MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN
Non-profit join - stock corporation
ALMATY UNIVERSITY OF POWER ENGINEERING AND TELECOMMUNICATION named after G. Daukeev
Department of *Electronics and robotics*

«Allowed to defence»
The head of department of «Electronics and robotics»*ChigambayevT.O. c.t.s., associate professor*

<div align="right">(Full name, academic degree, rank)</div>

_____«_____» _____2020 year
<div align="right">(sign)</div>

DEGREE PROJECT

On the topic: *Design and assembly of a hydrogen generator* _____

Specialty *5B071600 Instrumentation Engineering* _____

Done by: *Amangali Muratbek   PSa-16-3*
*(*Surname and initials of a student)   (group)

Research supervisor *Chigambayev T.O. c.t.s., associate professor* _____
<div align="center">(Surname, academic degree, rank)</div>

_____«_____» _____2020 year
<div align="center">(sign)</div>

Consultants on economic part: *Tuzelbayev B.I. Ph.D, associate professor* _____
<div align="center">(Surname, academic degree, rank)</div>

_____«_____» _____2020 year
<div align="center">(sign)</div>

on life and environmental safety part: *Begimbetova A.S. Ph.D, senior lecturer*
<div align="center">(Surname, academic degree, rank)</div>

_____«_____» _____2020 year
<div align="center">(sign)</div>

Compliance supervisor: *FazylovaA.R.senior lecturer* _____
<div align="center">(Surname, academic degree, rank)</div>

_____«_____» _____2020 year
<div align="center">(sign)</div>

Reviewer: *Rakisheva Zaure Bayanovna, associate professor*
(Surname, academic degree, rank)

Almaty, 2020

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

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ALMATY UNIVERSITY OF POWER ENGINEERING AND TELECOMMUNICATION named after G. Daukeev

Institute of *space engineering and telecommunications*_____

Department of *Electronics and robotics*_____

Specialty*5B071600 Instrumentation Engineering*_____

ASSIGNMENT

for execution of degree project

Student *Amangali Muratbek Erlanuly*_____

(Full name)

Topic of the work *Design and assembly of a hydrogen generator*_____

Approved by the order of the rector   № ___ from« 23 » october 2020 y.

Deadline of the finished work« 8 »   june2020 y.

Initial data required parameters of the results and initial data:

1. *Arduino Uno microcontroller*_____
2. *Arduino Relay*_____
3. *Converter*_____
4. *Flowmeter*_____

List of issues to be developed in a degree project or a summary:

1. *Consider the control of a prosthesis based on an image recognition system*_
2. *The choice of equipment, device description and principle of operation of__ the system*_____
3. *Program part*_____
4. *Development of life safety measures*_____
5. *Economic justification of the project*_____

List of graphical material (with precise indication of mandatory drawings);
*This degree project contains figures and tables*_____

Recommended basic literature:

    1. *Mauna Loa CO2 monthly mean data. Earth System Research Laboratory.*
    2. *Gelfand, Popov, Chayvanov: Hydrogen: combustion and explosion parameters. 2008.*

3. Digonsky S.V. Unknown hydrogen. 2006

4. Sven C. Electrochemical methods for producing limited compounds - M.: Foreign literature, 1951. -62p._____

Consultants for work with indication of the relevant section

Section	Consultant	Date	Sign
Life safety	*Begimbetova A.S*	*01.05.2020*	
Economic part	*Tuzelbayev B.I*	*27.05.2020*	

SCHEDULE
Of degree project preparation

№	Title of section, list of issues to be developed	Deadline for submission to instructor	Note
1	*Theoretical part*	*29.01*	
2	*Engineering part*	*05.03*	
3	*Program part*	*19.05*	
4	*Life safety*	*01.05*	
5	*Economic part*	*27.05*	
6	*Conclusion*	*07.06*	

Date of issue of the assignment_____ *« 20 »   01   2020 year*

The head of department_____*Chigambayev T.O.*_____
(sign)(Surnameand initials)

Supervisor: _____ *Eleukulov E.O*_____
(sign)(Surnameand initials)

The assignment for execution is accepted by: _____ *Amangali M.E*_____
(sign)(Surnameand initials)

Аңдатпа

Дипломдық жұмыстың тақырыбы: «Сутегі генераторын жобалау және құрастыру».Дипломдық жұмыста жалпы қолдануға арналған сутектік генератордың жасалуына керекті элементтер мен есептеулер көрсетілген. Сутекті генераторды жасау үшін құрғақ электролизер атты әдіс таңдалды. Сутекті генератордың сипаттамасы, жұмыс істеу және құрылымы ұсынылған, сонымен қатар сутектік генератордың өзін-өзі ақтауы мен шығыны есептелген. Сутекті генератордың күнделікті өмірде және, атап айтқанда, іштен жанатын қозғалтқыштарда пайдалану өзектілігі қарастырылған.

Аннотация

Тема дипломной работы: «Проектирование и конструирование генератора водорода».Диссертация описывает элементы и расчеты, необходимые для создания генератора водорода общего назначения. Метод, названный сухим электролизером, был выбран для создания генератора водорода. Представлены характеристики, работа и структура генератора водорода, а также рассчитаны срок окупаемости и потребление генератора водорода. Рассмотрена актуальность использования генераторов водорода в повседневной жизни и, в частности, в двигателях внутреннего сгорания.

Annotation

Theme of the graduation work is: "Design and construction of a hydrogen generator."The thesis describes the elements and calculations required for the construction of a hydrogen generator for general use. A method called a dry electrolyzer was chosen to create a hydrogen generator. The characteristics, operation and structure of the hydrogen generator are presented, as well as the payback and consumption of the hydrogen generator are calculated. The relevance of the use of hydrogen generators in everyday life and, in particular, in internal combustion engines is considered.

Content

Introduction

The main problem of the 21st century is ecology. Carbon dioxide emissions are the main culprit for global warming. Since the probable magnitude of the mutilation temperature in the XXI century based on climate models is 0.3-1.7°C for the minimum scenario of greenhouse gas emissions, 2.6-4.8°C for the scenario of maximum emission. This will entail an increase in the level of the world's oceans, heat and an increase in deserts [1].

Given the above, we need to make environmentally friendly fuels or make existing ones more ecological. Studying this issue, I came to the conclusion that hydrogen is the most environmentally friendlyfuel. But since it is very difficult to store hydrogen and it is impossible to produce it as fuel.Since hydrogen is very light, the mass and dimensions of existing metal cylinders, as well as the methods for its storage in them, are unacceptable.

Liquefied hydrogen occupies a small volume, but the thermal insulation of the tank with it is very cumbersome and expensive. In addition, handling liquid hydrogen is unsafe and requires trained personnel.Because of this, we can use hydrogen only to improve the combustion process. Thus, reduce the amount of fuel consumed and make it more environmentally clean.

In this thesis, taking into account all of the above, we will design and assemble a hydrogen generator for the car. And analyze the effectiveness in practice.

1 Theoretical part

1.1 Hydrogen

Hydrogen is the chemical element with the symbol H and atomic number 1. It has a standard atomic weight of 1.008, meaning it is the lightest element in the periodic table. Hydrogen is the most common chemical element in the Universe, with 75% of all baryonic mass being hydrogen. Stars are made up of mostly hydrogen. Hydrogen's most common isotope has one proton with one electron orbiting around it.

At standard temperature and pressure, hydrogen has no color, smell, taste, is not toxic, is a nonmetal and burns very easily. When alone, it usually binds with itself to make H_2

In its pure form on Earth, hydrogen is usually a gas. Hydrogen is also one of the parts that make up a water molecule. Hydrogen is important because it is the fuel that powers the Sun and other stars. Hydrogen makes up about 74% of the entire universe. Hydrogen's symbol on the Periodic Table of Elements is H.

Pure hydrogen is normally made of two hydrogen atoms connected together. Scientists call these diatomic molecules. Hydrogen will have a chemical reaction when mixed with most other elements. It has no color or smell.

Pure hydrogen is very uncommon in the Earth's atmosphere. In nature, it is usually in water. Hydrogen is also in all living things, as a part of the organic compounds that living things are made of. In addition, hydrogen atoms can combine with carbon atoms to form hydrocarbons. Petroleum and other fossil fuels are made of these hydrocarbons and commonly used to create energy for human use.

Hydrogen has three isotopes; the others are called deuterium and tritium. Like regular hydrogen, they both have only one proton and one electron, but deuterium also has one neutron and tritium has two. These other types of hydrogen are important in nuclear energy and organic chemistry reactions.

Some other facts about hydrogen:
- It is a gas at room temperature;
- It acts like a metal when it is solid;
- It is the lightest element in the Universe;
- It is the most common element in the Universe;
- It burns or explodes when it touches a flame;
- Glows purple when it is in plasma state.

1.2 What is hydrogen generator

Today there are many types of hydrogen generators. But the most commonly used are generators that release hydrogen by electrolysis.

A hydrogen generator by electrolysis is a special device for the decomposition of various component compounds or solutions by means of an electric current. These devices are mainly used in large-scale production. For example, extraction of active metal compounds from ore, refining of metals and

application of metal coatings on products. It is also used in ordinary home conditions. It is mainly used as a fuel in the determination of water pollution, in the case of "live" water intake and in transport and home heating systems.

The principle of operation of the device is the method of electrolysis. This appliance works by receiving direct current from an external power supply. Simplified type of unit with two or more electrodes made in the form installed in the case. Electrolytes are installed inside the case. During direct current supply, the solution decomposes. Positively charged ions are attracted to the cathode, and negatively charged ions are attracted to the anode.

The main indicator of such devices is performance. That is, how much solution the device produces over a period of time. In addition, the following parameters may affect the performance of the device:

- voltage level, which should be from 1.8 volts to 2 volts. If it is less than 1.8 volts, the process may not work. If it is higher than 2 volts, the excess energy consumption will cause the electrolyte to overheat;

- the smaller the gap between the plates, the lower the resistance. Due to this, a large current flows through the electrolyte and the amount of gas released increases;

- the size of the plate, the size of the plate is directly proportional to the current flowing through the electrolyte;

- electrolyte concentration and its heat balance;

- indicators of electrolyte material;

- use of catalysts in the process.[2]

1.3 Hydrogen production process

Hydrogen - the first element of the periodic table - is the lightest gaseous substance with high chemical activity. During oxidation (that is, combustion) it emits a huge amount of heat, forming ordinary water. We characterize the properties of the element, designing them in the form of theses:

- Hydrogen burning is an environmentally friendly process, no harmful substances are released;

- Due to its chemical activity, free gas does not occur on Earth. But in the composition of water its reserves are inexhaustible;

- The element is mined in industrial production by a chemical method, for example, in the process of gasification of coal. Often a byproduct;

- Another way to obtain gaseous hydrogen is the electrolysis of water in the presence of catalysts - platinum and other expensive alloys;

- A simple mixture of gases hydrogen + oxygen explodes from the slightest spark, instantly releasing a large amount of energy.

- From the foregoing, the following conclusion suggests itself: 2 hydrogen atoms easily combine with 1 oxygen atom, but they are very reluctant to part. The chemical oxidation reaction proceeds with the direct release of thermal energy in accordance with the formula:

- $2H_2 + O_2 \rightarrow 2H_2O + Q$ (energy)

Here lies an important point that will be useful to us in the further analysis of flights: hydrogen enters into reaction spontaneously from ignition, and heat is released directly. To separate a water molecule, energy will have to be spent:

- $2H_2O \rightarrow 2H_2 + O_2 - Q$;

What does a primitive electrolyzer consist of;

- reactor - glass or plastic container with thick walls;
- metal electrodes immersed in a reactor with water and connected to a power source;
- the second tank acts as a water shutter;
- HHO gas exhaust pipes.

An important point. The electrolytic hydrogen plant operates only on direct current. Therefore, usethe AC adapter, car charger, or battery as the power source. An alternator will not work.

Two electrodes immersed in water are supplied with voltage, preferably from an adjustable source. To improve the reaction, a little alkali or acid is added to the container (at home - ordinary salt)(figure 1.1).
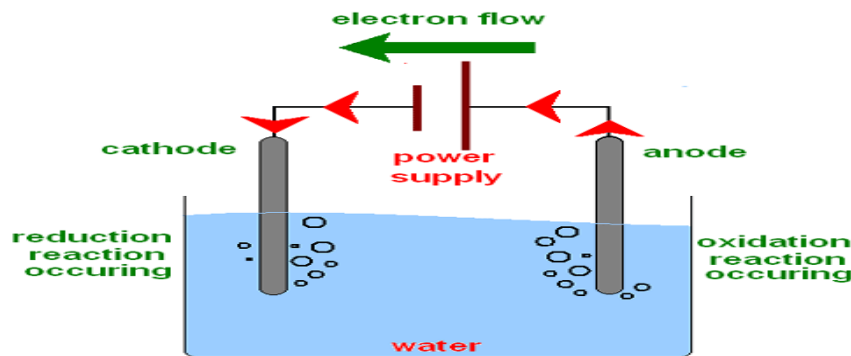

Figure 1.1 - Electrolyze

As a result of the electrolysis reaction, hydrogen will be released from the side of the cathode connected to the "minus" terminal, and oxygen will be generated near the anode.

Mixing, both gases through a tube enter a water trap that performs 2 functions: separating water vapor and preventing a flash in the reactor.

