MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

School of Industrial Automation and Digitalization
Department of Industrial Engineering

Made by: Alimanov Sanzhar

CAD/CAE/CAM modeling of parts of a multistage submersible pump

DIPLOMA WORK

Specialty 5B071200 – Mechanical Engineering

Almaty 2020

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Kazakh National Research Technical University named after K.I.Satbayev

Institute of Industrial Automation and Digitalization

Department of Industrial Engineering

APPROVED FOR DEFENSE

Head of the Industrial

Engineering Department, PhD

Arymbekov B.S.

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“_____”______________2020

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Topic: " CAD/CAE/CAM modeling of parts of a multistage submersible pump"

5B071200-Mechanical Engineering

Performed by Alimanov S.M

Reviewer

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"_____" _________2020

Scientific adviser

Candidate of Technical Sciences,

Associate Professor

______Isametova M.E

"_____" _________2020

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TASK

for completing the diploma work

For student: *Alimanov Sanzhar Maratovich*
Topic: *"CAD/CAE design of unnamed aerial vehicle design"*
Approved *by the order of university rector №762-b from "27" January 2020*
Deadline for completion the work *"24" May 2020*
Initial data for the diploma project: modeling of parts of a multistage submersible pump
Summary of the diploma project:

a) *Construction description;*
b) *Information about a multistage submersible pump and technology;*
c) *Selected material properties.*
d) *CAD/CAM C systems and their application in mechanical engineering*.

List of graphic material: *presented 20 slides of presentation of the diploma project*
Recommended main literature:

1. Malyuhv.N. Introduction to modern CAD: a Course of lectures. - Moscow: DMK Press, 2010. -192 p. - ISBN 978-5-94074-551-8
2. Дипломное проектирование по технологии машиностроения: [Учеб. пособие для вузов / В. В. Бабук, П. А. Горезко, К. П. Забродин и др.]

3. THE SCHEDULE

For the diploma work preparation

Name of sections, list of issues being developed	Submission deadlines to the scientific adviser	Notes
Theoretical part	03.03.2020	
Technical part	15.03.2020	
Calculation part	9.04.2020	

Signatures

Of consultants and standard controller for the completed diploma work, indicating the relevant sections of the work (project).

The section titles	Consultant name (academic degree, title)	Date	Signature
Theoretical part	Candidate of Technical Sciences,Isametova M.E	03.03.2020	
Technical part	Candidate of Technical Sciences,Isametova M.E	15.03.2020	
Calculation part	Candidate of Technical Sciences,Isametova M.E	9.04.2020	
Normcontrol	Candidate of Technical Sciences,Isametova M.E	24.05.2020	

Scientific adviser ________________ Docent, Isametova M.E
Signature

The task was completed by student: ___________ Alimanov S.M
Signature

Date: “24” May 2020

ANNOTATION

This diplom work with the design of a multi-stage submersible pump and its components using CAD / CAE. The aim of the diplom work is to design a multi-stage submersible wheel, with its further introduction into production. Distinguish this pump from the rest. In the process of doing the work, general information about the pump, its design features were studied.

Calculations were made of the main structural dimensions, as well as strength calculations, which should correspond to the acceptable values established by GOST.

An analysis of the results was performed in the SolidWorks program. The 3D model of the pump obtained during the design was investigated for emerging stresses, strains and loads.

АҢДАТПА

Бұл дипломдық жұмыстың тақырыбы CAD/CAE қолдану арқылы көп сатылы суасты сорғысы және оның тораптарын жобалау болып табылады. Дипломдық жұмыстың мақсаты - көп сатылы суасты доңғалағын жобалау, оны әрі қарай өндіріске енгізу. Бұл сорғының басқаларынан ажырату.

Жұмысты орындау барысында сорғы туралы жалпы ақпарат, оның дизайн ерекшеліктері зерттелді.

Есептеулер ГОСТ белгілеген қолайлы мәндерге сәйкес келуі керек негізгі құрылымдық өлшемдерден, сонымен қатар беріктіктен есептеулер жүргізілді. SolidWorks бағдарламасында нәтижелерге талдау жасалды. Жобалау кезінде алынған сораптың 3D моделі пайда болған кернеулер, штамдар мен жүктемелер үшін зерттелді.

АННОТАЦИЯ

В данной дипломной работе рассмотрены вопросы проектирования многоступенчатого погружного насоса и его узлов с использованием CAD/CAE.

Целью дипломной работы является проектирование многоступенчатого погружного колеса, с дальнейшим внедрением его в производство. Различите данного насоса от остальных.

В процессе выполнения работы были изучены общие сведения о насосе, его конструктивные особенности.

Были произведены расчеты основных конструктивных размеров, а также расчеты на прочность, которые должны были соответствовать допустимым значениям, установленным ГОСТом.

Был выполнен анализ полученных результатов в программе SolidWorks. 3D-модель насоса, полученная при проектировании, была исследована на возникающие напряжения, деформации и нагрузки.

CONTENTS

INTRODUCTION

Centrifugal pumps are called dynamic hydraulic machines. The functional task of such equipment is to pump liquid, which is done if the kinetic energy of rotation is converted into hydrodynamic energy of the stream. An electric motor is provided for rotating the pump shaft. The liquid reaches the impeller, on which there are blades on the casing necessary to act on the particles of the liquid and transmit that energy.

Centrifugal forces act so that the fluid is directed to the periphery of the impeller. In this area, through a special annular channel, which is also called a cochlea, fluid is supplied to the discharge pipe, that is, the diffuser. And the task of this element is to convert part of the dynamic energy into static.

A multistage centrifugal pump is a more advanced equipment, the device of which involves several impellers and stages located one after another. When choosing a centrifugal pump, you should pay attention to how the shaft is sealed. Modern models differ in face consolidation when, like older models, they have stuffing box packing. The first configuration is good in that it keeps the structure tight and prevents leakage. Even if the pump runs with vibrations or its shaft shifts somewhat, this will not cause leakage.

At the moment, there are a considerable number of pumps for pumping liquid and the most common of them are centrifugal. They differ in their design features and are single or multi-stage.

In this thesis, we consider a multi-stage centrifugal submersible pump.

1 Design technology using CAD / CAE systems

1.1Basic design principles

The design process is considered the initial frontier of development of products that have not yet taken place or the modernization of fresh ones. The design process is the receipt and translation of the original description of the product into the final description on the basis of the implementation of an important calculation and design set of cases.

