SAVONIA

Conversion Of An Ordinary Car To Fuel-cell Vehicle

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Bachelor's Thesis

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Abstract

Field of Study Technology, Communication and Transport			
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Nowadays, increasing levels of carbon dioxide and the fading oil reserves prompt to the idea of green energy based on sustainable development.

It was decided to solve the problem of the mass of carbon dioxide emissions into the atmosphere by taking a basic environment: everyday life.
Now, cars are not a luxury, but means of transportation, many emit combustion products.
The thesis was aimed at finding ways of optimal solutions to this problem. Many years ago there were some ideas, which were embodied in life (such as an electric car factory on the Volga from 1970-1980, and the range of Tesla Motors), as part of the development which have been delayed or even shut down for various reasons.

In a succinct work, lithium-ion batteries, hydrogen instead natural gas and gasoline were used. Based on fuel, there was a target to make this idea not only clean and legal, but attractive and pleasure to people`s eye.

The development of various companies is used in this project, such as Russian, Japanese and Western partners. The use of fuel cells, solar cells, electric motor and powerful security - allow you to use the suggested idea on any car. It also solves the problem of consumer demand. Everybody prefers different things: beautiful design parts of BMW, Futurism Toyota and Rolls-Royce. Decision was made based on personal view and each could choose his style of car.

The main thing that you need is the desire, skill and money. If you develop such projects, the cost of such model will fall significantly. After all, the current adaptation of gasoline Volkswagen Golf GTI 5 costs 30,000 euros with including car itself which costs 17-thousand.

Keywords
Electric vehicle; Fuel cell; Hydrogen; Tesla motors; 3D modeling; Autodesk Inventor; Innovations.

LIST OF CONTENT

All thesis work was divided in following way:
Engine research – Osolotkin Ilya
Control circuit research – Osolotkin Ilya
Hydrogen fuel cell research – Makarikhin Ilya
Perpetual motion – Osolotkin Ilya
DC controller research – Makarikhin Ilya
Additional energy research – Makarikhin Ilya
Hydrogen station research – Makarikhin Ilya
2d sketch and 2d sizing – Osolotkin Ilya
3d sketch and 3d sizing – Makarikhin Ilya
Finishing and solidification – Osolotkin Ilya
Visual graphic processing – Makarikhin Ilya
Design social research – Osolotkin Ilya
Fuel consumption and driving style social research – Makarikhin Ilya
Summer version – Osolotkin Ilya
Winter version – Makarikhin Ilya
Budget – Osolotkin Ilya
Other parts were done as teamwork

1 INTRODUCTION

It was decided to "kill two birds with one stone", solving the same time issues of the release of CO_2 into the atmosphere and rising consumption of petroleum products.

With the advent of the Industrial Revolution in the mid XIX century, there was a progressive increase of anthropogenic emissions of carbon dioxide into the atmosphere, leading to the disruption of the balance of the carbon cycle and increased concentration of CO_2. Currently, about 57 % of carbon dioxide which is produced by mankind, is used from the atmosphere by plants and oceans. The ratio of increase in the amount of CO_2 in the atmosphere to the entire CO_2 emissions is a constant of the order of 43 % and short period undergoing short-vibrations and oscillations with a period of five years.

Burning fossil fuels such as coal, oil and natural gas is the main cause of emissions of anthropogenic CO_2. Deforestation is the second leading cause. In 2008, as a result of burning fossil fuels into the atmosphere was allocated 8.67 billion tons of carbon (31.8 billion tons of CO_2), while in 1990 the annual emission of carbon was 6.14 billion tons. In summary, forests land use have led to increased levels of atmospheric carbon dioxide equivalent to burning 1.2 billion tons of coal in 2008 (1.64 billion metric tons in 1990). Total increase in 18 years is 3 % of the annual natural cycle of CO_2, which is sufficient to remove the system balance and to accelerate the growth of CO_2. As a result, carbon dioxide is gradually accumulated in the atmosphere and in 2011 the concentration was 39 %, that is higher than pre-industrial value.