From the second tank, explosive gas of HHO is fed to the burner, where it is burned to form water (figure 1.2).
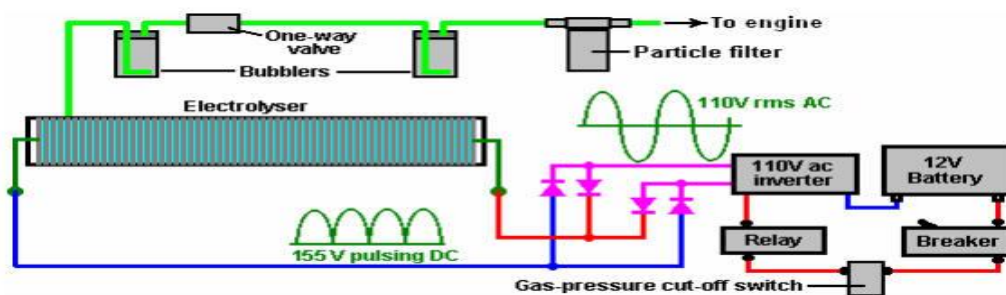

Figure 1.2 – Hydrogen generator diagram

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1.4 Advantages and disadvantages of hydrogen fuel

Advantages of HF:

- The main indisputable advantage of hydrogen cars is their high environmental friendliness, since water vapor is the product of hydrogen combustion. Of course, at the same time, various oils are burned, but there are much less toxic emissions than gasoline exhausts;
- Simple construction;
- The lack of expensive fuel supply systems, which are also dangerous and unreliable;
- Noiselessness;
- The efficiency of a hydrogen-fueled electric motor is much higher than that of an internal combustion engine.

Disadvantages of GF:
- There are also disadvantages to cars using hydrogen fuel;
- An expensive and complicated way to obtain fuel in industrial volumes;
- Lack of hydrogen infrastructure for refueling vehicles;
- No standards have been developed for the transportation, storage and use of hydrogen fuel;
- Imperfect storage technologies for such fuel;
- Expensive hydrogen elements;
- A lot of transport. The operation of a hydrogen-fueled electric motor requires hydrogen current converters and powerful batteries, which weigh quite a lot, and also have impressive dimensions;
- There is a danger of fire and explosion during the operation of hydrogen with traditional fuels;
- Having become acquainted with the advantages and disadvantages of hydrogen fuel, you can understand why the serial production of hydrogen cars is still delayed. However, due to the worsening ecology, this alternative energy source may be the only solution to the problem.[3]

1.5 Hydrogen Fuel Manufacturers

Global manufacturers still conduct tests in this area and even produce hydrogen-fueled vehicles:

- Toyota - Toyota Highlander FCHV model. The Toyota FCHV is a current hybrid hydrogen fuel cell vehicle development programme of the Toyota Motor Corporation, which was leased to a limited number of drivers in the United States and Japan beginning in 2002. "FCHV" stands for "Fuel Cell Hybrid Vehicle". A number of prototypes have been produced, up to the latest FCHV-adv ("advanced"). The FCHV designs are based on the first generation Highlander SUV, although a bus version is also in development. The powertrain consists of a 90 kW fuel cell supplied from onboard compressed hydrogen tanks, and a nickel–metal hydride battery in parallel. Battery and fuel cell can provide power to the 90 kW driving motors either singly or

together. The mechanism is very similar to the Hybrid Synergy Drive in the Toyota Prius and Toyota Auris HSD but with the fuel cell replacing the petrol internal combustion engine, thus minimising greenhouse gas emissions at point of use. At low speeds the FCHV can run on battery alone, with a range of about 50 km (31 mi). For high performance, such as when accelerating from rest, the fuel cell and battery supply power in tandem. The battery can also charge by regenerative braking, improving overall efficiency;

- Ford Motor Company tests with Focus FCV. The Ford Focus FCV (Fuel Cell Vehicle) is Ford's most recent hydrogen car. This is where Ford believes the future lies for this beleaguered car company. On September 5, 2006 Bill Ford stepped down as the CEO of Ford Motor Company. Before stepping down, however, the great grandson of Henry Ford devoted much of his time, energy and resources to the new technology of hydrogen cars. Ford has jumped into the hybrid market full force with its Escape Hybrid and Mercury Mariner Hybrid SUV's. Take this technology one-step further into advanced fuel cell vehicles and this is where the Ford Focus FCV comes into play. The Ford Focus FCV is where the future of the automobile industry is headed within the next 5 – 10 years. With President Bush's State of the Union Address on January 30 calling once again for more federal money to be put into the advancement of hydrogen cars and vehicles, the idea that there will indeed be a hydrogen highway one day leaves no doubts;

Honda with its model Honda FCX. The Honda FCX (commonly referred to as Fuel Cell eXperimental) is a family of hydrogen fuel cell automobiles manufactured by Honda.As of March 2007, there are more than twenty Honda FCX vehicles in the hands of customers, including the state of New York, cities of Las Vegas, Chula Vista, San Francisco and the South Coast Air Quality Management District in three different American states.Limited marketing of a latest fuel cell vehicle named FCX Clarity, based on the 2007 concept model, began on June 19, 2008 in Japan and the United States. Honda believes it could start mass-producing the next model evolved from the FCX concept by the year 2018;

- Hyundai releases Tucson FCEV. The Hyundai ix35 FCEV or Tucson FCEV is a hydrogen fuel cell electric vehicle developed by Hyundai. It is the first SUV-like vehicles to be sold commercially, as well as the first commercially mass-produced hydrogen fuel cell vehicle in the world. Different versions are known, the previous version was based on the Hyundai Tucson FCEV, and the upcoming model is based on the current ix35 FCEV. The first generation was introduced in 2001, with the Hyundai Santa Fe FCEV, and had a range of 100 miles (160 km), with a top speed of 78 mph (126 km/h). The second generation Tucson FCEV was introduced in 2005, used a graphite bipolar plate and had a range of 186 miles (300 km), with a top speed of 93 mph (150 km/h). The third generation is based on the Hyundai ix35 (2009), production was semi automatic and used a metal bipolar plate. The current version and fourth generation is the 2012 ix35 FCEV. The Tucson ix35 FCEV has a more powerful electric engine rated at 100 kW (134 horsepower), and a range of about 369 miles (594 km). This improvement in range is due in part to the Tucson ix35 FCEV's greater space for holding Hydrogen

tanks of compressed hydrogen, higher storage pressure, as well as fuel cell technology advances. The cars have made use of a "sandwich" design concept, aimed at maximizing room for both passengers and the propulsion components. The fuel cell is a proton exchange membrane fuel cell (PEMFC).

1.6 Types of hydrogen generators

The types of hydrogen generators operating by electrolysis are as follows:
- dry electrolyzer;
- flow electrolyzer;
- membrane electrolyzer;
- diaphragm electrolyzer;
- alkaline electrolyzer.

The structure of a dry electrolyzer is shown in Figure 1.3. Its peculiarity is that by manipulating the number of cells, the device can be supplied with a voltage much higher than the minimum electrode potential. [4]
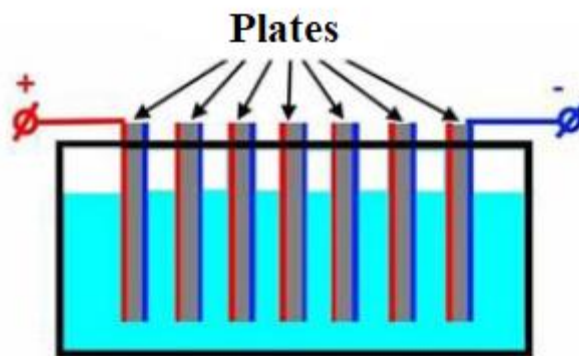

Figure 1.3 - The structure of a dry electrolyzer

A simplified version of the flow electrolyzer is shown in Figure 1.4. This device contains a bath "A" with electrodes and a tank "D" completely filled with solution.
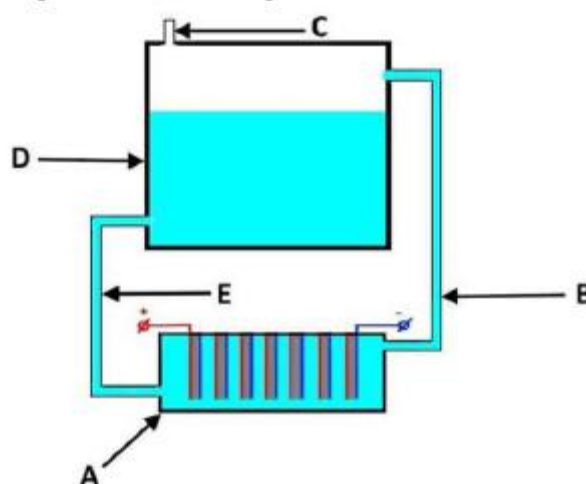

Figure 1.4 - The structure of the flow electrolyzer

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The principle of operation of the device is as follows:

- during the electrochemical process, the gas is collected together with the electrolyte in the tank "D" through the tube "B";

- In tank "D" there is a process of gas release from the electrolyte solution, then it is discharged through the tube "C";

- the electrolyte is returned to the hydrolysis bath through the "E" tube.

The peculiarity of the membrane electrolyzer is the use of a solid electrolyte in a polymeric form. The peculiarity of such devices is the presence of two functions of the membrane. It not only transports protons and ions, but also physically releases solutions such as electrodes. The structure of the device can be seen in Figure 1.5:
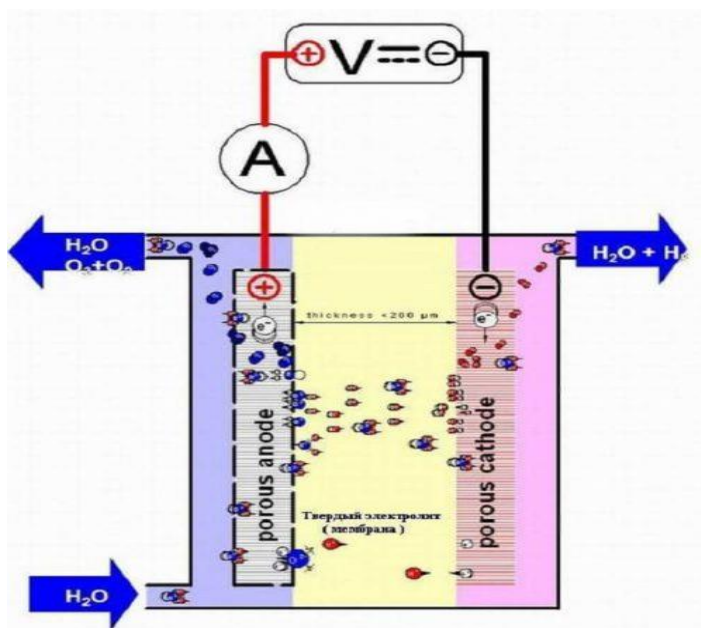

Figure 1.5 - The structure of the membrane electrolyzer

1.7 Combining atoms

The structure of an atom consists of particles consisting of a negatively charged orbital electron and a positively charged proton. In the case of a constant neutral electric field, the number of negatively charged electrons is equal to the number of positively charged protons. Therefore, the atom is neutrally charged.

If one or more electrons are displaced from the atom, then the atom has a positive electric charge and is considered a positively charged ion. And if the displaced electron combines with an atom in a stable or normal state, then the atom has a negative charge and is considered a negatively charged ion.

The voltage potential difference can displace one or more electrons from the atoms due to the different polarity of the field between the electrodes. This phenomenon is shown in Figure 1.6. The effect of electric force works according to Newton's and Coulomb's laws.

$$E_{in} \xrightarrow[Det.]{Gas} M_d C^2$$

THERMAL GAS IGNITION
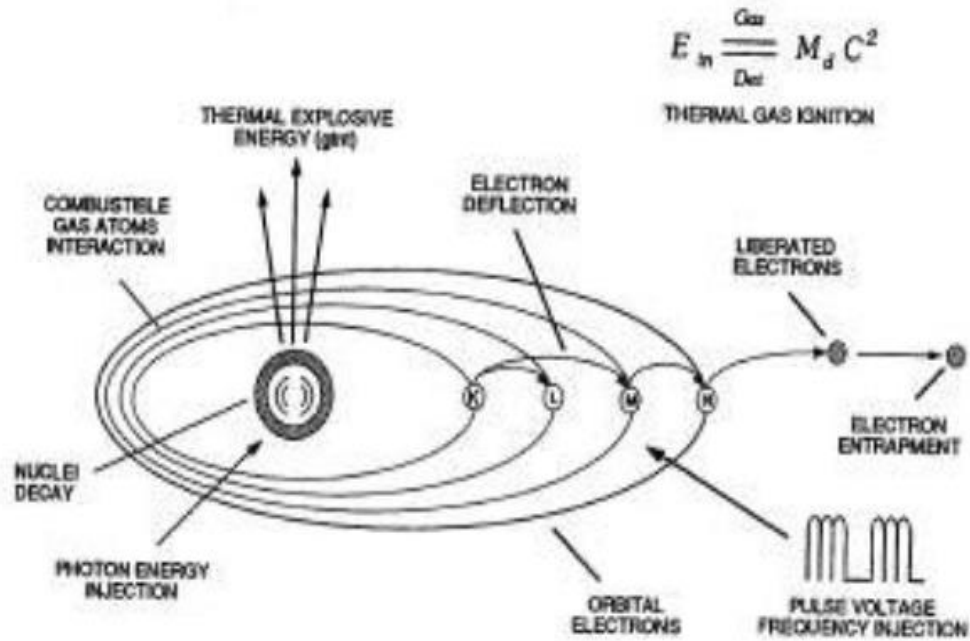
Figure 1.6 - Level hydro-explosion process

Electric gravity connects or separates oppositely charged atoms using covalent bonds to form gas, solid, and liquid molecules.