Automatic designing is called obtaining design conclusions with support for human interaction and automation. The existing system is called an automatic design system. The system alignment provides a set of thoughts on the design of difficult systems, this alignment is more cumulative between a large number of alternatives and as a consequence it is used more often. One of the leading aggregate foundations of the system is considered to be the discussion of the interaction of all kinds of difficult systems and parts of certain phenomena.

System engineering studies similar difficult technical systems, all kinds of methods for their design and explores the overall organization of the matching process, the application and formation of technical systems and methods, the basics of their design and research. In systems engineering, the goal-setting of the system and the ability to carry out a discussion of the system through the prism of selected goals are fundamentally important. Actually, that can help the designer to discard insufficiently important data in the design and modeling of something or another model and not directly run over to the formulation of optimized tasks. Automatic design systems are one of the most difficult advanced artificial-origin systems in fact, which makes preparing their design impossible without a system layout or other alternatives. As a consequence of this, system engineering is considered a necessary part in the study of advanced automatic systems and technologies for their use, for example, how without it, the study of the data of all is considered practically unbelievable. A flashy case of the need for a system alignment in modeling is considered the probability through this system to give design continuity and the likelihood of reapplying information and developments during the design of difficult engineering structures. Next, we look at all sorts of layouts and varieties of the system layout for the conclusion in these difficult systems. In the structural scenario, as a variety of systemic, it will be necessary to combine all kinds of systems of their components (blocks) and submit evaluation aspects to the information when sorting their selective synthesis with preparatory monitoring of these components.

The block-hierarchical alignment to design consists in decomposing difficultly outlined objects into simple descriptions of these objects and, in accordance with this, decomposing means into hierarchical values, one uses the opinion of an ascending and descending manner of design that suggests a way of analyzing individual parts of a joint, not easily described object, considering its component basic parts, they differ in what level of the hierarchy the test of the provided system begins. Object-oriented design layout (OOP) is specialized in leading to review and develop information systems and, above all, their software (software). A prerequisite for the provided specialization is a number of advantages that this layout distinguishes in the conclusion of tasks by complex information systems and integration into their software:

- Highlights the probability of the highest value of structuring the model, distributing the data and procedures of the model taking place between the classes of objects;
- Reduces specification size
- Reduces the possibility of data refraction due to incorrect actions by limiting access to specific categories of data in objects.

Descriptions in any class of objects of allowed appeals and software integration. For all the layouts for the design of difficult systems, the proper features are still characteristic:

- Structuring of the design process, expressed by the decomposition of design tasks and documentation, the identification of stages, boundaries of design procedures. This structuring is considered the essence of the block hierarchical alignment to design;
- Iterative nature of design
- Typification and unification of design conclusions and design tools.

1.2 Modern CAD / CAE systems and their applications in mechanical engineering

CAD (computer-aided design). CAE (computer-aided engineering) systems make it possible to avoid the classical methods of design, revealing the likelihood of creating this on individual computers. These systems are programs that work with graphics, and also with tolerance analysis, calculation of global inertial qualities, FEM modeling and visualization of analysis results.

The main function of CAD / CAE systems is to determine the geometry of the structure of the model as a characteristic from which all subsequent calculations and measurements will be based on determining the actual cycle.

The superiority of the design method provided is considered to be the ability to design more difficult details and simplify preparatory calculations of the product. As a consequence of this, these systems are usually considered automatic design systems.

It is possible to subsequently introduce and apply the geometric information to the CAD system in CAE- and CAM-systems, in fact, that CAD-systems are prepared by the unimaginably necessary part of advanced design, which allows saving time and reducing the number of misses associated with the need for modeling and determination important model geometry.

For advanced CAD systems, the modular construction principle is applied. The basic modules of the designed model are used for solid-state and surface modeling, the creation of systems from the basic components of the form, make the creation of drawings with volumes and tolerances. Design continuity is guaranteed by the user's probability of replenishing the "library" with unique models. The assembly is performed with the support of functions by calling or referring to the components and models in the library archives, their transformation, development of fresh assembly details, strengthening their state of relatively different components of the assembly and setting the freedom of these elements.

There are auxiliary modules of design engineering, which have all chances to be applied for more specific, but not wide specialization. These modules have every chance to be used, for example, when it is necessary to design panels from composite materials, develop stereotypes and foundry molds, pipeline systems, welded systems, wiring electrical cables and bundles. The life of these modules for CAD systems is increasing their usefulness in automated design.

CAE-technology uses computer systems to analyze the geometry made in a CAD model, to model and study the behavior of an object, to improve and optimize its system with support for the automation of engineering calculations, analysis and simulation of body processes, will realize dynamic modeling. The CAE system has the ability to execute:

-Kinematic test (the ability to determine the line of movement of movement and the dynamics of the links of the mechanism;

-Dynamic test with gigantic displacements and destruction (used to simulate the behavior of materials during operation of the facility or in the evaluation of technological processes, for example, the stamping process or other high-speed, strongly non-linear processes);

-Payment of hydro and gas-dynamic processes;

-Testing and testing logic and synchronization (simulate the operation of difficult electrical circuits, for example, when developing an element base for control systems and so on);

-Modeling of elastic-stressed, deformed, thermal state, system sway, determination of critical loads. Most often produced in accordance with the method of final components);

-Payment of states and transitional at the macro level;

-Simulation of difficult production systems based on global service models.

At this moment, there are a huge number of companies, developers offer a number of universal software systems in which CAD / CAE technology is sold, based on methods that provide the process of automatic design in the field of engineering. CAE systems include these programs as Ansys, MSC Nasctran, NX Nastran, Cosmos / M, Nisa. Moldflow, ABAQUS, LS-DYNA, MSC-ADAMS, MSC, T-Flex Test. CAD systems include CATIA (Dassault Systemes). UNIGRAPHICS NX (Siemens PLM Software), Pro / Engineer (PTC). AutoCAD Inventor Professional, KOMPAS-3D, SOLIDWORKS.

2 Multistage Submersible Pump Details

2.1 Basic information about a multi-stage submersible pump

Submersible pumps are actively used both in the household and in industry. Depending on its design, they are referred to as multi-stage pumps or single-stage. The proprietary pumping equipment contains a special internal device, but it also stands out with specific technical features and, in accordance with this, the areas of use.