Thus, despite the fact that (as in 2011) the total anthropogenic CO_2 emissions do not exceed 8 % of the annual natural cycle, an increase in concentration is caused not only by the level of anthropogenic emissions, but also the by constant growth of emissions over time.

This problem should be solved. The appearances - are advertising. Without a beautiful shell people will unlikely use anything, especially if the buyer has the option to choose something nice for his eyes. That is why there is a more detailed solution than creating new brand machines.

It was decided to show the ability to convert any machine to the pure green energy.

2 SPECIFICATION

It was complicated to find suitable parts and features for this project, so we combined technologies of electric cars, some prototypes and sport-car systems to solve this problem

2.1 Engine

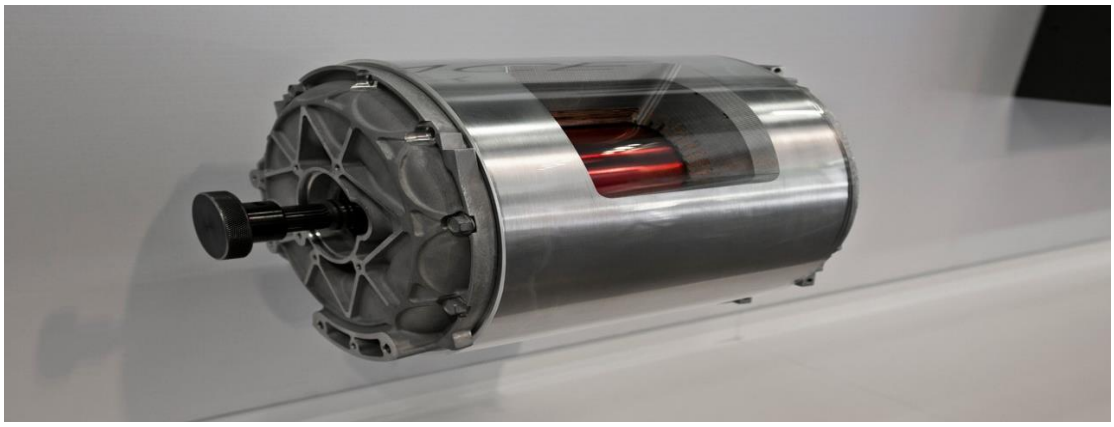


Figure 1 Tesla Motor

The electric motor Tesla Model S (Figure 1) is a direct descendant of the engine, which was developed by Nikola Tesla. It has a brushless 4 pole 3-phase AC motor with liquid cooling.
It is extremely small sized in comparison with internal combustion engines. The engine is located on the rear axle between the wheels.

The motor consists of two parts: a rotor and a stator. Used materials (from the outer to the inner layer) are aluminum, steel, and copper. A single point of contact in the motor is bearings. This eliminates the engine from the transmission and use of direct drive. The motor provides a maximum vehicle speed - 208 km / hour (130 miles / hour) on a single transmission. The engine produces 100% torque at any speed, it is very efficient, and it has the ability to regenerate.

The dynamic characteristics of Tesla Model S through this engine can be compared with the car Mercedes S class or BMW 7th series. The ratio of power to weight in Model S is best in its class. With engine torque of 600 Nm, and with power 416 Hp. the car accelerates from 0 to 100 km / h in 4.2 s.[i]

Energy consumption in Tesla is measured in watt-hours per kilometer. The first thousand kilometers showed an average real rate of about 250 Wh per 1 km. Multiply this figure by 100 and get about 25 kWh of energy consumed per 100 kilometers.[ii]