When an oxygen atom picks up two electrons from hydrogen and combines with a hydrogen atom, it forms a water molecule. Here the oxygen atom is purely negatively charged. This is because an oxygen atom has 10 negatively charged electrons and 8 positively charged protons. The hydrogen atom then consists only of uncompensated protons and remains a pure positively charged atom. Thus, the number of positively charged and negatively charged particles is equal. This phenomenon is shown in Figure 1.7.

Figure 1.7 - Atomic and molecular structure of water

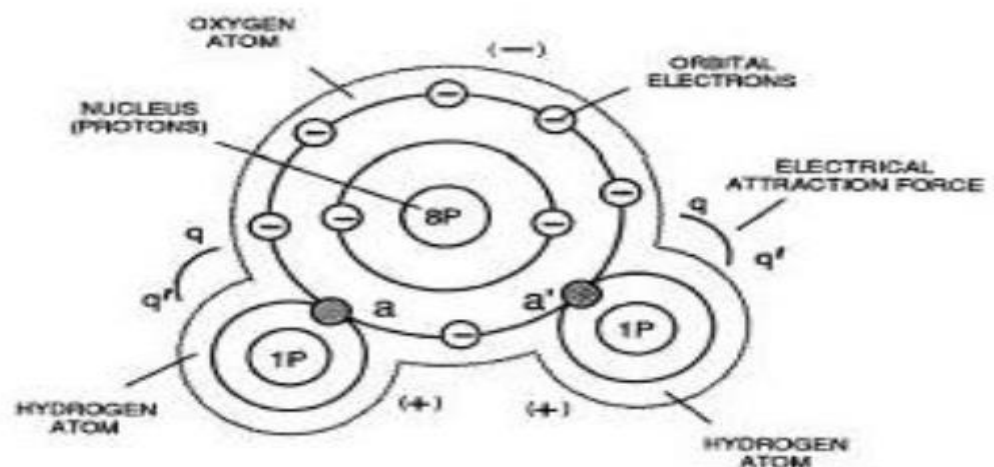### 1.8 The use of hydrogen

Modern industry is difficult to represent without the use of technical gases at different stages of production. Today, hydrogen enters the trio of the most demanding gas industries, giving up only oxygen and nitrogen. Use of Hydrogen is shown on figure 1.8.

Figure 1.8 – The use of hydrogen

1.8.1 Chemical industry

In Russia, the main area of hydrogen consumption is the production of chemical products, preferably ammonia and methanol.

Leads in the consumption of hydrogen are enterprises that produce ammonia NH 3. Currently, 2.46 million tons are used in 28 enterprises in Russia. hydrogen per year.

Hydrogen consumption during the synthesis of methanol CH 3 OH amounted to 0.6 million tons.

Hydrogen consumption in the remaining segments of the chemical industry does not exceed 90 thousand tons. - 3% of the volume of consumption.

1.8.2 Petroleum industry

Consumption of oil refineries in hydrogen is increasing, which is necessary to obtain fuel from heavy high-grained raw materials. A huge amount of hydrogen is required for the installation of hydro-desalination, hydrocracking of distillates, hydro-purification, isomerization, production of lubricants. In addition, hydrogen is used in refineries for activation of reforming catalysts and regeneration of isomerization catalysts.

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1.8.3 Metallurgy

The main area of application of hydrogen in metallurgy is the production of metallized raw materials by the method of direct recovery of iron. Now in this process about 320 thousand tons are used. hydrogen.

Significant volumes of hydrogen are consumed in technological processes of rolling production (in the thermal processing of cold-rolled rolling). Hydrogen consumption - about 15 thousand tons. in the year.

Hydrogen is also used in metallurgical enterprises to create a protective nitrogen-hydrogen atmosphere during heat treatment.

1.8.4 Glass industry

In the glass industry, hydrogen is used in the production of sheet glass by the float method, as well as for the production of quartz glass, which is made by melting pure rock crystal, quartz or quinoa pine.

1.8.5 Energy

In energy, hydrogen is used to cool powerful turbogenerators, thanks to its high thermal conductivity and diffusion coefficient, as well as non-toxicity. According to estimates, in the energy sector at thermal power plants, nuclear power plants consume about 4-5 thousand tons. hydrogen per year.

1.8.6 Food industry

In the food industry, hydrogen is used in the processes of hydrogenation of oil and fat in the production of solid fats (margarine). The volume of hydrogen consumption by oil refineries is estimated at the level of 1.5 thousand tons. in the year.

Among the other consumers of hydrogen are enrichment plants, factories engaged in the production of nuclear fuel, enterprises of electronic and electrotechnical industry, transport and gas companies, pharmaceuticals.

2 Assembly of hydrogen generator

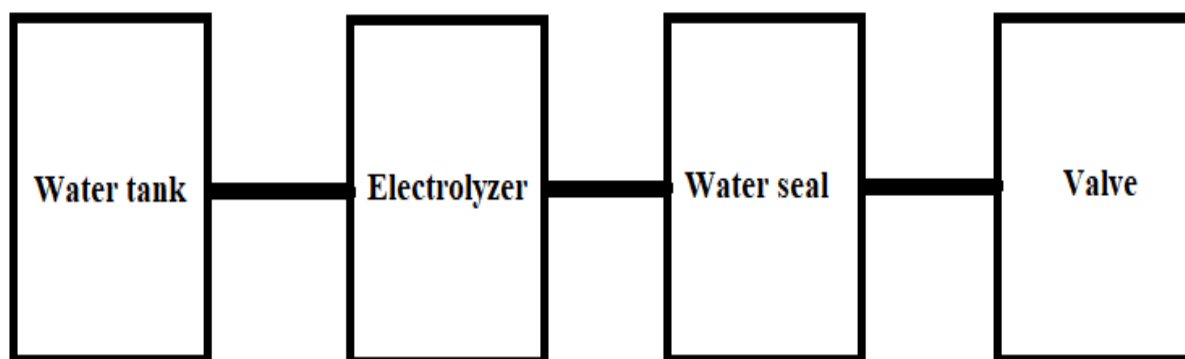## 2.1 Block diagram of hydrogen generator

Figure 2.1 – Block diagram of hydrogen generator

Block diagram of hydrogen generator is shown at figure 2.1. Hydrogen generator consists of following parts:

- Water tank – to store water needed for electrolysis;
- Electrolyzer - physicochemical process consisting in the separation of the constituent parts of dissolved substances or other substances on the electrodes, which are the result of secondary reactions on the electrodes, which occurs when an electric current passes through a solution or an electrolyte melt;
- Water seal -water plug in the pipe. This is a bend of the pipe, or a difference in the height of two pipes, arranged so that a certain amount of water remains in the pipe always;
- Valve - a device designed to open, close or regulate the flow of something, under certain conditions.

2.2 Cell assembly

An electrolyzer is a device for the electrochemical process of the same name, which requires an external power source. Structurally, this apparatus is a bath filled with electrolyte, in which two or more electrodes are placed.

An electrolyzer is a special device that is designed to separate the components of a compound or solution using electric current. These devices are widely used in industry, for example, to obtain active metal components from ore, metal refining, metal coating products. For everyday life, they are rarely used, but are also found. In particular, for home use, devices are proposed that can determine the contamination of water or get the so-called "living" water.

The basis of the device's operation is the principle of electrolysis, the discoverer of which is the famous foreign scientist Faraday. However, the first water electrolyzer 30 years before Faraday was created by a Russian scientist named Petrov. He proved in practice that water can be enriched in a cathode or

anode state. Despite this injustice, his work was not in vain and served the development of technology. At the moment, numerous types of devices that work on the principle of electrolysis have been invented and successfully used.

For this thesis, I took a dry cell. To assemble this type of electrolyzer, I first took a 1x1 stainless steel sheet. And with the help of an angle grinder, I cut 12 plates from it and at the same time left a hole for the inlet and outlet of water and gas and made another hole for connecting to the current (Figure 2.2).

Figure 2.2 – Plates

To isolate the plates from each other, I used rubber from the tire of the machine with the size of the plate. And he made a hole inside the rubber so that water could safely pass between the plates (Figure 2.3).

Figure 2.3 – Rubber plate

And we collect the available parts according to the principle of plate-rubber-plate and leave a hole to turn on the electric wire for electrolysis. Using bolts and nuts we attach them for sealing . Then after that we make 2 holes in the platinum to let out water and get gas. And we fasten the tubes into the holes using sealant (Figure 2.4).

Figure 2.4 – Assembled electrolyzer

2.3 Microcontroller based control

To control the hydrogen generator using a microcontroller, we need the following elements:
-Arduino uno;
- LSD display;
- Button;
- Relay.

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. Arduino Uno is shown at figure 2.5
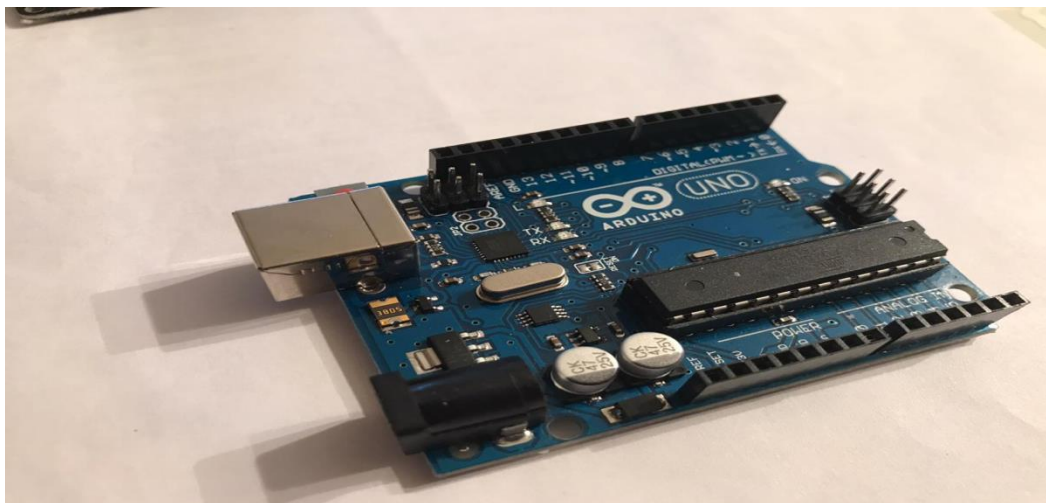

Figure 2.5 – Arduino Uno board

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Arduino Uno board has following characteristics:
- The operating voltage is 5V;
- The recommended input voltage will range from 7v to 12V;
- The input voltage ranges from 6v to 20V;
- Digital input/output pins are 14;
- Analog i/p pins are 6;
- DC Current for each input/output pin is 40 mA;
- DC Current for 3.3V Pin is 50 mA;
- Flash Memory is 32 KB;
- SRAM is 2 KB;
- EEPROM is 1 KB;
- CLK Speed is 16 MHz.

LCD matrix technology for modern monitors. The liquid crystal effect was discovered in 1888. A liquid crystal is a liquid with a crystalline structure. Liquid crystals have special optical properties, so they are used to create a matrix of LCD monitors.

The matrix is the main part of the LCD monitor. It creates an image on the screen. The quality of the monitor depends directly on the matrix installed on it.

The DFRobot Display Shield monitor-keyboard was chosen for this thesis. The main feature of this monitor is the presence of 6 buttons. This sets the frequency without the use of redundant products. There is also a 2x16 LCD monitor. Outputs 4, 5, 6, 7, 8, 9 and 10 are directly connected to the monitor. The first button is for restarting the Arduino. The remaining buttons can be used differently by program. The appearance of the DFRobot Display Shield monitor-keyboard is shown in Figure 2.6
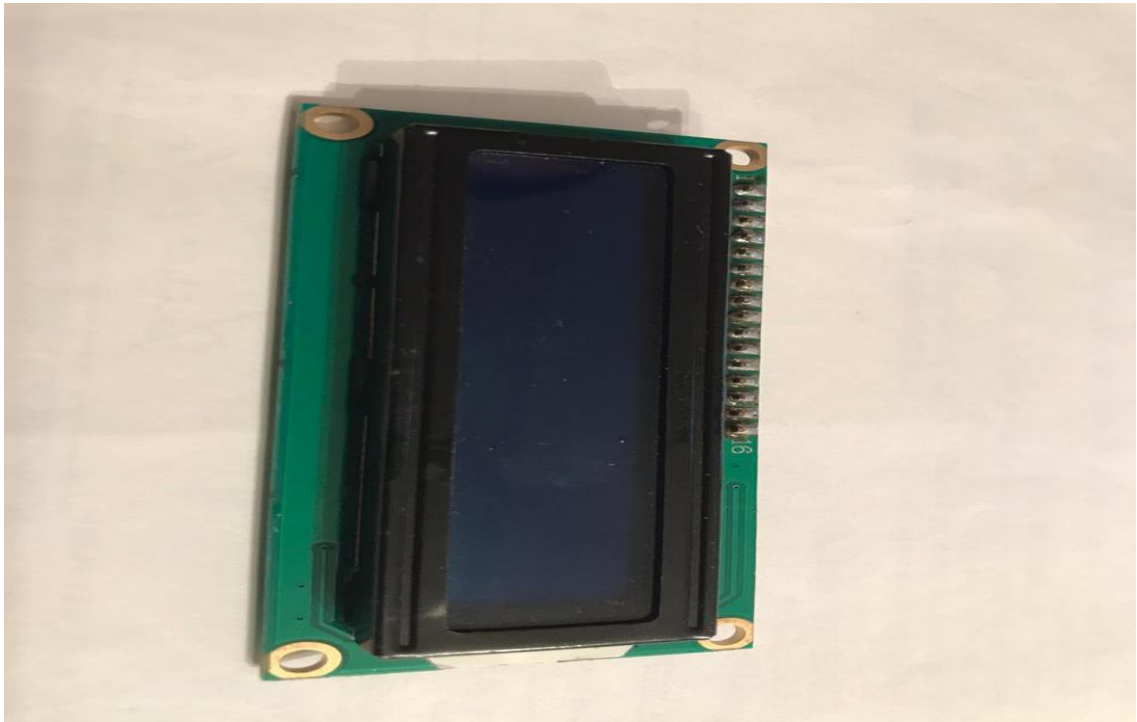

Figure 2.6 – 16x2 LCD Display

Relay Arduno allows you to connect devices operating in modes with relatively large currents or voltages. We can not directly connect to the board Arduino power pumps, engines, even the usual incandescent light bulb - the board is not intended for such loads and will not work. That is why we need to add to the scheme of the relay, which you can meet in any project. In this article we will talk about what kind of relay they are, how they can connect their arduino project.A relay is a gateway that allows you to connect electrical circuits together with perfectly different parameters. The normal gateway to the river connects water channels located at different heights, opening or closing the gate. The relay in the arduino connects or disconnects the external device in a fixed pattern by closing or disconnecting a separate electrical network in which they are connected. With the help of arduino and relays we control the process of switching on or off as well, as we turn on or turn off the light at home - by giving the team a shutdown or disconnection. Arduino gives a signal, the same closing or unlocking of the "powerful" chain will do the relay through special internal mechanisms. The relay can represent itself in the form of a remote control, with the help of which we perform the necessary actions with the help of relatively "weak" signals.The relay is characterized by the following parameters:

- Tension or current of work;
- Tension or current release;
- Time off work and leave;
- Working current and tension;
- Internal resistance.