Submersible pumps have every chance of being a part of technological systems for increasing pressure or supplying water at enterprises and residential areas. The desired model relates to the field of development of pumps and compressors and has the ability to be used in submersible multistage centrifugal pumps for oil production from wells.

2.2 Stage submersible multistage centrifugal pump

The degree of a submersible multistage centrifugal pump is popular, having an impeller with vanes located between the main and driven disks forming the flow path of the impeller, and a guiding apparatus with vanes located between the lower and upper disks forming the flow path of the guiding main wheel of the impeller, protrusions directed in a circular direction, performing the functions of an auxiliary retaining wheel of a vortex pump.

The operation of such a retaining wheel is associated with an increase in the pump drive power, especially in the property zone with small feed values. Closest to the claimed technical conclusion is the degree of a submersible multistage centrifugal pump, consisting of an impeller with vanes located between the main and driven disks forming the flow path of the impeller, and a guide vane with blades located between the disks forming the flow path of the guiding apparatus. In this case, the impeller blades are L-shaped, the protruding output sections of which are located around the circumference behind the outer edge of the main disk and form an axial radial lattice, which ensures the reversal of the jet of water from the exit of the impeller from circular to axial.

An embodiment is possible in which the impeller blades are not bad to the main disk.Another embodiment is likely, in which the impeller blades are at an angle to the main disk, not exceeding the meaning of the output angle of the blades 5 by more than 20 degrees.

At the input and output of the flowing part of the guide vane, there are, in accordance with this, input and output annular video cameras that provide hydraulic association of the flow parts of the impeller and the guide vane. Between the contacting horizontal surfaces of the impeller and the guide apparatus, axial bearings are supplied.

2.3 Disadvantages of a multi-stage submersible centrifugal pump

As a multi-stage, for example, a single-stage pump stands out for the advantages that make the device data. The superiority of the pumps in question include:

- Compact dimensions and low authority (since the pumping equipment shaft is directly combined with a drive electric motor, which in fact eliminates the need for additional transmission mechanisms);

- High reliability and long service life, inaccessibility of the need to implement the ongoing maintenance;

-Minimizing the risk of pressure surges (the liquid medium pumped by the pumps provided on the similarity is served in a pressure head in a smooth mode);

-Lack of valve components (this makes it possible to pump dirty watery environments that have insoluble solids in their composition);

-Simplicity of the system (it is precisely as a result of this that any multistage or single-stage pump is affordable);

-The simplicity of the centrifugal pump system guarantees its maintainability, modernization and conversion between defects of single and multi-stage pumps distinguish:

-A sufficiently low efficiency when working in the mode of small productivity (this is done by the task that in the case when it is required to pump a small size of an aqueous medium under high pressure);

-Inability to start quickly (for these devices to start working, their working video camera must first be filled with liquid).

2.4 The Technical result of using the model

The technical result of the application of the desired model is the creation of a submersible multistage centrifugal pump stage, which ensures a decrease in the pump drive power when pumping gas-liquid consistencies and allows to reduce the overall axial value of the pump. In addition, the technical conclusion should be allowed to facilitate and reduce the cost of the technology for preparing the details of the stage. The indicated technical result is achieved by the fact that the degree of a submersible multistage centrifugal pump is made of an impeller having a hub and vanes, a guide apparatus, 6 upper and lower disks with vanes located between them, forming a flowing portion of the guide apparatus. At the input and output of the flowing part of the guide vane, there are, in accordance with this, input and output annular video cameras, which provide hydraulic association of the flow parts of the impeller and the guide apparatus. The impeller blades have inlet portions elongated to the hub, located around the circumference with the formation of an axial radial lattice. Elongated sections of the impeller blades have every chance of owning protrusions that are circumferentially below the upper disk of the guide apparatus and spinning in the output ring video camera of the guide apparatus.

Guide installation has the ability to be collapsible. In this case, the upper disk of the guide vane is removable. The impeller has the ability to be made as a wheel open in the likeness and equipped with blades mounted exactly on the hub. A centering bearing can be installed between the shaft and the guide unit.

The set of significant symptoms of the claimed technical conclusion has the ability to be repeatedly used in the manufacture of pumps.

The technical result is to reduce the power consumption and, in accordance with this, to increase the coefficient of the desired pump exposure, especially in the area of small feed. The claimed technical conclusion guarantees a reduction in the axial dimension and simplification of the preparation of the system.

2.5 Principle by which both single-stage devices and multistage pumps work

The liquid that appears in the inside of the pump before starting it, when the impeller rotates, is captured by the blades and begins to move together with them.Under the action of centrifugal force, the liquid is thrown to the walls of the internal video camera, due to which the highest pressure is formed near them.When moving through the area of the discharge pipe, the liquid, which is under the highest pressure, is pushed into it.When the water pumped by the pump is thrown back to the walls of the working video camera in the central part of the latter, an air resolution is formed, in fact, which contributes to the absorption of the aqueous medium through the inlet pipe.

Due to the above principles of operation in pumps as a single-stage, for example, and multi-stage similarity, the continuity of the process of suction and pushing out of the pumped water during rotation of the impeller is guaranteed.

The scope of the use of pumping equipment provided on the similarity is importantly expanded by the precedent, which, unlike piston devices, does not vibrate the pressure of the water in the pipeline system it serves. As already mentioned above, single-stage and multi-stage centrifugal pumps have design features that determine the differences in their technical properties. So the leading substances of a single-stage pump system are:

-Case, which is often called the "snail";

-Working wheels with blades;

-Sealing components of the shaft;

-Shaft combined with a drive motor and providing impeller rotation;

-Sealing components of the camcorder with an oil bath;

- Support for the bearing unit;

- Bearing support;

-Hole, with the support of which the oil value is monitored in the camcorder;

A single-stage centrifugal pump, unlike multi-stage models, is equipped with one working wheel. A centrifugal multistage pump has the ability to own 2 or more working wheels with vanes in its own equipment, in fact, which makes it important to increase the efficiency of such equipment. Due to the presence of several working wheels, centrifugal multistage devices, if you associate them with single-stage ones, have certain advantages:

- With the support of multi-stage pumps, it is possible to realize the pumping of water with a higher productivity, characterizing the amount of watery medium that a hydraulic machine passes through itself per unit time.