Tesla uses a three-phase asynchronous motor with variable voltage. Unlike some other motors that use permanent magnets, the engine is based on a magnetic field created entirely by electricity. In electric Tesla motor there is a rotor and a stator. Rotor is a steel sleeve, through which the copper plates are omitted, and it allows current to flow from one side of the rotor to another. Electricity on the rotor is not directly served. The current occurs when the passage of the electrolyte through the conductor which made of copper plates creates the magnetic field, which generates an alternating current in the stator. The motor acts as a generator or an engine, depending on the actions of the driver. When you press the gas pedal, power module senses the need for torque. If the pedal is pressed 100% available torque is chosen completely, and if not, then, it depends on the pressure on the pedal. If it there is no any pressure, engine is used to recover energy. Engine starts only when the power module sends a desired number of AC power to the stator that generates torque. Tesla motor is adapted to operate at high speed, but even this requires heat removal. For this purpose a passive cooler is installed and it is cooled by wind or the fan. Traction motor is very small; the size of a watermelon and weight is light as possible using aluminum. The power module transfers up to 900 amps of current to the stator. The winding which is made of copper is much more than a conventional engine. Copper wire is insulated with special polymers that provide heat transfer and stability under extreme driving conditions. Unlike conventional induction motors, which use aluminum as a conductor, in this engine cooper is used. Working with cooper is more difficult, but its resistance is less, so it is better at conducting current. Stator is a thin steel plate, which is held by winding copper wire. The wires are divided into three types according to the number of phases of electricity that can be imagined as a sinusoidal wave oscillation, smooth combination of which provides an uninterrupted supply of electricity. The alternating current in the copper winding stator creates a rotating magnetic field and induces a flow of particles in the rotor. The current creates a second magnetic field in the rotor, which follows the moving stator field. The result of this process is the torque. When the driver releases the gas pedal, power module puts the field behind the stator field of the rotor. As a result, the rotor has to be slowed down to its field in compare to the level of the stator field. The direction of current in the stator changes and starts the flow of energy through the power module back into the battery. This is called energy recovery.[iii]

Without going into details of the basic theory of electrical engineering, the main note is that electric motors with windings connected by a star are much softer than the motors whose winding connection is a triangle, but it should be noted that when connecting the motor windings of a star is not able to give the maximum power. If you connect winding triangle, the engine will give full rated capacity (approximately 1.5 times higher than in star connection), but the values will be high in rush currents. Therefore, the most desirable (in particular very important for high power electric motors) connection wye is delta; this starts the motor in star, and then (when the motor is "left on the rating momentum"), automatically switches the connection diagram to a triangle.

2.1.1 Control circuit

This control circuit should look like showed below in Figure 2:

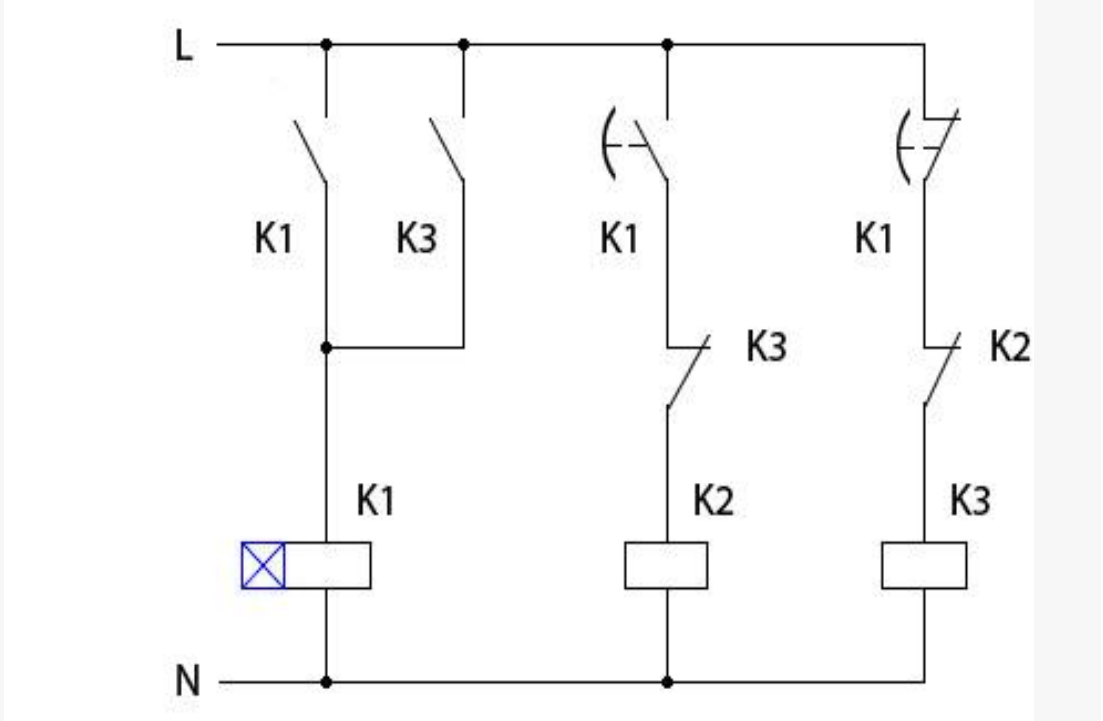


Figure 2. Scheme of control circuit

When connecting auxiliary voltage through the contact NC (normally closed) the relay K1 and K2 NC are contacts in the contactor coil circuit K3.

When the starter switches K3, K3 opens the contact in the circuit coil actuator K2 (blocking accidental activation) and closes the contact K3 in the magnetic starter coil circuit K1 - it is combined with the time switch contacts.

When the K1 contactor closes the contact K1 in the magnetic starter coil circuit K1 and simultaneously activates relay time, relay time opens K1, K3 contactor coil circuit closes the contact time relay K1 coil circuit starter K2. Disabling starter K3, K3 closed contact circuit magnetic of the starter coil K2. Enabling starter K2, K2 opens the contact in the circuit of the coil starter K3.

In figure 3 the more detailed scheme of connections is shown. At the beginning of the windings U1, V1 and W1 the operating voltage is fed through the power contacts K1. Operation of the magnetic starter K3 and its power contacts K3, thus joining the ends of the windings U2, V2 and W2 - the motor windings are connected to a star. Next time relay, combined with the actuator K1, K3, and disabling the starter at the same time including K2 - K2 closes the power contacts and energizes at the ends of the motor windings U2, V2 and W2. Now the motor is turned on by delta. More details can be found from Figure 3 below. [iv]