Depending on the type of these internal locking mechanisms and the features of the device, it is possible to distinguish two main groups of relays: electromechanical relays (including auxiliary electromagnetic components) and solid-state relays (included). Arduino relay is shown in figure 2.7
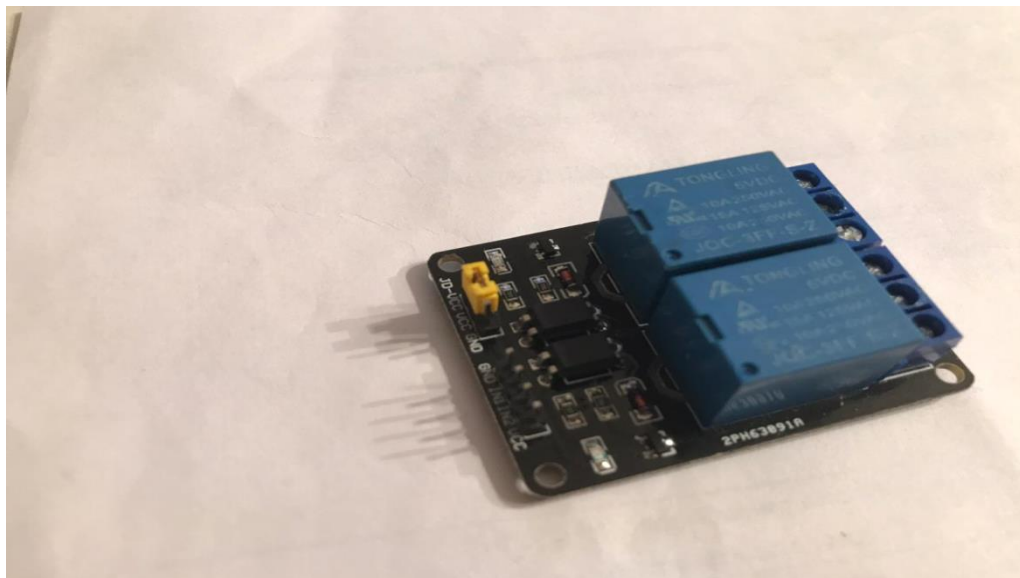

Figure 2.7 – Arduino relay

Proteus Design Suite, developed by the British company Labcenter Electronics, is a software package for automated design of electronic drawings.

Features of the package Proteus VSM capability to model the operation of programmable devices, microcontrollers, microprocessors, etc. Component libraries have reference data. The Proteus VSM package also includes a printer orientation system. The Proteus package consists of two parts, two programs: ISIS - a program for synthesis and modeling of electronic drawings, and ARES - a program for the production of printed circuit boards. The schematic of the Proteus software package is shown in Figure 2.8.
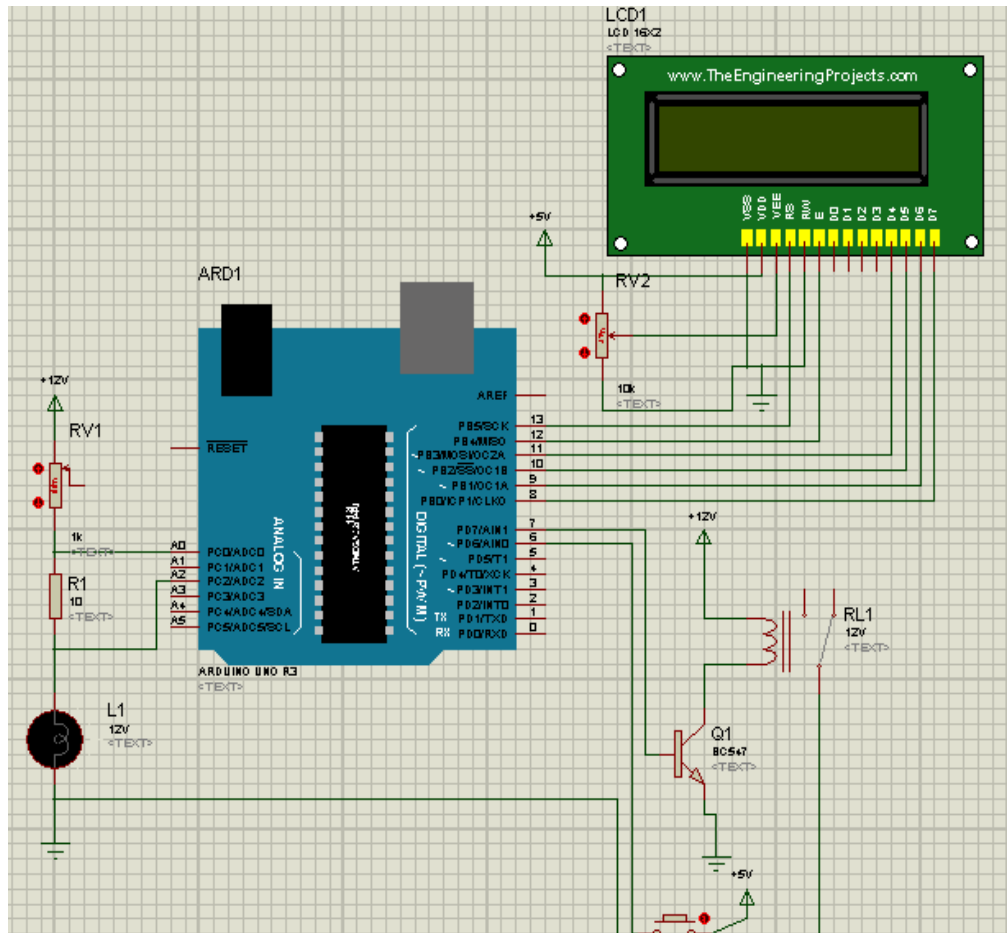
Figure 2.8 - Schematic in Proteus VSM

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of

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the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

Using an arduino IDE sketch to control a hydrogen generator. To control the generator, I used the button to turn the generator on and off. And he used a liquid crystal display to view the status of the generator and the current that flows into the generator. First, he introduced the variables for determining the data coming through the analog channel to determine the current strength since the Arduino Uno does not have a built-in multimeter. And he introduced another variable for the button to turn the hydrogen generator on and off(figure 2.9).

```
LiquidCrystal lcd(13, 12, 11, 10, 9, 8);
int adc_value = 0;
int voltage_peak_value = 0;
float voltage_average_value = 0;
float dc_voltage_V0 = 0;
float ac_voltage_V0 = 0;
float dc_voltage_V1 = 0;
float ac_voltage_V1 = 0;
float dc_current_I0 = 0;
float ac_current_I0 = 0;
unsigned long resistance;
unsigned long sample_count = 0;
void setup() {
  pinMode(7,OUTPUT);
  pinMode(6,INPUT);
```

Figure 2.9 – Variables

Then he made it so that using the formula it was possible to determine the current strength entering the generator. And when you press the button, the Liquid

Crystal Display showed the word "Generator is on" which indicates that the generator is operating at operating power and you can already use it (figure 2.10).

```cpp
void loop() {
if(digitalRead(6)==HIGH){
  digitalWrite(7,HIGH);
  if(digitalRead(6)==HIGH){
  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  lcd.setCursor(1,0);
  lcd.print("Generator ON");
  }
   voltage_peak_value = 0;
  for(sample_count = 0; sample_count < 5000; sample_count ++)
  {
      adc_value = analogRead(A2);
      if(voltage_peak_value < adc_value)
          voltage_peak_value = adc_value;
      else;
      delayMicroseconds(10);
  }
  dc_voltage_V1 = voltage_peak_value * 0.00488;
  ac_voltage_V1 = dc_voltage_V1 / 1.414;
  dc_current_I0 = (dc_voltage_V1 - dc_voltage_V0) * 100;
  ac_current_I0 = (ac_voltage_V1 - ac_voltage_V0) * 100;
  lcd.setCursor(4, 1);
  lcd.print(dc_current_I0);
  lcd.print(" mA");
  delay(1000);
 }
}
```

Figure 2.10 – Captions on LCD screen

2.4 Designing a hydrogen generator housing using SolidWorks

SolidWorks is a software package in the system of automated design of stages of design and technological preparation of production at industrial enterprises. This program provides the development of products of various difficulties. Works in Microsoft Windows environment. Manufacturers are SolidWorks Corporation. The company was first founded by John Hirstick in 1997 and is now an independent part of Dassault Systemes. The program was developed in 1993. It was first released in 1995. This program competed with such programs as AutoCAD, Autodesk Mechanical Desktop, SDRC I-DEAS and Pro / ENGINEER. SolidWorks was the first to provide solid state modeling on the Windows platform.

This program can solve the following tasks:
- 3D design of products of different complexity;
- preparation of structural documents in accordance with GOST standards;

- production design;
- redevelopment;
- communication design;
- engineering examination;
- material and labor standards;
- operational analysis of technology during design;
- process and data management in the design development of production.

I chose HDPE or PE HD material, low density high density polyethylene for the device case. The dimensions of the case are 30x20x10 cm (length, width, height, respectively). Each part of the case and the whole case itself is shown in Figures 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17.

This is a hard type of plastic, which practically does not emit harmful substances and is resistant to oils, gasoline and temperature effects. It is used for the manufacture of containers for food, packaging of milk, detergents, children's toys, sports and travel reusable bottles, road bumpers, and even for the production of children's slides.

According to the DIN 4102 standard, the PND is combustible in accordance with class B: B1 - difficultly flammable and B2 - normally flammable. Auto-ignition temperature is about 350 ° C.

Toxicity: Not Toxic. In essence, the chemical composition of polyethylene contains only carbon and hydrogen. Therefore, almost the only substances released during the burning of polyethylene are carbon dioxide, carbon monoxide (carbon monoxide), water and a small amount of soot.