- Multistage pumps are ready to create a flow of water with more high pressure indicators, measured in meters of water column. Almost the onslaught of water, which make multi-stage electric pumps in the likeness, is formed from the sum of the pressures formed by any of its stages. This quality of multi-stage hydraulic machines allows to achieve higher water pressure in the piping systems they serve and move it over them to longer distances and more important heights.Scheme of a multistage submersible centrifugal pump is shown in Figure 1.

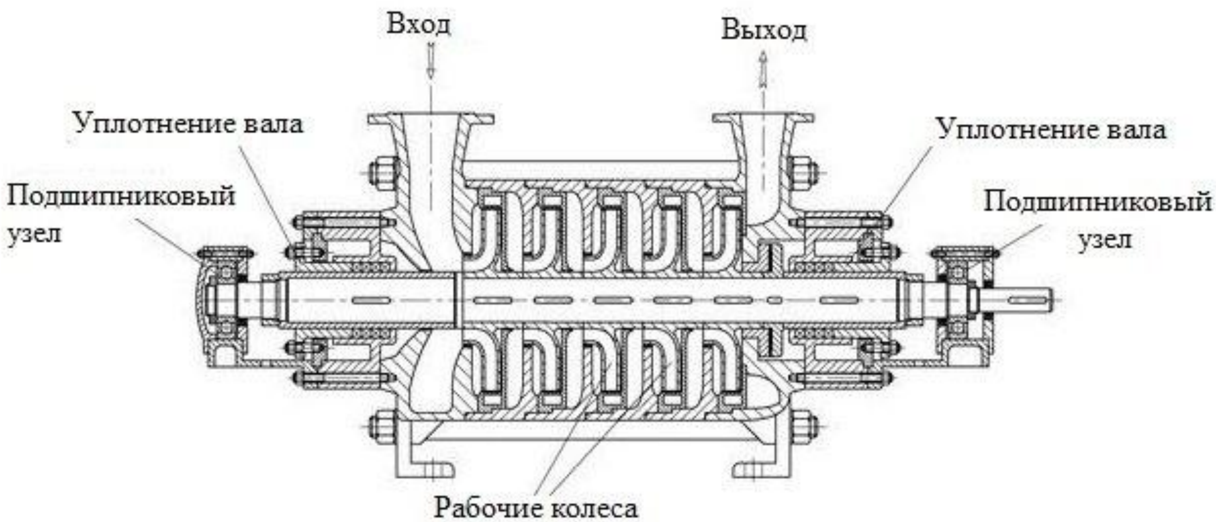


Figure 1 – Scheme of a multistage submersible centrifugal pump

A multi-stage centrifugal pump, depending on its own design, can be sectional or spiral. In sectional devices similar to a watery medium, in the process of pumping, it alternately moves from 1 section to the last, with this onslaught of water increasing still alternately.

2.6 Grounds for classification

Centrifugal submersible pumps (as multi-stage, for example, and single-stage) are divided into various categories according to a number of their own characteristics and varieties of design.Double-bearing horizontal multi-stage submersible pump is illustrated in Figure2. So, depending on the spatial position of the axis of the working shaft, they have every chance to 1 of the appropriate types:

- Horizontal centrifugal submersible pumps;

- Devices with a vertical location of the working axis;

Figure 2 – Double-bearing horizontal multi-stage submersible pump

A horizontal submersible pump, the axis of rotation of the shaft and impeller of which are placed strictly in the horizontal plane, is, as a rule, a large-sized apparatus used for industrial purposes. Multistage horizontal submersible pumps are used to equip pumping stations that provide independent water supply systems, in which similar devices are used together with a hydraulic accumulator. In this way, a horizontal pump urgently requires more space for its own installation.

Submersible pumps with a vertical axis of the shaft and impeller have found more widespread in the domestic sphere. In this constructive implementation, it can be presented as a surface multi-stage pump used for servicing an independent water supply system, for example, drainage or fecal. Vertical centrifugal pump for the home is in Figure 3.

Figure 3 – Vertical centrifugal pump for the home

Another aspect in which various categories are distinguished between single and multi-stage pumps is the location of such an axis with respect to the pumped aqueous medium. So, depending on the parameter provided, the pumps have every chance of being surface (or ground), submersible and semi-submersible. Surface instruments, in which it has the ability to play a vertical multi-stage and single-stage or horizontal multi-stage and single-stage pump, are placed on the ground plane, outside the well, but close to it. This equipment is placed, tightly protected from moisture, in a pit, on a specially prepared area or in a separate room.

One of the more important defects of the pumping equipment provided on the similarity is that, in fact, during operation it emits a rather large amount of noise. It is in the footsteps to take into account the fact that the surface centrifugal pumps can only be selected if the depth of the well from which it is planned to pump out water with their support is not higher than 10 meters.

Centrifugal multistage submersible pumps, similar to those during operation, are completely immersed in the pumped medium. Separate models of vertical submersible centrifugal pumps similarly have every chance of being located in the pipe along which the pumping out of the aqueous medium is performed.

Figure 4 – Centrifugal Semi-Submersible Multistage Vertical Pumps

When using submersible pumps, it is possible to raise water from a serviced well from a depth of 40 meters or more. Submersible pumps in the likeness are ready to guarantee the pumping of an aqueous medium with a capacity of up to 16 m3 / hour, while this onslaught has the ability to reach 200 meters of water column. Submersible pumps literally do not make noise during their own operation, because they are completely present in an aqueous environment.

The classification of single-stage pumps is also performed according to a number of other characteristics:

- Developed water supply pressure (devices of low (up to 2 10 megapascals), medium (up to 6 10 megapascals) and highest (over 6 10 megapascals) pressure);

-Speed (normal, quiet and high-speed);

-Appointment (plumbing, fire, industrial, ground, and so on);

-Type of connection of the impeller with the electric motor (direct-drive, cantilever, coupling, pulley).

The efficiency of multi-stage submersible pumps depends on the model and design and has the ability to stay in the spectrum of 60-92%.