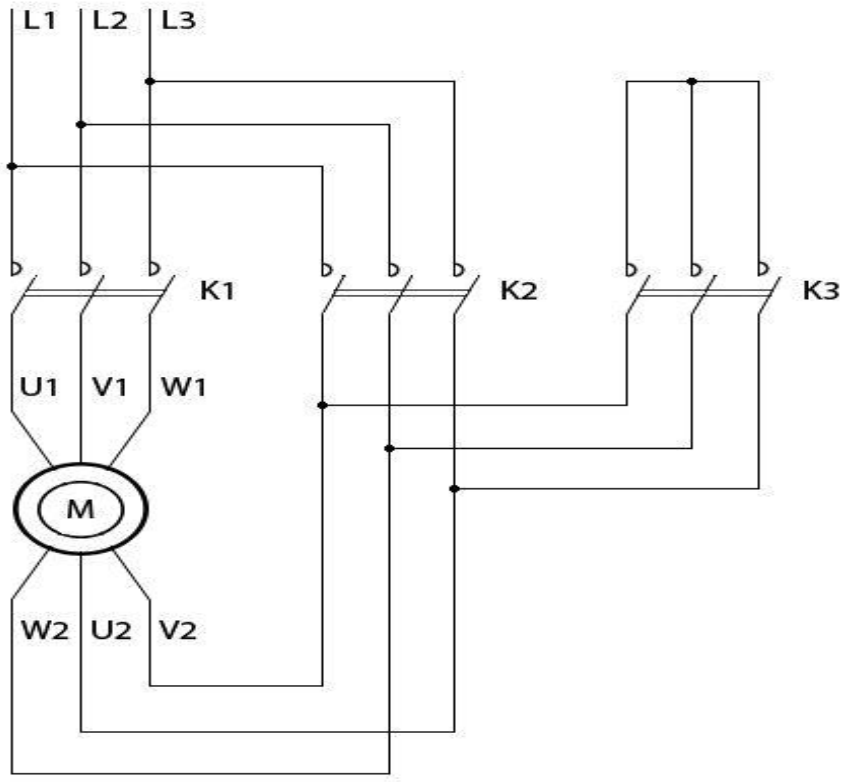


Figure 3. Scheme of control circuit #2

2.2 POWER

Fuel cells are not the invention of today. The physical principle of operation was known in the 19th century. Prototypes of power supplies in its class were developed in the USSR for the automotive and aerospace industries. Another thing that turned the history has left those experiences in the past and the present general technological backwardness of Russian industry has created a situation where the need is, and there is no production. Chernogolovka is a science city outside Moscow, where a concentrated cluster of research institutes are dealing with chemical and physical profile.

2.2.1 Battery without energy

At the Institute of Problems of Chemical Physics Laboratory (IPCP) there is staff that provides the Russian know-how in the field of alternative energy sources for hydrogen and taking the first steps to organize such production. The produced power supplies are of direct relevance to the topic of the thesis: one of their uses is associated with motor power.

The principle of operation of the hydrogen-air fuel cell is the same as the conventional battery. It is the movement of ions through the electrolyte from the anode to the cathode. The only difference is that the battery converts all the chemical energy into electrical energy, which is located inside the case, on the sacrificial anode. Fuel element itself carries no energy, the energy source is the fuel and oxidizer that come from outside. In the laboratory of IPCP hydrogen fuel cells are built with a solid polymer electrolyte. The fuel (hydrogen) is supplied under pressure to the surface of the electrode and by applying an electrode catalyst dissociates, i.e. it loses electrons. Through a polymeric membrane having lost electrons, protons move to the cathode, which as an anode is a plate coated with catalyst. «Lost» electrons go through the anode current collector to an external circuit. Air is blown to the cathode (oxidizer in the form of oxygen), whereby the permeated hydrogen ions are recovered by using electrons coming from the chain and are connected with the oxygen atoms forming water - the only reaction product. This process can be called "cold combustion", in which there is a direct conversion of chemical energy into electrical energy. An alternative could be the combustion of hydrogen with the utilization of the heat generated by the principle Carnot heat engine (e.g., a rocket engine). The advantage of "cold combustion" is much greater efficiency, which makes fuel cells a very promising source of energy.

In the laboratory of IPCP battery power 0.5kV is built. In fact all water-hydrogen batteries are sets of plate elements, each of which is a separate fuel cell - assembly, called membrane-electronic unit (OIE). OIE - is a "sandwich" (Figure 6) available at the polymer membrane overlaid on both sides of the electrode plates with the catalyst.