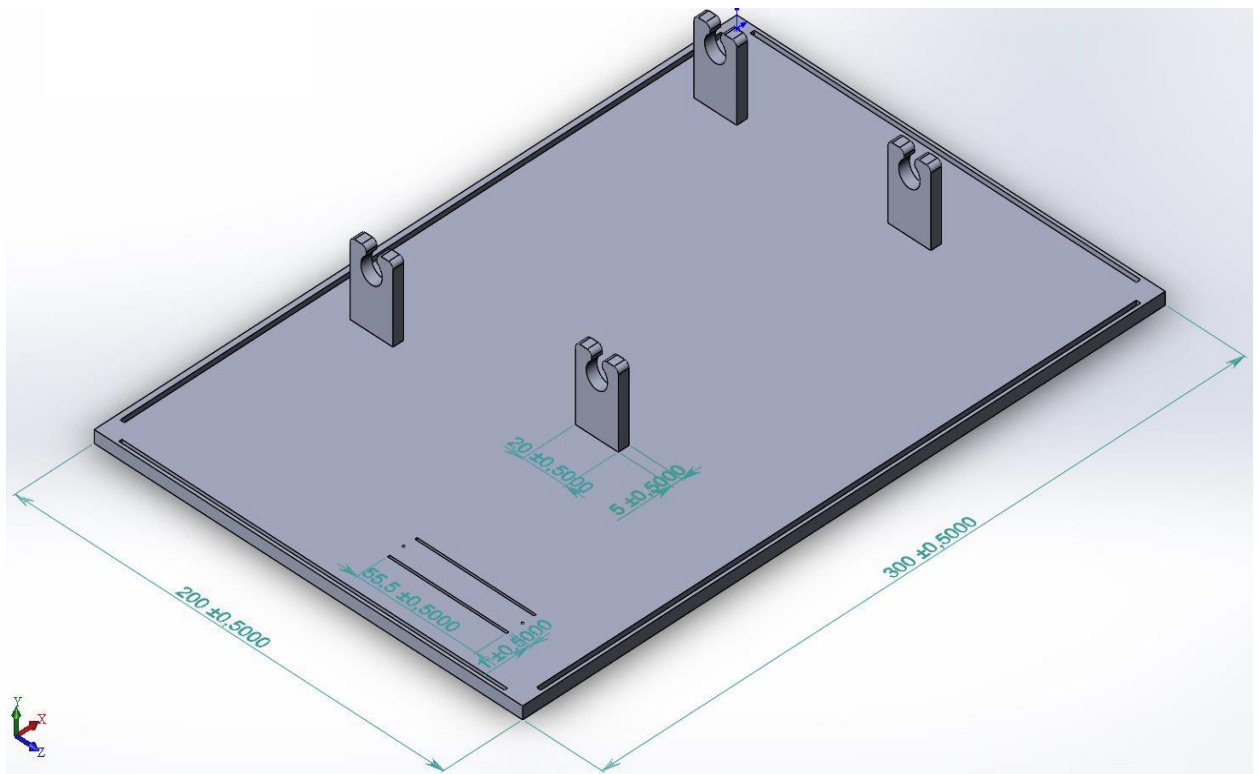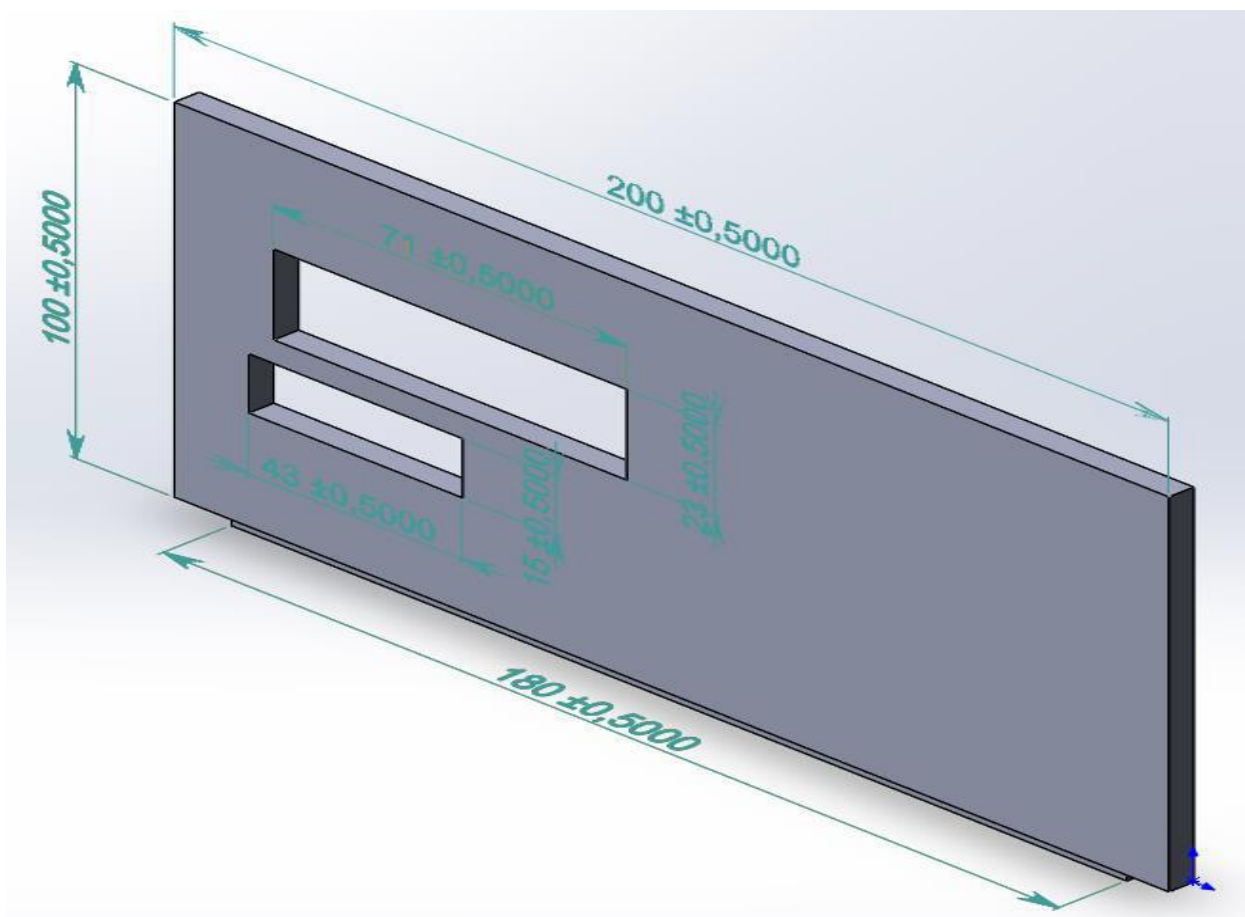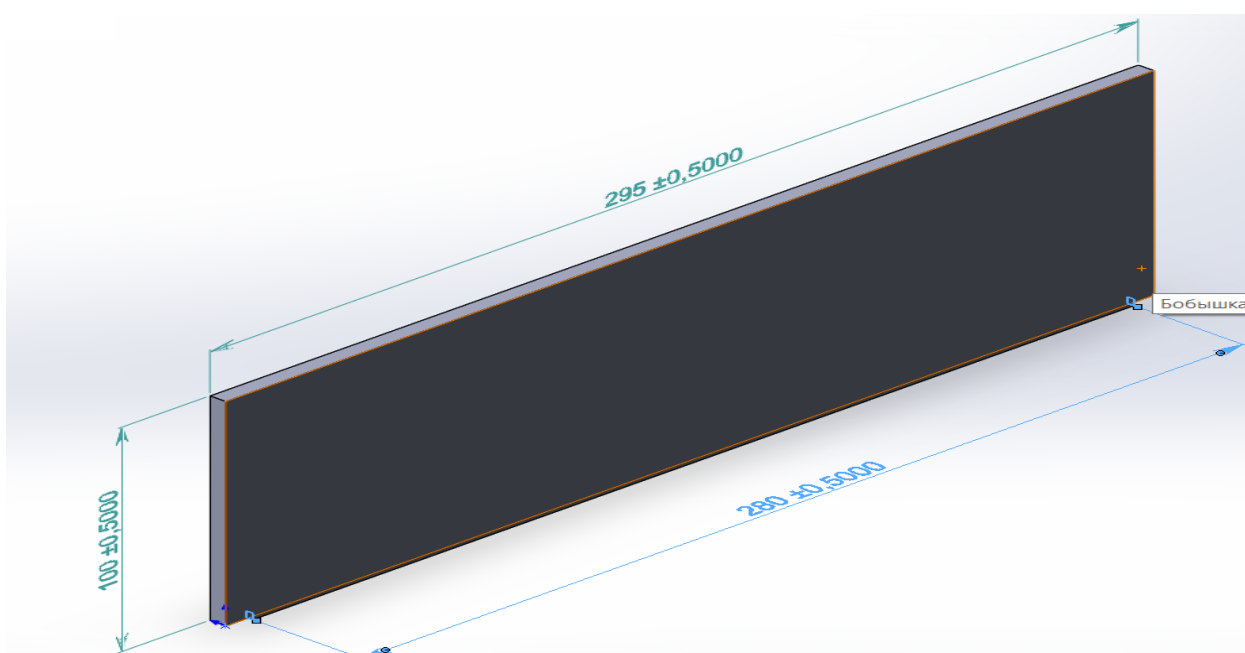Figure 2.11 – Bottom of the case

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Figure 2.12 – Front of the case

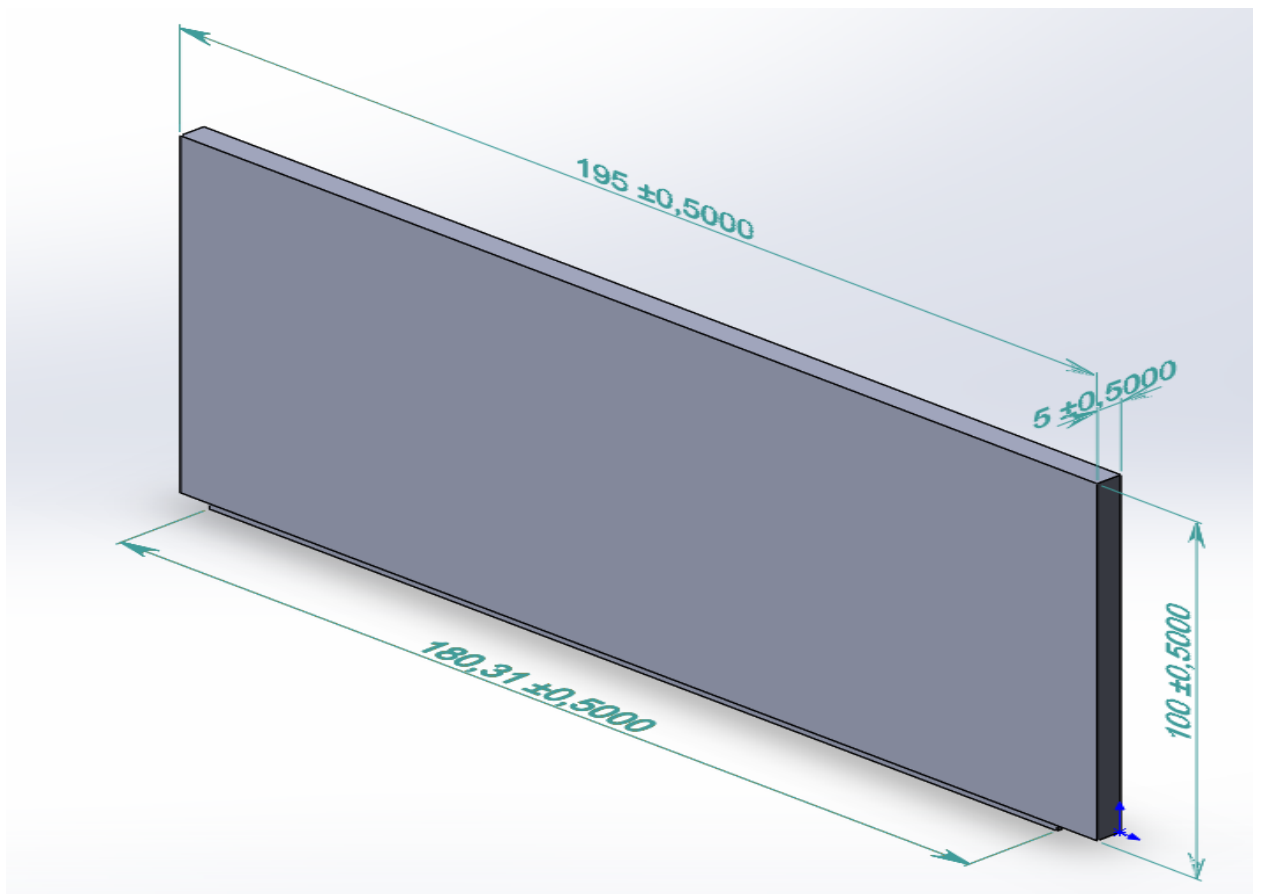

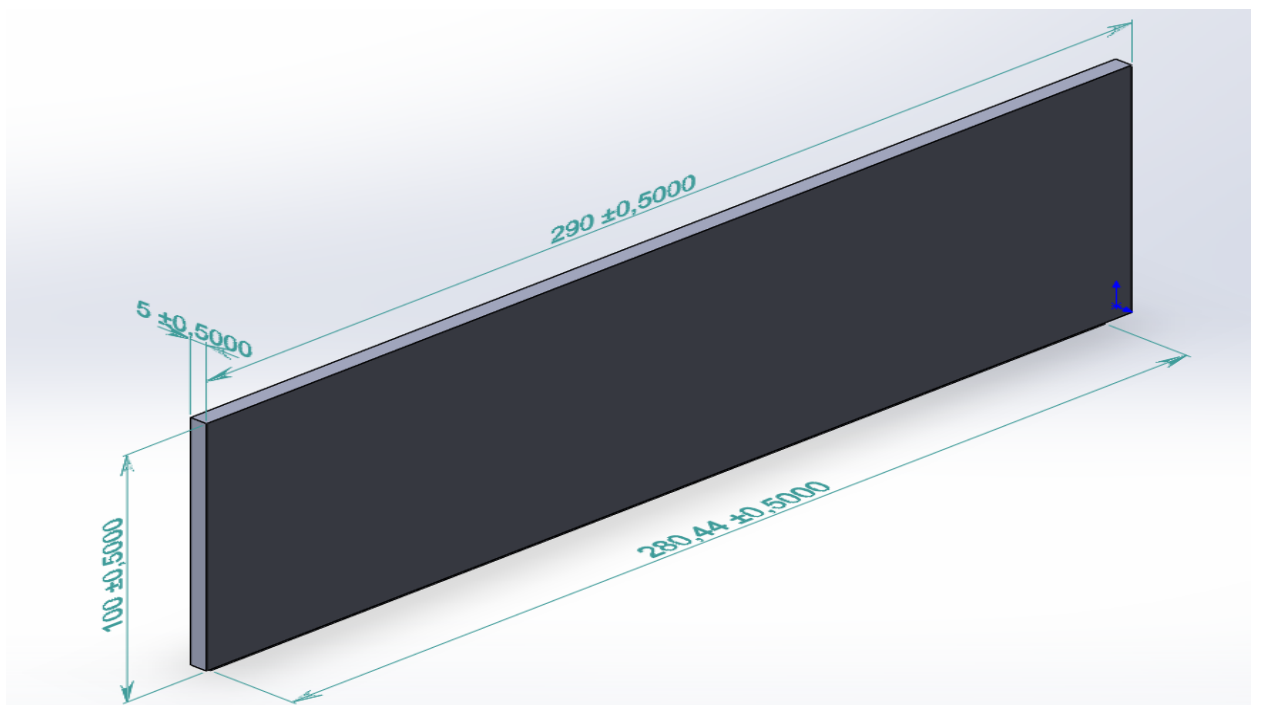Figure 2.13 – Left side of the case

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Figure 2.14 – The back of the case