Figure 5 – Submersible centrifugal multistage pump for wells

3 Modeling of pump parts TsMG 6.3 / 50

3.1 Type of pump TsMG 6.3 / 50, technical specifications

In this paper, we consider a 3D model of a centrifugal submersible pump with a drive based on a cylindrical multi-stage gearbox. SolidWorks complex was used for design, with the help of which three-dimensional models of unit parts were created. The three-dimensional model was created according to the exact passport data of a real centrifugal pump of the TsMG 6.3 / 50 brand. For ease of assembly and disassembly, the housing design is divided into two parts. Some elements of the pump are simplified (or absent), which is not a significant change in design. Closed impeller modeling is also carried out in two stages. The spiral cochlea is divided into three components.

The model is saved in a special format in the form of codes and symbols, which allows you to print it on a 3D printer. The manufacture of parts of any complexity is achieved by forming a frame according to the type of honeycomb. Carbon fiber is used as the material. The pump with the drive is mounted on a frame, which, unlike other models, is made of plates of polystyrene sheets of certain sizes by gluing.

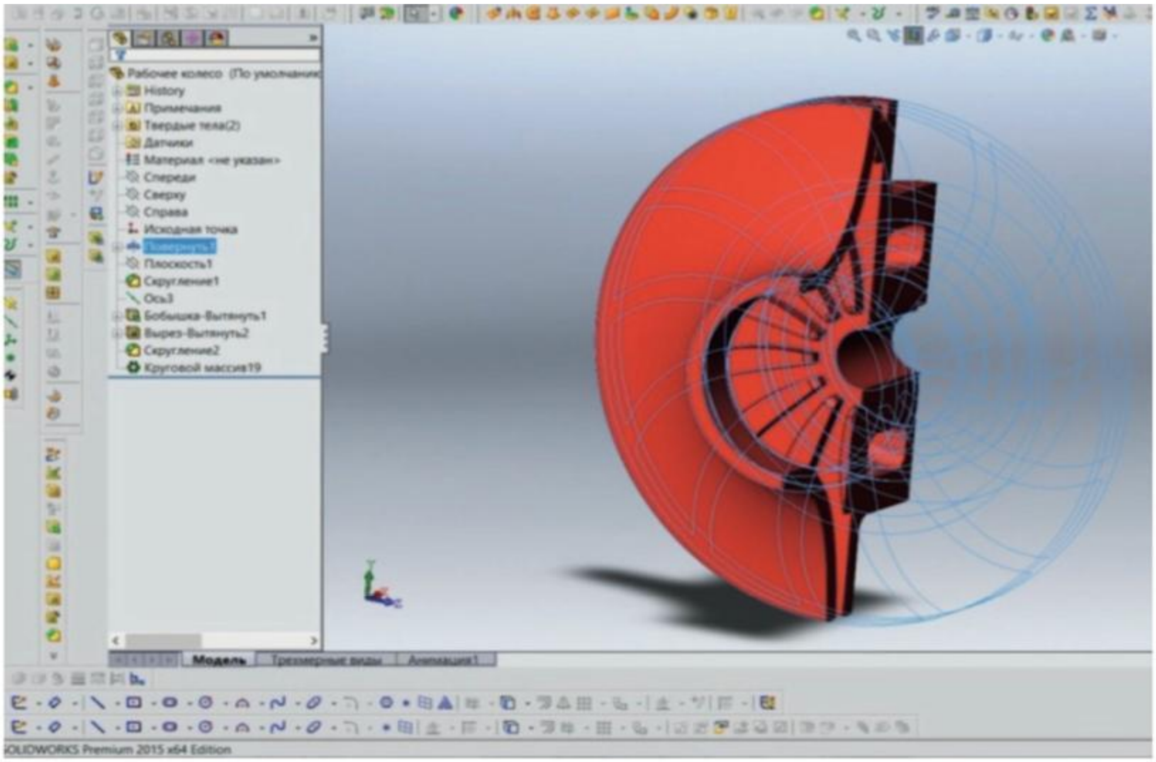
The use of a 3D model of a centrifugal pump in the educational process will improve the perception of the material when studying the disciplines “Machine parts and design fundamentals” and “Hydraulic machines and compressors”.

A centrifugal pump of the TsMG brand is designed for pumping methanol into a regeneration column and is available with an AIM type electric motor with an explosion-proof casing.

A three-dimensional pump prototype is modeled on the exact nameplate data of a centrifugal pump. For the basic dimensions, the dimensions of standard bearings were taken, the sizes of which determined the scale of the model.

3.2 Modeling of parts of a multi-stage submersible pump TsMG 6.3 / 50

The main stages of the pump simulation process: Selection of the assembly drawing of the pump.Determination of the scale of the future model.Selection of the basic dimensions of the pump casing according to the dimensions of standard rolling bearings.Development of the design of the impeller in the basic dimensions.Design of a shaft depending on the sizes of the driving wheel.Creating a cochlea, lid and flange on the liquid suction line.Combining all parts into a single assembly.Figure 6 shows an impeller.