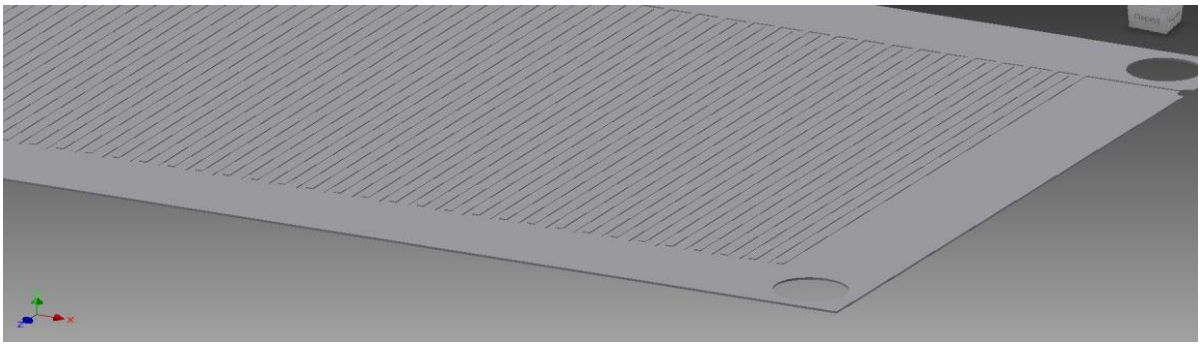


Figure 4. Plate with channel for hydrogen

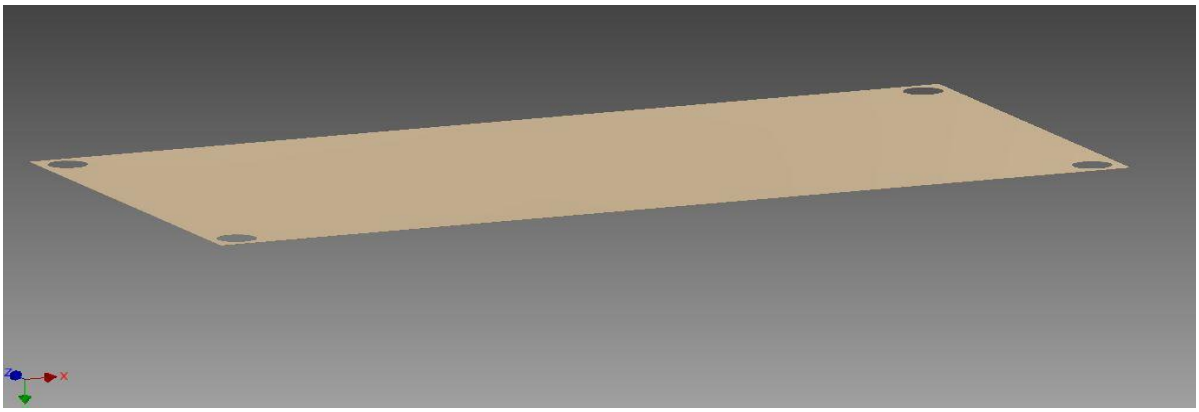


Figure 5. Nafion membrane

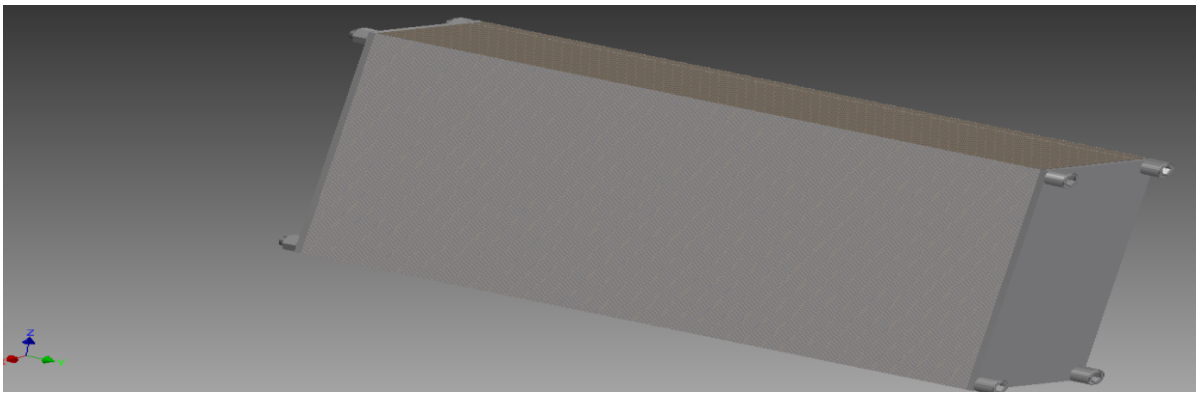


Figure 6. Assembled 3D model of fuel cells

Outer casing of MEBa form is a strong plate (Figure 4) that performs the functions of the collector and prevent profluvium element from hydrogen pressure. The battery is also equipped with a fans for supplying an oxidant (oxygen from the air) and cooling design.