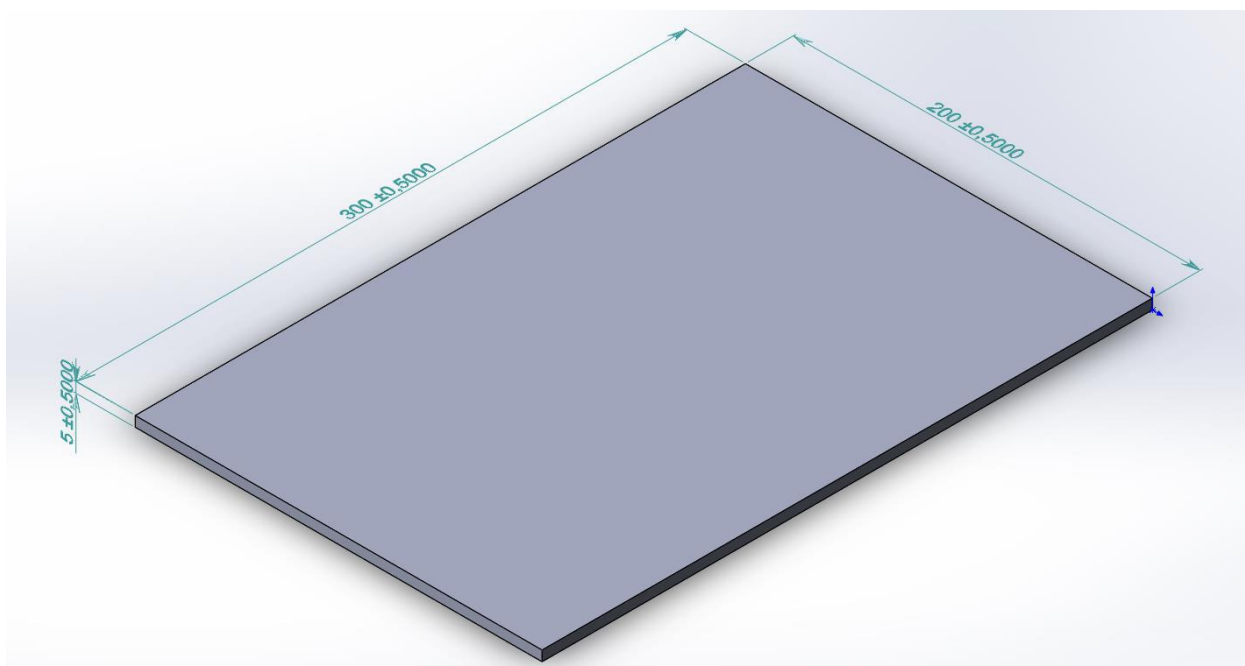

Figure 2.15 – Right side of the case
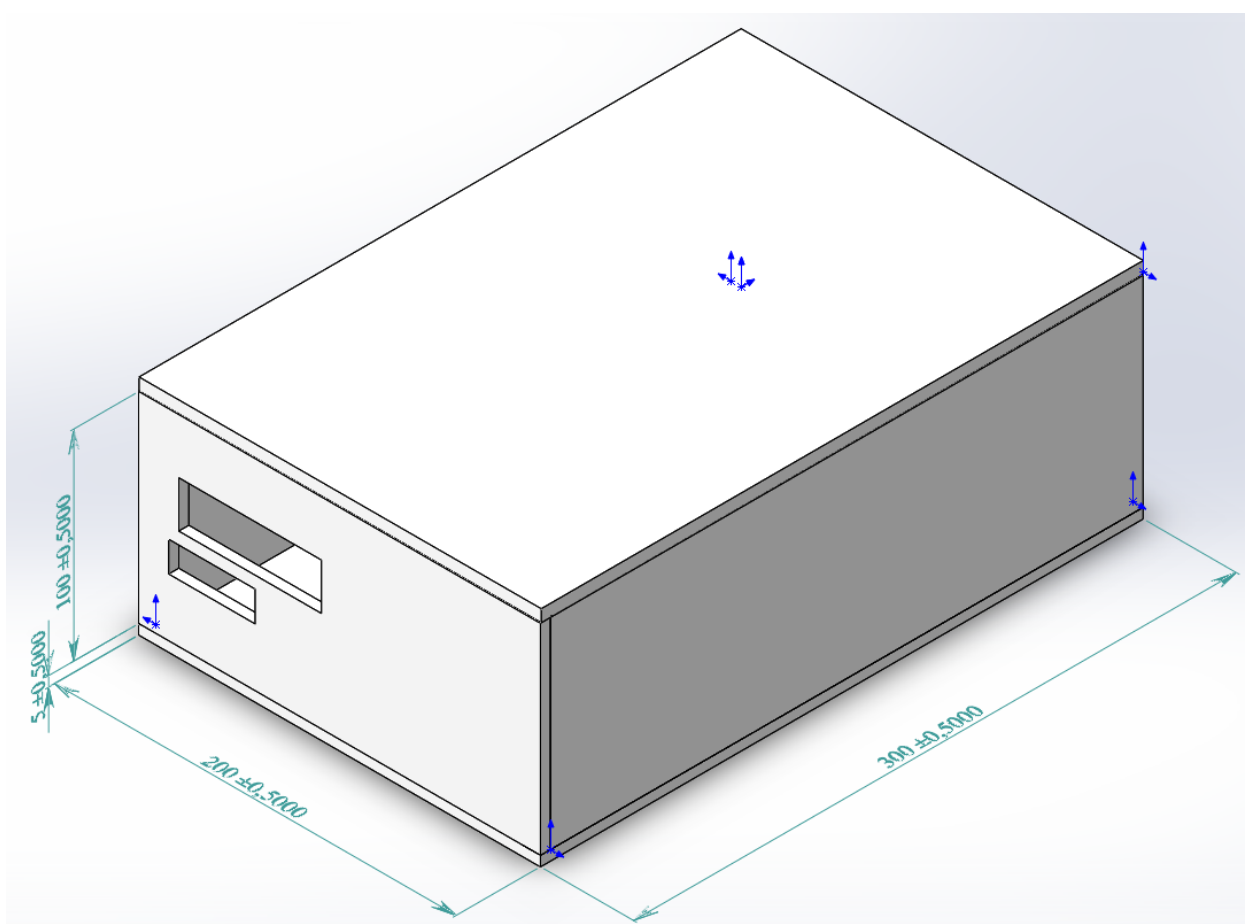
Figure 2.16 – Upper part of the case

Figure 2.17 – Assembled case

3 Feasibility study

3.1 Description of the work and justification of the need

Thesis considers methods of planning and construction of hydrogen generators for internal combustion engines and for domestic use.

In times of shortage of fuel and energy resources, the use of hydrogen generators instead of traditional fuel-generating devices in various industries is a topical issue, especially in power plants, heavy heat-intensive industries, metallurgy and ordinary households. After all, obtaining hydrogen through water is environmentally safe. One of the main goals of this thesis is to find an economically viable way to obtain hydrogen by water. In addition, the laminar flame rate of molecular hydrogen is 10 times higher than that of propane, and the minimum energy required to induce a flame is 16 times lower. This means that the efficiency of conventional fuel heat is correspondingly lower than the efficiency of hydrogen heat, so the amount of hydrogen used as fuel is much smaller than conventional fuel (1 ton of hydrogen with a minimum combustion heat of 4.1 tons of conventional fuel). 1 m3 of hydrogen is equal to $3.6 \cdot 10\text{-}4$ tons of conventional fuel).

The purpose of the thesis is to increase the efficiency of the GHG through a hydrogen generator, reduce fuel consumption by 30% and develop an advanced type of hydrogen generator that uses less energy.

The general task of calculating and designing a hydrogen generator for IGC assumes the following:

- increase the understanding of hydrogen generators;

- to find a method that uses much less energy than traditional methods of hydrogen distribution;

- introduction of hydrogen generators in IPS complexes;

- reduction of fuel consumption;

- reduction of harmful substances emitted by the hydrogen generator.

3.2 Calculate and determine the cost of assembling a hydrogen generator

To determine the cost of calculation and assembly work, it is necessary to calculate the following costs:

- remuneration of key employees (ie for employees directly involved in the work);

- additional payment;

- payment to the labor fund;

- the amount of contributions to the social tax from the labor fund;

- amount of depreciation transfer;

- the cost of rent, including utility bills;

- amount of material costs;

- the cost of certification and licensing;

- the amount of costs for search and advertising of the buyer;

- amount of taxes (road, transport, etc.);
- the amount of overhead costs.

3.3 Calculation of labor intensity and duration of calculation and assembly of a hydrogen generator for IPS

In this thesis, the calculation and design of a hydrogen generator for IDP consists of the following steps:
- study of the subject area;
- analysis of types of hydrogen generators and the most productive method;
- calculate the performance of the chosen method;
- Construction of a hydrogen generator for IPS;
- development of a special program;
- device testing;
- installation of the device in the IRS system.

According to the stages of labor intensity and the set of types of work, the labor intensity of the assembly work is probabilistic in the human-solar way, which is assessed by an expert. Because it consists of several factors that are difficult to take into account.

3 employees will be involved in the project development. They are: chief engineer, programming engineer, design engineer.

The Chief Engineer performs the main tasks, as well as as the Chief Engineer, monitors the performance of work tasks, the progress of work throughout the period and provides the necessary advice. The engineer-programmer is engaged in information and software of the device, and the engineer-designer is responsible for assembly work, including welding.

Estimation of labor intensity for the construction of a hydrogen generator for IPS is shown in Table 3.1.

Labor intensity of the project work:
- Chief Engineer - 32 man-days;
- programming engineer - 16 man-days;
- design engineer - 16 man-days.

Table 3.1 - Calculation of labor intensity for the construction of a hydrogen generator for IPS.

№	Content of work	Performers	Duration, days
1	Subject area Research	Chief Engineer Programmer engineer Design engineer	8 4 4
2	Analysis of types of hydrogen generators and the most productive method	Chief Engineer Programmer engineer Design engineer	5 2 2
3	Calculate the performance of the selected method	Chief Engineer Programmer engineer Design engineer	2 1 1

№	Content of work	Performers	Duration, days
4	Construction of a hydrogen generator for IPS	Chief Engineer Design engineer	7 5
5	Development of a special program	Chief Engineer Programmer engineer	3 5
6	Testing the device	Chief Engineer Programmer engineer Design engineer	3 2 2
7	Installation of the device in the IRS system	Chief Engineer Programmer engineer Design engineer	4 2 2
Overall			64

3.4 Calculation and calculation of staff costs for the assembly and installation of a hydrogen generator for IPS.

The basic salary of employees is calculated according to the following formula:

$$S_{basic} = S_{aver} \cdot T, \tag{3.1}$$

where, S_{basic} - basic salary of employees (tenge);
S_{aver} - the average daily salary of an employee (tenge);
T - labor intensity (64 man-days);
Basic salary for the chief engineer:

$$S_{basic} = 5000 \cdot 32 = 160\ 000 \text{ tg.}$$

Basic salary for a software engineer:

$$S_{basic} = 4000 \cdot 16 = 64\ 000 \text{ tg.}$$

Basic salary for an engineer-designer:

$$S_{basic} = 4000 \cdot 16 = 64\ 000 \text{ tg.}$$

The salary is calculated for 21 working days. The calculation of the basic salary is shown in Table 3.2.

Table 3.2 - Basic salary calculation

Employees	Monthly, tg / month	Salary tg / day.	Labor intensity, man-days.	Amount, tg.
Chief Engineer	105000	5000	32	160000
Programmer engineer	84000	4000	16	64000
Design engineer	84000	4000	16	64000

Employees	Monthly, tg / month	Salary tg / day.	Labor intensity, man-days.	Amount, tg.
S_{basic} of employees				288000

The calculation of the cost of rest and sickness of employees is determined by the following formula, ie the additional salary of employees (calculated on average 10% of the base salary):

$$S_{add} = 0,1 \cdot S_{basic}, \tag{3.2}$$

Additional salary for the chief engineer:

$$S_{add} = 0,1 \cdot 160000 = 16\ 000 \text{ tg.}$$

Additional salary for a software engineer:

$$S_{add} = 0,1 \cdot 64000 = 6400 \text{ tg.}$$

Cost of additional salary for a design engineer:

$$S_{add} = 0,1 \cdot 64000 = 6400 \text{ tg.}$$

3.5 Social transfer calculation

According to the Tax Code of the Republic of Kazakhstan, the social tax is 9.5% of the salary fund (SF). And the payment of the pension fund (PF) is 10% of the subsidiary. No social tax is levied on the pension fund.

