to 3300 m [5]. ESPS are intended for pumping of stratum fluid from oil wells and are used for forced extraction of fluid.

On the one hand, at present the quality of ESPS has significantly improved, but on the other hand, this improvement is accompanied by increased costs. Meanwhile, moderate cost and quality of Russian machinery have been up till now an important factor of competitiveness. Only recently the production of some types of oil and gas equipment started to rise, the improvement of quality and competitiveness became an urgent issue. It can be solved by fabrication methods.

II. FABRICATION OF PARTS

Electric centrifugal pump for oil production has a multistage and multisection design [5]. The peculiar features are characterized by materials, designs, number of bearings, friction couples, and application.

The main components of a section are body, shaft, stages, top and bottom radial bearings, impeller, head and foundation.

Submersible pump impeller is required for movement of fluid, it is the main working component of ESPS and is intended for operation in friction units under severe conditions. These properties determine its reliability and wear resistance.

Impeller fabrication of polymer composite materials, improved corrosion resistance, no salt deposits and clogging of flow channels, as well as decreased weight of rotor provide long faultless operation of pump and increase its quality. However, study of fabrication of pump parts demonstrated that it was insufficient for complex

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shaped parts. The fabrication process should be reviewed in terms of improved strength, accuracy of fabricated casts, high quality of surface, decrease in turnover of molding compounds, and improvement of hard-working conditions.

At present engineering companies fabricate submersible pump impellers by means of casting into dispensable sand molds [6]. Casting is intended for production of cast items of metal melt solidified in molds after certain time. The molds are made of molding compounds by compaction. The obtained casts are shot blasted in order to remove sand burning and molding mix, and are directed for machining to obtain final products [7]. Submersible pump impellers are fabricated by this technology for many years.

Additive technologies are proposed as an alternative fabrication of parts. Additive manufacturing (AM) or layer-by-layer synthesis is a rapidly growing trend of digital production [8]. In some cases, they are applied for fabrication of final products [9].

A. Comparative analysis of the applied methods

The proposed alternative based on additive technologies is characterized by certain advantages. The main of them are the accuracy of final casts, high quality of their surface, possible fabrication of complex shaped parts, moderate turnover of molding compounds. In addition, the hard-working conditions are improved due to implementation of these methods, which is attributed to reduced dust and gas emissions.

One of the trends of the proposed approach is SLS technology (Selective Laser Sintering), (Selective Laser Melting) [10].

In this case the constructing material is loose powdered materials, and laser is not a light source as in SLA machines but a heating source used for fusion of powdered particles.

Another trend is layer-by-layer sintering of metal powdered compositions. Development of this trend promoted development of production of metal powders. The alternative shape fabrication based on 3D synthesis of required shape from fluid substance provides a new approach to fabrication of precise parts [11].

Commercial implementation can be accompanied by difficulties in 3D simulation and programming, CAM technologies, technologies of reengineering, etc. However, expenses for personnel training will be reimbursed in the form of high quality and reliable products. Taking into account that implementation of 3D medium is possible and available, commercial implementation of this method is quite possible for fabrication of complex shaped parts of petroleum engineering. 3D model of impeller is illustrated in Fig. 1.

Fig. 1. 3D model of impeller.

The following conclusions were obtained on the basis of comparison of fabrication methods.

Submersible pump impeller fabrication using layer-by-layer synthesis is characterized by the following advantages:

1. Decrease in time consumption for R&D projects.
2. Increase in strength of products by 15–20% with consideration for thermal treatment.
3. Cost efficiency due to unnecessary manufacture of auxiliaries.
4. Possible fabrication of complex shaped parts.

Fig. 2. Cross section of cast part.

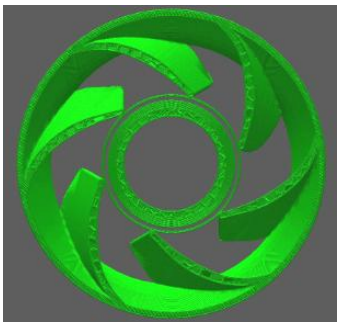

Fig. 3. Cross section of part fabricated by 3D printing.

In order to implement the new method based on additive technologies, the study was performed at facilities of engineering company where a submersible pump impeller was fabricated as 3D model. Then a sample part was fabricated by 3D printing. The cross section of cast part and the cross section of 3D printed part are illustrated in Figs. 2 and 3. The 3D printed part was tested for strength and shape accuracy. On the basis of comparison, it is possible to conclude that the preliminary assumptions have been confirmed: application of layer-by-layer synthesis reduces fabrication time, increases strength of supporting part, does not require for auxiliaries, easily handles complex geometry, and completely eliminates hard working conditions. However, it is required to consider for actual factors upon development of additive manufacturing which are comprised of requirements to supporting material, restriction of assembling angle, wall size, hole size and its accuracy [12].

III. RESULTS

While using AF technologies for fabrication

of pump impellers, it is possible to save up to 75% of raw stuff.

Additive technologies in engineering industry provide the following:

− fabrication of complex shaped and unique parts without involvement of mechanic machining and expensive auxiliaries;

− improved profitability of small-scale fabrication and exclusive variants;

− elimination of human factor upon fabrication of parts: the process is totally automatic;

− decreased weight of parts due to decrease in thickness of walls, elements, development of cell and other structures;

− possibility to fabricate complex, integrated parts per single process cycle;

− no cast defects and stresses in parts;

− control of physicomechanical properties of fabricated item.

IV. CONCLUSION

In conclusion it should be mentioned that application of the proposed fabrication method of submersible pump impeller makes it possible to fabricate items directly of powder eliminating preliminary procedures of development and manufacture of casting equipment as well as intermediated mechanical machining. Using a preliminary obtained CAD model of a complex shaped part, this part is grown layer-by-layer upon selective fusion of powder particles. Application of additive method influences significantly the reduction of expenses, improvement of quality and reliability of complex shaped parts in engineering industry.

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