One of the elements is Nafion membrane (Figure 5) and it is an industrial standard, but the material has one drawback: at -2 °C it loses its properties. In the laboratory, special additives came up that made the threshold of -20 °C, but in the future plans of this threshold is -60 °C to use these elements in the Arctic.

The power supply system consists not only of the battery, but it is a complex, which includes also the cylinder, which contains pressurized hydrogen (up to 300 atm.) and lithium-ion battery for the trigger, that is needed to start the battery itself. As it is known, hydrogen is an explosive substance, so the requirements for appropriate storage vessel should be satisfied. Also it is necessary to reduce the weight of the bag results. Such batteries can be used. The output of the construction has a weight of 6 kg – as much as a drone with a lithium-ion battery. However, if it flies with a lithium-ion battery for half an hour, then with hydrogen up to 5-8 hours. However, it must be taken into account, because the car has more space than in unmanned aircraft.[v]

2.2.2 Hydrogen fuel cell

But because for car operating Russian elaboration is only the technology of future, today choice is - CTHFC series fuel cells (Figure 7).
All of them are based on Self-humidifying technology. This technology can ensure fuel cells' more stable operation in atrocious and working weather.
CTHFC 5000 fuel cell system (Figure 7) is a highly integrated fuel cell system with compact design (Specifications are on the table 1), which includes: fuel cell stack, fans, IC board and solenoid valve.
5000 Watt is a suitable power for the mobile applications, for instance PC, tourist car and backup power system.

Figure 7. CTHFC series fuel cell

Table 1. Specifications of the battery[vi]

Performance	Rated power	5000W*
	Rated voltage	72V
	Rated current	69.5A
	DC Voltage range	60-117V
	Efficiency	≥50%
Fuel	Pure hydrogen	≥99.95%
	Pressure	0.6–0.7bar
	Hydrogen consumption	61.5L/min(rated power)
Oxidant/coolant	Air	
	Pressure	Ambient Pressure
Physical	Mass	25 Kg
Characteristics	Length*width*height	635mm×190mm×270mm
Operation	Environment temperature	-5-40°C
Condition	Relative Humidity	20%-95%
control box	Length*width*height	145mm×100mm×85mm
	Weight	1.5kg
solenoid valve(two)	Length*width*height	76mm×36mm×78mm(single)
	Weight	0.5Kg(single)

2.2.3 Perpetual motion

In the near future people in different countries will be able to purchase hydrogen-air electric cars powered by Toyota and other automakers. Energy sources are hydrogen fuel cells. These vehicles are advertised as completely environmentally friendly vehicles, which do not release into the environment harmful substances.

But in fact, all these vehicles won't be pure green, until the hydrogen is produced from natural gas or fossil fuels.

Of course, hydrogen can be produced in other ways, the most common is the electrolysis, the splitting of water into hydrogen and oxygen by means of electric current. Unfortunately, such a process requires the use of expensive catalysts of platinum and other precious metals, or has a negative energy balance.
When the amount of electricity consumed substantially exceeds the amount of the chemical energy which contained in the hydrogen.

But soon, this situation may change dramatically, thanks to the work of scientists from Stanford University. The group of Professor Hongdzhi Day (Hongjie Dai) has developed quite inexpensive device electrolysis, which is sufficient for the electrical potential generated by penlight batteries size AAA. Naturally, the key point of the new technology is a new catalyst that does not contain platinum or iridium, but uses compounds composed of nickel and iron elements which are abundant on the Earth.