The salary fund can be calculated by the following formula:

$$SF = S_{basic} + S_{add} \tag{3.3}$$

where, S_{basic} is the basic salary;
S_{add} - additional salary;
Amount of salary fund for the chief engineer:

$$SF_1 = 160000 + 16000 = 176\ 000 \text{ tg.}$$

Amount of salary fund for programming engineer:

$$SF_2 = 64000 + 6400 = 70\ 400 \text{ tg.}$$

Amount of salary fund for engineer-designer:

$$SF_3 = 64000 + 6400 = 70\ 400 \text{ tg.}$$

Total amount of salary fund:

$$\Sigma SF = 176000 + 70400 + 70400 = 316\ 800 \text{ tg.}$$

The amount of contributions to the Pension Fund (PF) is calculated by the following formula:

$$PF = SF \cdot 0.1, \tag{3.4}$$

where, OJSC is the salary fund.

Amount of contributions to the pension fund for the chief engineer:

$$PF_1 = 176000 \cdot 0.1 = 17\ 600 \text{ tenge.}$$

The amount of contributions to the pension fund for a software engineer:

$$PF_2 = 70400 \cdot 0.1 = 7040 \text{ tenge.}$$

The amount of contributions to the pension fund for the design engineer:

$$PF_3 = 70400 \cdot 0.1 = 7040 \text{ tenge.}$$

Total amount of the pension fund:

$$\Sigma PF = 17600 + 7040 + 7040 = 31\ 680 \text{ tenge.}$$

We determine the amount of social tax contributions by the following formula:

$$T_{soc} = (SF - PF) \cdot 0.095, \tag{3.5}$$

Amount of social tax contributions for the chief engineer:

$$T_{soc1} = (176000 - 17600) \cdot 0.095 = 15\ 048 \text{ tg.}$$

The amount of social tax contributions for a software engineer:

$$T_{soc2} = (70400 - 7040) \cdot 0.095 = 6019 \text{ tg.}$$

The amount of contributions to the pension fund for the design engineer:

$$T_{soc3} = (70400 - 7040) \cdot 0.095 = 6019 \text{ tg.}$$

Total amount of the pension fund:

$$\Sigma T_{soc} = 15048 + 7040 + 7040 = 27\ 086 \text{ tg.}$$

Total amount of social contributions:

$$\Sigma C_{soc} = \Sigma SF + \Sigma PF + \Sigma T_{soc} = 316800 + 31680 + 27086 = 375566 \text{ tg.}$$

Social contributions related to employees are shown in Table 3.3:

Table 3.3 - The amount of social contributions

	Salary fund, tg	Pension fund, tg	Social tax, tg
Chief Engineer	176000	17600	15048
Programmer engineer	70400	7040	6019
Design engineer	70400	7040	6019
Overall ΣSF, ΣPF, ΣTsoc	316800	31680	27086
The total amount of social contributions: $\Sigma C_{soc} = 375\ 566$ tg.			

3.6 Calculation of material costs

The amount of material costs can be determined by the following formula:

$$C_m = \Sigma R_i \cdot C_i, \tag{3.6}$$

where, Ri - i cost of various material resources, natural numbers;

Ci - i price of a copy of a different material resource, tg;

i - type of material resource;

n - number of types of material resources;

Calculations of the cost of material resources are shown in Tables 3.4 and 3.5:

Table 3.4 - The amount of costs for material resources and assembly

Name of material	Brand	Unit of measurement	Number	Price for 1 piece,tg	Amount,tg
Plastic canister	10l	Piece	1	1000	1000
Plastic bottle	1.5l	Piece	1	300	300
Metal sheet	1x1m	Piece	3	1500	4500
Arduino	Uno	Piece	1	4000	4000
LCD Display	16x2 LCD	Piece	1	1500	1500
Soldering iron	CT-853K	Piece	1	3500	3500
USB	3.0	Piece	1	500	500
Copper wire	1m	Piece	2	300	600
Pipe	50cm	Piece	2	200	400
Overall				12800	16300

Table 3.5 - Software costs

Name of material	Brand	Unit of measurement	Number	Price for 1 piece,tg	Amount,tg
Laptop	Lenovo Ideapad 11	Piece	3	100 000	300 000
Mouse	Defender	Piece	3	1 200	3 600
Programs	Arduino IDE, Proteus, Solid Works	Piece	1	80 000	80 000
Overall				19200	383 600

The cost of transportation is 10% of the total amount of materials. It is defined by the following formula:

$$T_m = C_m \cdot 0.1,$$

(3.7)

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Amount of freight costs:

$$T_m = 16300 \cdot 0{,}1 = 1630 \text{ tg.}$$

It will take 2.5 months to complete the project (64/25 = 2.56). In this regard, the office building will be rented. The amount of rent for an office building in Almaty is 90,000 tenge (for 1 month). The total amount of rent for the project is 225,000 tenge. Of this amount:
- working area equal to 24 square meters;
- electricity;
- cold and hot water;
- heating system;
- security service;
- costs such as internet.

The full cost of the project is given in the following formula:

$$C_{project} = 375556 + 16300 + 225000 + 383600 = 1\,000\,456 \text{ tg.}$$

The cost of each phase of the project is shown in Table 3.6:

Table 3.6 - Estimates of project costs

Costs of the project development stages Amount, tg.	Cost, tg
Social contributions	375 566
Cost of material resources and assembly	16 300
Software costs	383 600
Expenses for rent and utilities	222 500

3.7 Depreciation charges

Depreciation is determined by the following formula:

$$C_d = N \cdot S, \tag{3.8}$$

where, N - average annual depreciation rate,%;
S - starting price of the device, tenge.

According to the section of the Tax Code of the Republic of Kazakhstan dated 25.12.2017 N 120-VI 3RK "On taxes and other payments to the budget" the maximum depreciation rate for vehicles and devices (group II) is 25%, and computers, software and information processing devices (For group III) the marginal depreciation rate is 40%.

Amount of depreciation for the device:

$$C_d = 16300 \times 0.25 = 4075 \text{ tg.}$$

Amount of depreciation for software and information processing devices:

$$C_d = 383600 \times 0.4 = 153440 \text{ tg.}$$

3.8 Calculation of the estimated cost of work

The amount of the potential cost of the project is set in such a way that the performance, properties and timeliness meet the level of financial interest of the executor and the buyer.

The agreed cost of the project is calculated by the following formula:

$$P{oi} = C_{project} \cdot (1 + P/100) + VAT. \qquad (3.9)$$

where, $P\square\square$ - agreed price of the project, tenge;
$C_{project}$ - the cost of the project, tenge;
P - average level of profitability,%;
VAT - value added tax,%.
The amount of the agreed price of the project:

$$P\square\square = 1000456 + 120054.72 = 1\ 120\ 510{,}72\ tg.$$

The value-added tax rate on the additional cost of the project is calculated by the following formula:

$$VAT = C_{project} \times 0.12 = 1000456 \times 0.12 = 120054.72\ tg. \qquad (3.10)$$

3.9 Evaluation of work efficiency

The main indicators of the scientific impact of research work are the novelty of the work, the degree of theoretical elaboration, prospects, the degree of dissemination of results and the probability of implementation will be found. The scientific impact of research can be characterized by two indicators: the degree of scientific innovation and the level of theoretical refinement.

The indicator that characterizes the scientific effect is determined by the following formula:

$$En = 0.6\ Xnew + 0.4\ Xtheor, \qquad (3.11)$$

where, Xnew, Xtheory - indicators of the degree of scientific novelty and the level of theoretical refinement;
0.6; 0.4 - coefficients of indicators of the degree of scientific novelty and the level of theoretical development.

In terms of the degree of scientific novelty, this work is relatively new. Because this technology exists only abroad, and in Kazakhstan it is not used yet. The degree of scientific novelty of the project on the novelty of R&D is 4 points. And the level of theoretical elaboration is 6 points, as shown in the table of elaboration.

Depending on these indicators, the scientific impact of the project will be as follows:

$$Width = 0.6 \times 4 + 0.4 \times 6 = 4.8.$$

The cost of the project was 1,000,456 tenge. The scientific effect is 4.8 points. The work is relatively new, depending on the degree of scientific novelty and the level of theoretical refinement.
- low cost;

- no use of expensive accessories;
- efficiency in terms of electricity consumption;
- small size and mass.

4 Life safety

4.1 Assessment of the stability of an engineering complex to the effects of an air-gas mixture explosion.

Since the purpose of the thesis is to assemble a hydrogen generator indoors I have to calculate the stability of an engineering complex to the effects of an air-gas mixture explosion. During electrolysis, explosive gas is released. And I have to calculate how many mg of gas per cubic meter so that an explosion or rapid fire occurs.

The engineering and technical complex of the facility includes buildings and structures, technological equipment and communications, electricity networks, heating networks, water supply, sewage and gas pipelines.
Destruction and damage of buildings, structures, technological installations and pipelines in oil refining, chemical and some other industries with explosive, gas and fire hazardous technologies can lead to the outflow of gaseous or liquefied hydrocarbon products and potent toxic substances. When hydrocarbon products are mixed with air, explosive or fire hazardous mixtures are formed, and zones of dangerous chemical contamination follow the trail of the toxic cloud.

Explosive mixture is a mixture with air of gases, flammable liquids, combustible dust or fibers.

An explosion is a fast-moving process of physical or chemical transformation of substances, accompanied by the release of a large amount of energy in a limited volume, as a result of which a shock wave is generated and spread in the surrounding space, which can pose a threat to human life and health, cause material damage, damage the environment and become a source emergency situation.

In most explosions, the source of energy release is the chemical transformations of substances associated with oxidation. There are many substancesin which, in one form or another, a large amount of energy is stored in the form of intramolecular and intermolecular bonds. Under normal conditions, these substances are sufficiently stable and can be in a solid, liquid, gaseous or aerosol state.However, as a result of the initiating effect (heat, friction), exothermic processes begin in them, proceeding at high speed and leading to an explosion.

The most common condensed (solid) explosives (BB) are TNT, RDX, smoke powder, pyroxylin, ammonal, etc.

Explosions of condensed explosives occur in a detonation mode, in which a blast wave in a charge propagates at a constant speed.

Examples of explosions, the energy release of which is due to physical processes, can be emergency pouring of molten metal into water, in which evaporation occurs explosively due to extremely fast heat transfer, and explosions of compressed or liquefied gases.

In this case, the energy is determined by the processes associated with the adiabaticexpansion of vapor-gas media and overheating of liquids. At industrial

enterprises, the most explosive are gas-air (DHW) and dust-air (PBC) mixtures formed in normal or emergency situations.

Of gas-air mixtures, the most dangerous explosions of mixtures with air are hydrocarbon gases, as well as vapors of flammable liquids (table 4.1).

Table 4.1 – Flammable liquids characteristics

Gas or steam	Explosive limit, vol.%	
	Lower	upper
Knallgas (Oxyhydrogen)	4.5	95

Explosive combustion is based on the rapid chemical reactions of oxidation of combustible materials with atmospheric oxygen. The main parameter characterizing the danger of explosion is the concentration limits of flame propagation (ignition).

The lower (upper) concentration ignition limit (LEL) is the minimum (maximum) content of the fuel in the mixture; the combustible substance is an oxidizing medium in which the flame can propagate through the mixture at any distance in the presence of an ignition source (flame, spark, heated body). Inside these limits, the mixture is combustible, and outside of them, the mixture is incapable of burning.

The NKPV value is used in the calculation of explosion-proof concentrations of hot water and PWS inside technological equipment, pipelines, ventilation systems, as well as for a comparative assessment of the explosiveness of substances.

The concentration limits of ignition in percent volumetric when calculating the explosion-proof concentrations of hot water and dusty mixture must be converted in grams per meter cubic using the following equation:

$$K_x = \frac{X * V_t}{22.4} \qquad (4.1)$$

Where K_x – concentration of gas on air, g/m^3; X – concentration of gas on air, vol.%; V_t - volume of 1 mole of gas under given conditions, m^3

Explosive limits of oxydrogen varies from 4.5% to 95%.

At 18-20^0 C temperature volume of 1 mole is $22.4 \cdot 10^{-3} m^3$

To find lower flammability limit:

$$K_x = 4.5 \cdot 10^{-2} \cdot 18/22.4 \cdot 10^{-3} = 36.16 g/m^3.$$

To find upper flammability limit:

$$K_x = 95 \cdot 10^{-2} \cdot 18/22.4 \cdot 10^{-3} = 763.39 g/m^3.$$

In practice, there are free air explosions, ground (surface) explosions, indoor explosions (internal explosion) of hot water or air conditioning systems, as well as explosions of large clouds of hot water. The total energy release during the explosion is estimated by the energy potential of the explosion.

Operation of any production facility of increased danger can always lead to serious emergencies (hereinafter referred to as emergencies), accidents, and also accidents, including fatal ones.

As a result of an industrial accident, explosions and fires are possible, as well as their consequences; destruction and damage of a building, structure, machinery and equipment, flooding of the territory, failure of communication lines, energy and utilities networks, etc.

Places in buildings where the formation of explosive combustible mixtures is possible are called rooms of explosive industries. Destruction of equipment and buildings leads to significant material losses, and secondary factors of explosions (fragments of equipment, fragments of building envelope) can become injuries (deaths) of personnel. The solution to the problem of protection of explosive buildings has not only economic, but also social significance.

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The task of increasing the safety of buildings of explosive production is solved in two stages. At the first stage, the possible parameters of the explosion of combustible mixtures are determined, and at the second stage, technical solutions are selected that allow to limit the overpressure inside the room to a safe level.