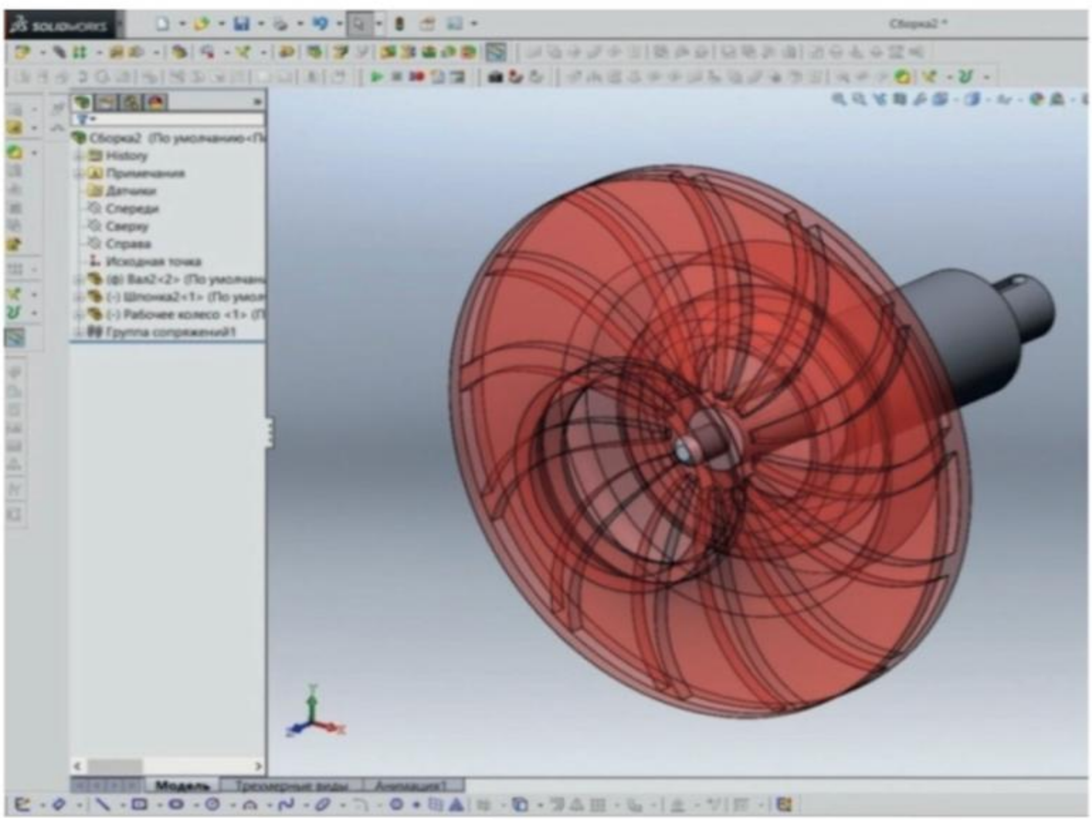


Figure 6 – Impeller

The impeller is the main body of a centrifugal pump, which ensures the absorption of fluid into the working chamber with its subsequent pumping into the pipeline line. The designed pump uses a closed impeller. The impeller blades, creating pressure and driving the fluid flow, are fixed between two disks with an inlet on the front (driven) disk. The impeller was modeled in two stages. The first involves the development and creation of the wheel itself, the second stage consists of scaling the thickness and length of the blades on the surface of the rear (drive) disk. picture 6 show the impeller.

The pump shafts are designed to transmit rotation from the electric motor to the impeller, as well as to fix on them the parts involved in the transmission of rotation, we can see that in picture 7. Two keyways are provided on the shaft: one for mounting the impeller; the second for landing a magnetic coupling connecting the impeller shaft to the motor shaft. The dimensions of the shafts for landing the impeller and magnetic coupling are also calculated on the basis of the dimensions of real bearings.

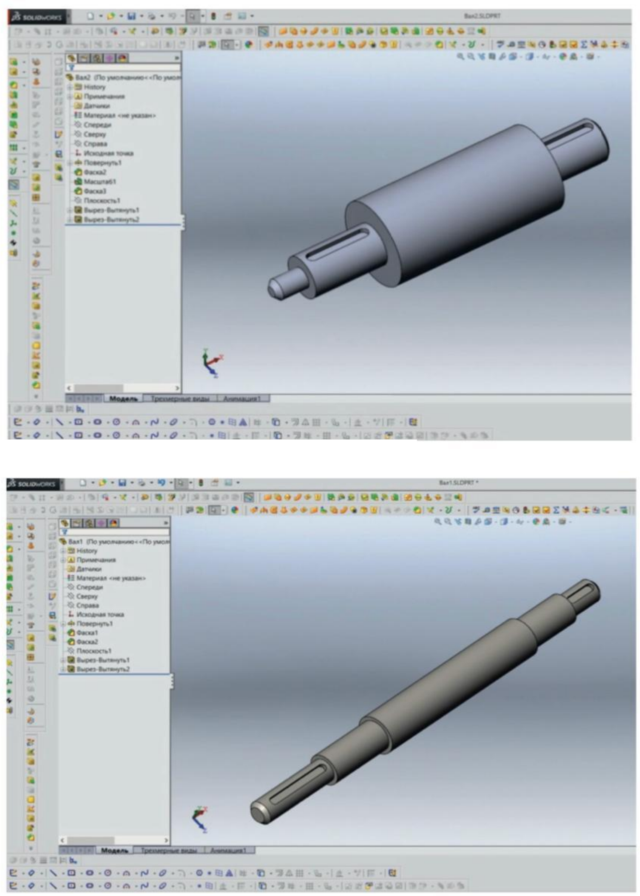


Figure 7 – Transmission of rotation

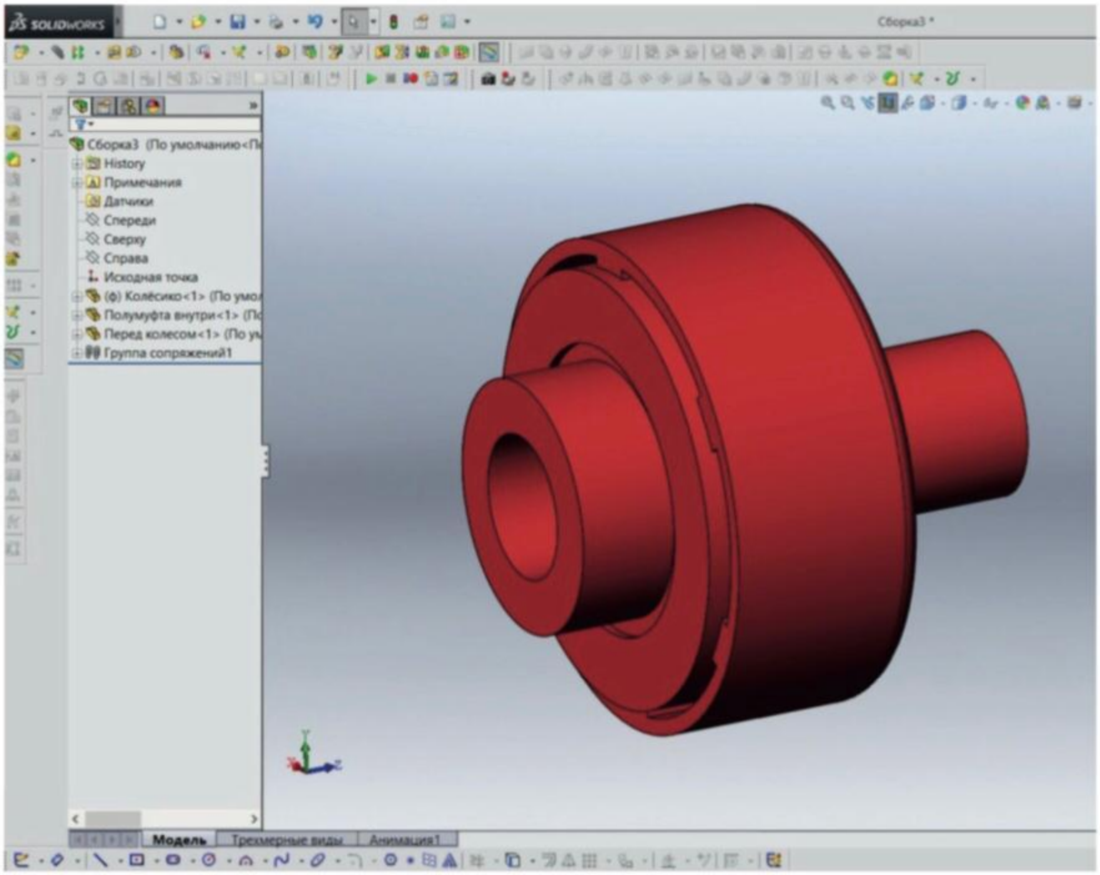


Figure 8 – Magnetic clutch

The cochlea is designed to collect fluid exiting the wheel and direct it into the discharge pipe. In our case, a spiral-type snail is modeled. For ease of design, it was divided into three parts: the flange part, the body and the rear part, shows in the picture 9. The bearing caps have cavities in which the stuffing box is located to seal the joints and holes in the housing through which the pump shaft passes. An oil seal mounted on the rear side of the cochlea from the impeller side is designed to prevent fluid leakage from the working area to the chamber where the bearings are located and oil circulates to cool and lubricate them, in the

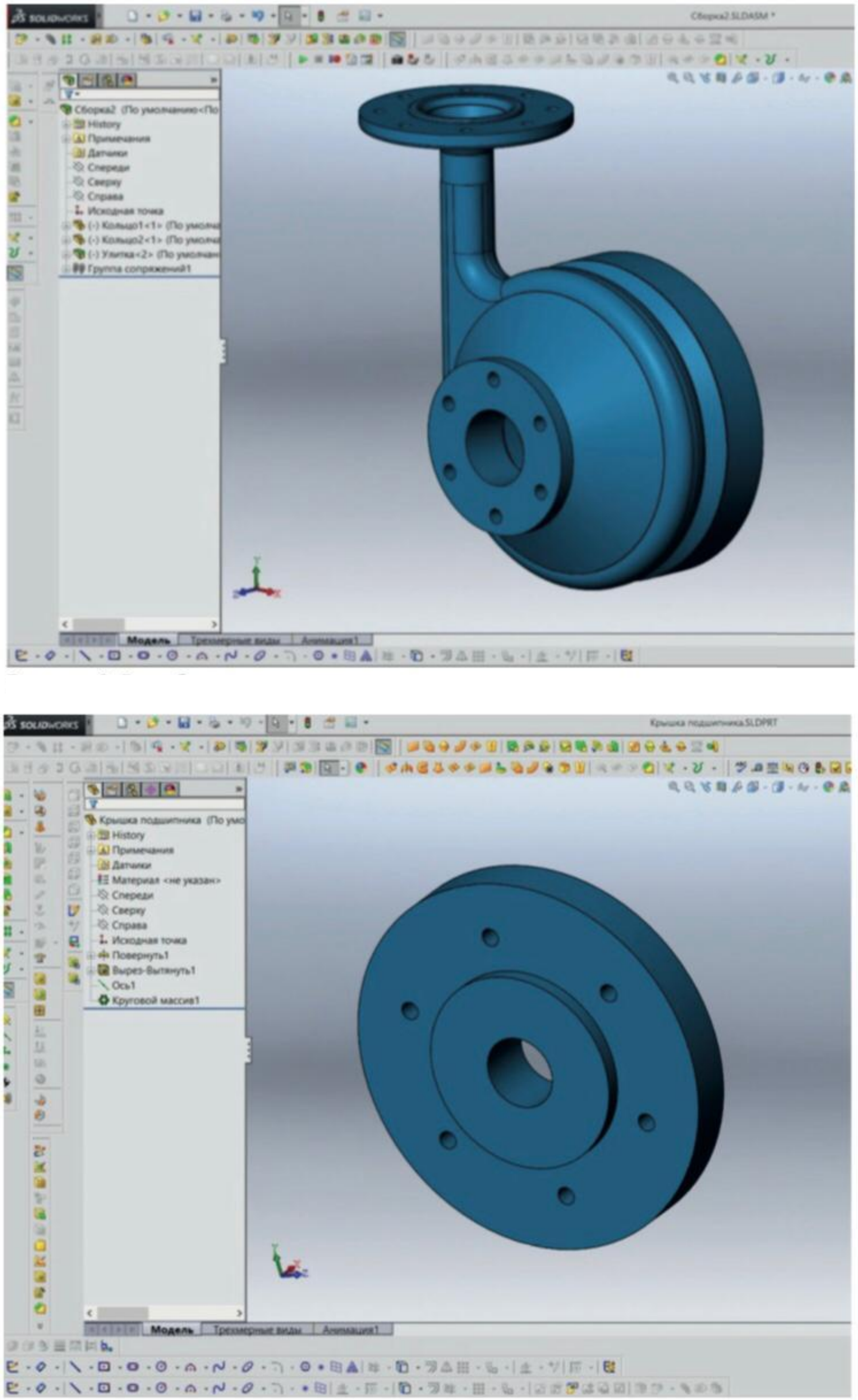


Figure 9 – Flange part and the body

The 3D model of the centrifugal pump is shown in Figures 11, 12. The model is saved in a special format in the form of codes and symbols, which allows it to be printed on a 3D printer.