The use of technical measures is associated with the material costs of creating technical devices and structures (protection and blocking systems, light and sound alarms, danger, alarms and automatic fire extinguishing, emergency ventilation, control and automatic control and automatic process control) for fire prevention, conducting tests of safety systems and emergency response.

Explosion protection devices include hydraulic locks, fire arresters, inert gas, nitrogen or steam supply systems, emergency ventilation, emergency pressure relief valves (safety valves and membranes, ball valves, etc.).

The list of fire equipment will consist of equipment, taking into account vehicles, installations, tools and a number of other devices that are directly involved in fire fighting. Automatic fire extinguishing systems should also be considered. The differences are in the varieties of the composition (substance) used, which will be selected depending on the class and degree of distress. These include:
- gases and their compounds;
- carbon dioxide;
- freon;
- nitrogen;
- water vapor;
- sand;
- foam;

- water.

Based on their placement principles, fire extinguishing media can be divided into stationary, semi-stationary and mobile. They can function both in automatic and in manual mode. The primary means of extinguishing fires include fire extinguishers.

4.1.1 Stationary installations

They are used to eliminate fires that are still in the initial stages of occurrence, while the participation of people will be optional. Similar installations are found in almost any buildings and structures. They are divided into several subspecies, such as powder, gas, foam and water. The last two types of installations are presented in the form of branched piping systems with small openings. The type of installation - deluge or sprinkler will depend on the heads used. Remote start can be either manual or automatic. It is customary to use automatic installations to quickly eliminate the accident.

4.1.2 Foam installations

Used to effect on flammable liquids. They are used to protect structures and buildings and technical equipment stored in them. Such installations should contain a number of substances that will be stored in special tanks designed for their storage. Their performance will depend on the characteristics of the substance used. Selected water sources will also play an important role.

Such installations, depending on the source of ignition, can be divided into:
- Combined;
- Local volumetric;
- General volume;
- Local surface;
- General surface;
- Water installations.

Used in rooms where the hazard level is at a high level. The principle of their functioning is that the dispensers and pumps used are extremely necessary for irrigation through water. Thus, the source of ignition is localized.

Used subspecies of the device:
- fire extinguishing modular devices;
- deluge units;
- sprinkler devices with remote start capability;
- sprinkler fire extinguishing systems.

4.1.3 Gas installations

With the help of such equipment, fires are extinguished, and special containers based on gas (argon, nitrogen, freon) are stored in the tanks used. Switchgears can significantly reduce consumption and apply it over large areas.

The main functions of the equipment:
- to create a certain amount of gas used, which should be enough to carry out fire fighting;

- gas will be delayed until the evacuation of personnel from the selected premises;

- timely detection of the source of ignition and the alarm, which is equipped with the system.

4.1.4 Powder

Such automated stationary devices used to extinguish fires are used to localize fire sources in order to prevent its spread throughout the protected area. When compared with the varieties listed above, they cannot be used to extinguish fires that are directly related to chemical and combustible elements. And even they cannot guarantee the cessation of burning.

They can be used to extinguish fires at such enterprises and territories as:
- Gas distribution substations;
- Dumping overpasses and tank-type parks;
- Open type food pumps;
- Technological installations of the external type;
- Administrative buildings;
- Electrical cabinets, electrical equipment and even transformers;
- Diesel generators;
- Power plants;
- Left-luggage offices;
- Trading enterprises;
- Depot for locomotives;
- Garages;
- Station stations;
- Drying and spray booths;
- Storerooms for household purposes;
- Warehouses;
- Industrial premises.

Similar systems cannot be used to eliminate fires:
- chemicals and mixtures based on them, polymeric materials;
- flammable substances and materials that are prone to spontaneous combustion.

4.2 Determination of indoor air exchange

The definition of air exchange in a room is primarily dependent on the type of room, domestic, commercial or industrial use. Hours and hours of operation, intensity, etc. The table presents typical examples of the multiplicity for calculating the total desired air exchange in the room.

In addition to the type of room, the type of equipment that you are going to use in the room indirectly affects the definition of air exchange, namely:
- fan performance;
- air pressure generated by the fan;
- length and cross section of the ventilation system;
- use of recirculation, recuperation or supply and exhaust ventilation;

- climate control systems used.

For proper arrangement of ventilation, it is necessary to determine the amount of air exchange in the room for an hour, there are several ways.

One of the methods for determining the total air exchange is based on the air exchange rate, where the frequency is selected depending on the type of room and compiled on the basis of the studies. According to the multiplicity table for each room.

$$L = V_{ind} \cdot Mp \ (m3 \ / \ h), \qquad (4.2)$$

Where,
- L– Air volume for complete air exchange M3 / h;
- V_{ind} - the volume of the calculated premises, m3;
- Mp - the rate of air exchange based on the table of the ratio.

Table 4.2 – Air exchange rate of room

Industrial premises and premises of large volume	Air exchange rate
Theatre, cinema hall	20-40m^3 per person
Office	5-7
Bank	2-4
Bar, café	9-11
Kitchen room in café, restaurant	10-15
Supermarket	1.5-3
Pharmacy	3
Garage, car repair shop	6-8
Toilet	10-12
Dance hall, disco	8-10
Smocking room	10
Industrial dyeing shop	25-40
Mechanical workshop	3-5
Classroom	3-8

The determination of the volume of the premises is carried out according to the following formula:

$$V \ (m3) = A \cdot B \cdot H, \qquad (4.3)$$

Where,
A is the width of the room in meters;
B is the length of the room in meters;
H - the height of the room in meters.

Depending on the amount of air received, ventilation equipment is selected.

To select ventilation equipment we should calculate volume of room:

$$V(m3) = 3 \cdot 4 \cdot 2.5 = 30m^3$$

Then to find air volume for complete air exchange we multiply room volume to air exchange taken from table:

$$L= 30m^3 \cdot 5=150m^3/h$$

4.2.1 In-depth calculation of total air exchange

Specific calculation on one person

Also, when calculating the total air exchange in the room, you can use the formula, which indicates the standard amount of air per person for this room:

$$L = L1 \cdot NL \ (m3 / h), \qquad (4.4)$$

Where,

L1 - standard amount of air per person, m3 / h * people;

NL - the total number of people arriving at the same time at the same time

There are the following regulatory amounts of air per person:

20 m3 / hour per person - with slight physical activity;

45 m3 / hour per person - with mild physical activity;

60 m3 / hour per person - with heavy physical work.

To calculate volume for complete air exchange we multiply standard amount of air per person to number of person arriving indoors at the same time:

As the activity on indoors are mild physical we should take $45m^3$ as the standard amount of air for each person. And the number of person arriving on indoors are 1.

$$L=45 \cdot 1=45(m^3/h)$$

Table 4.3 - Characteristics of the vkom air conditioner

Voltage, V/50 Hz	230
Full power, Wt	36
Current, A	0.25
Bandwidth, m^3/h	210
RPM, min -1	1310
Noise level, dB(A)	34

Summing up the calculations, we can say that Oxyhydrogen is a very explosive mixture, even in small volumes. To produce Oxyhydrogen, the room must be well ventilated.Also theroom is small wehaveenoughsmallfantocleantheair. In addition, the work requires safety.Safety measures include a set of technical and organizational measures aimed at creating safe working conditions and preventing industrial accidents.

At any enterprise, measures are taken to ensure that the labor of workers is safe, and large funds are allocated for the implementation of these goals. The factories have a special security service subordinate to the chief engineer of the plant, developing measures that should ensure safe working conditions for the worker, monitoring the state of industrial safety and ensuring that all workers entering the enterprise are trained in safe working practices.At the plants, measures are systematically carried out to reduce injuries and eliminate the possibility of accidents. These activities are reduced mainly to the following:

- Improving the design of existing equipment in order to protect workers from injuries;

- Installation of new and improvement of the design of existing protective devices for machine tools, machines and heating installations, eliminating the possibility of injury;

- Improvement of working conditions: ensuring sufficient lighting, good ventilation, dust suction from treatment sites, timely disposal of production waste, maintaining normal temperatures in workshops, workplaces and at heat-emitting units;

- Elimination of the possibility of accidents during the operation of the equipment, breaking of grinding wheels, breaking of rapidly rotating circular saws, splashing of acids, explosion of vessels and high-pressure pipes, ejection of flames or molten metals and salts from heating devices, sudden switching on of electrical installations, electric shock, etc. .;organized familiarization of all those who come to work with the rules of conduct on the territory of the enterprise and the basic safety rules, systematic training and testing of knowledge of working rules of safe work;

- Providing workers with safety instructions and workplaces with posters that clearly show hazardous places in the workplace and measures to prevent accidents.

- However, as a result of a dismissive attitude on the part of the workers themselves to safety measures, accidents are possible. To protect yourself from an accident, you need to study the safety rules and constantly observe them.

4.2.2 General requirements for industrial safety.

1. Upon receipt of a new (unfamiliar) job, require additional safety instruction from the master.

2. When doing work, you need to be careful not to be distracted by extraneous matters and conversations and not to distract others.

3.On the territory of the plant (in the courtyard, building, access roads), comply with the following rules:

- Do not go unnecessarily to other shops of the enterprise;

- To be attentive to the signals given by crane operators of electric cranes and drivers of moving vehicles, to execute them;

- Bypass loading and unloading places and not be under a raised load;

- Do not pass in places not intended for passage, do not crawl under a standing train and do not cross the path in front of a moving vehicle;

- Do not cross over conveyors and roller tables in undefined places and do not crawl under them, do not enter without permission for fences;

- Do not touch electrical equipment, terminals and wires, general lighting fixtures and do not open the doors of electrical cabinets;

- Do not turn on and stop (except in emergency cases) machines, machine tools and mechanisms, the work of which is not entrusted to you by the administration of your workshop.

4. In case of injury or ailment, stop work, notify the master and contact the medical center.

The following are special safety requirements.

Before starting work:

1. Put in order your work clothes: fasten or wrap around the sleeve cuff with a wide elastic band; tuck clothing so that there are no fluttering ends of clothing: remove the ends of a tie, scarf or scarf; put on a tight-fitting hat and pick up hair under it.

2. Wear work shoes. Work in light shoes (slippers, sandals, sandals) is prohibited due to the possibility of injury to the legs with sharp and hot metal shavings.

3. Carefully inspect the workplace, put it in order, remove all obstructing and obstructing objects. Arrange tools, accessories, necessary material and parts for work in a convenient and safe manner for use. Make sure that the working tool and accessories are working.

4. Check that the workplace is sufficiently lit and that the light does not blind the eyes.

5. If you need to use a portable electric lamp, check that the lamp has a protective net, that the cord and the insulation rubber tube are working. The voltage of portable electric luminaires should not exceed 36 V, which must be checked by the inscriptions on the shields and current collectors.

6. Make sure that the floor in the workplace is in good condition, without potholes, without slippery surfaces, etc., that there are no bare electrical wires nearby and all hazardous areas are fenced.

7. When working with hoists or hoists, check their serviceability, raise the load to a small height and make sure the brakes, slings and chains are reliable.

8. When lifting and moving heavy loads, only one person should give signals to the crane operator.

9. The slinging (mooring) of the cargo must be reliable, with shanks (ropes or cables) of appropriate strength.

10. Before installing large-sized parts on a stove or on an assembly table, pre-select installation and fastening devices (supports, measuring spacers, elbows, jacks, pressure bars, bolts, etc.).

11. When installing heavy parts, choose a position that allows it to be processed with one or fewer installations.

12. Choose a scheme and a processing method in advance, take into account the convenience of changing tools and making measurements.

During operation:

13. When sharpening the tool on grinding wheels, it is imperative to wear safety glasses (if the wheel does not have a protective shield). If there is a protective screen, then do not push it aside, but use it for your own safety. Check whether the handrail is well installed, bring it as close as possible to the grinding wheel, at a distance of 3-4 mm. When sharpening, stand not against the circle, but in a half-turn towards it.

14. Monitor the health of the fencing of the rotating parts of the machines on which you have to work.

15. Do not remove chips with your hands, but use a wire hook.

16. All tool workshops use compressed air with a pressure of 4 to 8 atm. At this pressure, an air stream is very dangerous. Therefore, compressed air should be used with great care so that its stream does not accidentally get into the face and ears of the person using it or working nearby.

Conclusion

The purpose of the thesis is to design and calculate a hydrogen generator for general use. The first section provides a comprehensive overview of the hydrogen molecule, ie its performance as a fuel, methods and devices for its production. The second section considers the elements required for the construction of a hydrogen generator by the method of a specific dry electrolyzer. The technical and economic section calculates the cost of calculation and assembly of a hydrogen generator and its economic efficiency compared to other devices. The artificial lighting and ventilation systems in the room to be assembled in the Life Safety Department were calculated.

Summing up the general thesis, the process of decomposition of hydrogen allows to obtain atomic energy from ordinary water by a simple method of excitation of ions of combustible gases to a critical state. The circuit of increasing the voltage creates an electric polarization process that disrupts the covalent bond of the water molecule without the use of conductive electricity. The electron release scheme not only reduces the mass of flammable gases, but also generates electricity by transporting free electrons.

The decomposition process of hydrogen prevents the formation of water molecules during the combustion of gas, allowing to obtain 2.5 million barrels of water equivalent to the thermal energy of oil. During this process, abnormal heat of combustion is released during the combustion of hydrogen compared to conventional fuels, and the process of decomposition of hydrogen is environmentally safe.

Obtaining hydrogen by electrolysis is a universal project, as it is modified for different types of energy consumption. The fuel cell can be used in a variety of sizes, such as injector lights, aircraft engines, and rocket engines.

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