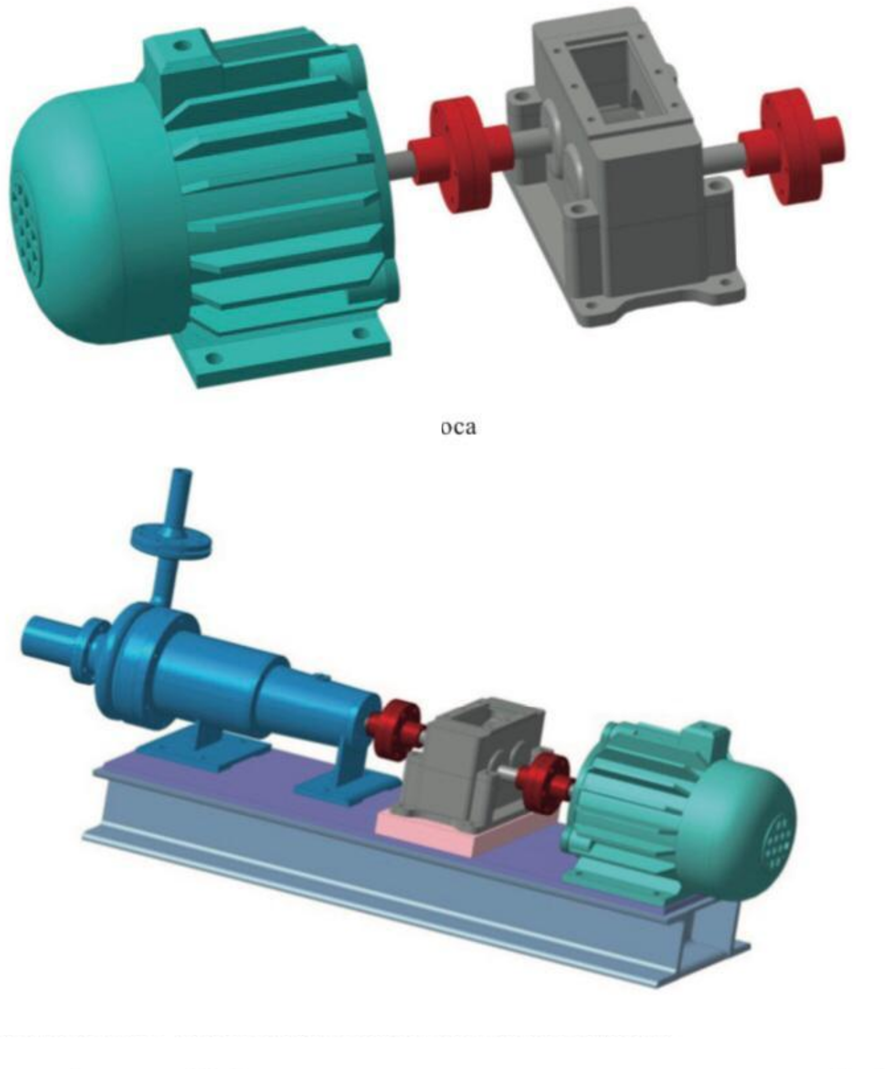


Figure 10 – 3D-model of the pump

When printing, parts are grown by forming layers and frames according to the type of honeycomb. and. As a material for the manufacture of 3D models, a carbon fiber of the T-PLA type of 1.75 mm was used. Its advantage over other materials is that it has a low weight, high tensile strength, extensibility and heat resistance. Carbon fiber models have an attractive appearance and do not require additional processing. The pump drive consists of a multi-stage cylindrical spur gearbox and an electric motor. The motor shaft is connected to the drive shaft of the gearbox using a flange coupling. A similar coupling connects the low-speed shaft of the gearbox to the pump shaft. Drive parts are also materialized by printing them on a 3D printer. A niche for installing a micromotor and a power supply is provided in the motor housing, which turns a static model into a device with moving elements. Installation of real horizontal centrifugal pumps is carried out on plates placed on separate foundations or frames of various profiles. In this case, the pump with the drive is mounted on a frame, which, unlike other models, is made of plates of polystyrene sheets of certain sizes by gluing (Figure 14). Thus, this paper presents a variant of a three-dimensional model of a centrifugal pump and its drive. A feature of this model is the use of the built-in micromotor, which allows to “revive” the rotating elements of the centrifugal pump and its drive, which contributes to the visual study of the principle of operation of the pump unit. Installation of real horizontal centrifugal pumps is carried out on plates placed on separate foundations or frames of various profiles. In this case, the pump with the drive is mounted on a frame, which, unlike other models, is made of plates of polystyrene sheets of certain sizes by gluing (Figure 14). Thus, this paper presents a variant of a three-dimensional model of a centrifugal pump and its drive.

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Is it advisable to pump water with a centrifugal multistage pump with a capacity of 6.3 m3 / h through a 150x4.5 mm pipeline?

Decision:

We calculate the flow rate of water in the pipeline:

$Q = (\pi \cdot d^2) / 4 \cdot w$

$w = (4 \cdot Q) / (\pi \cdot d^2) = (4 \cdot 6.3) / (3.14 \cdot 0.141^2) \cdot 1/3600 = 0.42$ m / s

For water, the flow velocity in the discharge pipe is 1.5 - 3 m / s. The resulting value of the flow velocity does not fall into this interval, from which we can conclude that the use of this centrifugal pump is impractical.

A centrifugal pump pumps liquid with a density of 1130 kg / m3 from an open tank to a reactor with an operating pressure of 1.5 bar with a flow rate of 6.3 m3 / hour. The geometric height difference is 12 m, with the reactor located below the tank. The pressure loss due to friction in pipes and local resistance is 32.6 m. It is required to determine the useful power of the pump.

Decision:

We calculate the pressure created by the pump in the pipeline:

$H = (p2-p1) / (\rho \cdot g) + Hg + h\text{п} = ((1.5-1) \cdot 105) / (1130 \cdot 9.81) - 12 + 32.6 = 25.11$ m

The useful power of the pump can be found by the formula:

$NP = \rho \cdot g \cdot Q \cdot H = 1130 \cdot 9.81 \cdot 6.3 / 3600 \cdot 25.11 = 686$ W

CONSLUSION

The thesis is dedicated to the design of the multi-stage submersible pump TsMG 6.3 / 50 and its components using CAD / CAE. In the course of the work, general information about the pump, basic technical data and characteristics, the composition of the pump, its device, equipment and components, and the hydraulic system were studied.

Having received this information, certain work related to the study of the design features of the pump was performed. Information has been studied, sorted, linked by sections and specific points.

In the thesis, the basic technical data of the multistage submersible pump TsMG 6.3 / 50 were described, which determine the characteristics of the pump. A general view of the pump was shown. Based on the results of the work, a 3D model of the TsMG 6.3 / 50 centrifugal pump and its drive were developed, the presented development is the first step in creating a three-dimensional working model of a multistage submersible centrifugal pump.

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