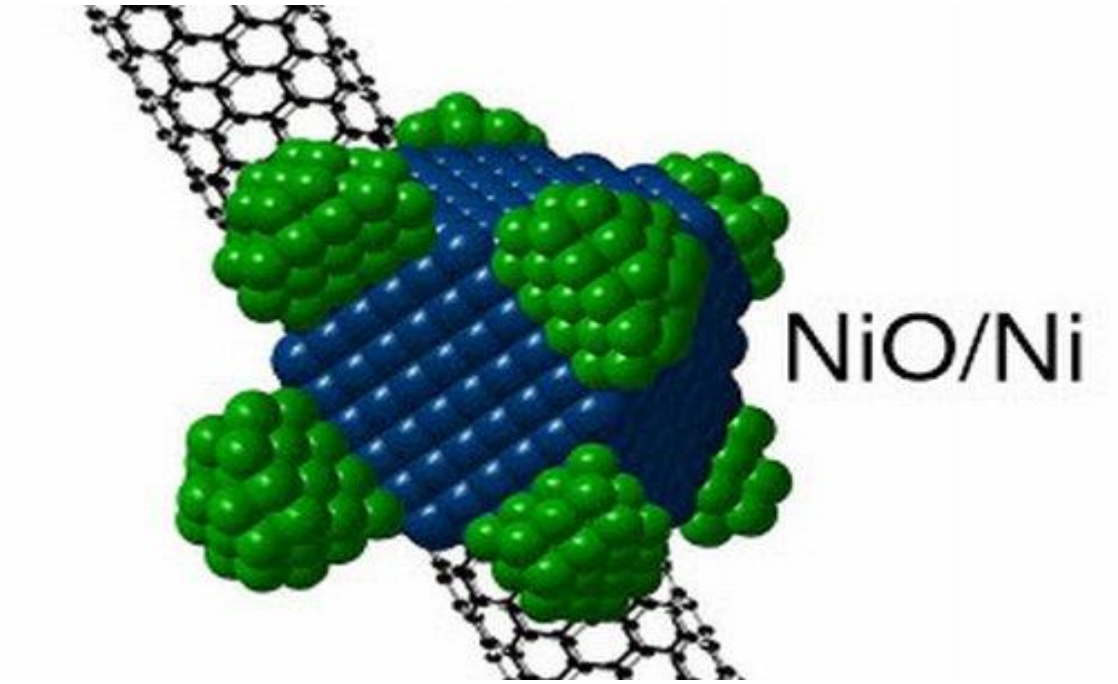


Figure 8. Nickel oxygen molecules

"For several decades, scientists have been searching for a cheap effective catalyst, whereby the electrolysis process can go at room temperature and at low electrical voltage" - says Professor Day, - "In the end, we managed to stumble upon a com-

plex compound of nickel and iron, which works just as effectively as platinum. And it was a complete surprise. "

The main discovery was made by Gong Ming (Ming Gong), a graduate student of Professor Dai. "Ming found a nickel-iron / nickel-oxide (Figure 8) compound, which acts as a catalyst for effective pure nickel, pure iron or pure oxides of these metals," - said Professor Day, - "This is a compound which efficiently decomposes water into oxygen and hydrogen, We do not fully understand what processes are taking part in this "

Electrodes of new catalyst are sufficiently stable, but they decompose very slowly over a long time. Available prototypes can operate continuously only for a few days. And large-scale use of such catalysts requires a period of continuous operation, calculated in months and years. "The results of our recent studies allow to hope for a long service life of the electrodes of the new catalyst" - says Professor Day, - "And then our technology will be widely used for the direct production of hydrogen using solar energy, wind power and energy from other renewable sources. " [vii]

2.3 DC controller

Figure 9. DC controller

Table 2. DC Controller specifications.[viii]

Place of Origin:	Zhejiang, China (Mainland)
Brand Name:	YUYANGKING
Model Number:	YKZ4860AB (Figure 9 model #3)
Battery current:	60 A - 100 A
Brake signal input:	0-5 V
Supported speed:	>50000 rpm
Standby power dissipation:	<3 W
Working frequency:	15.6 KHz
48V dc motor controller work temperature:	-30 ℃ to 70 ℃
Full power working temperature range:	0 ℃ to 80 ℃
48V dc motor controller size:	195x117x60mm

2.4 FUEL STORAGE

The best way to storage and supply hydrogen in car is nitrous oxide system (Figure 10-11). Main reason is that these systems are well known with great experience and a lot of testing. There is also lots of equipment for almost any car (balloons, lines, pressure electric and manual gauges, supply systems and chargers)

Figure 10. “Nos” system

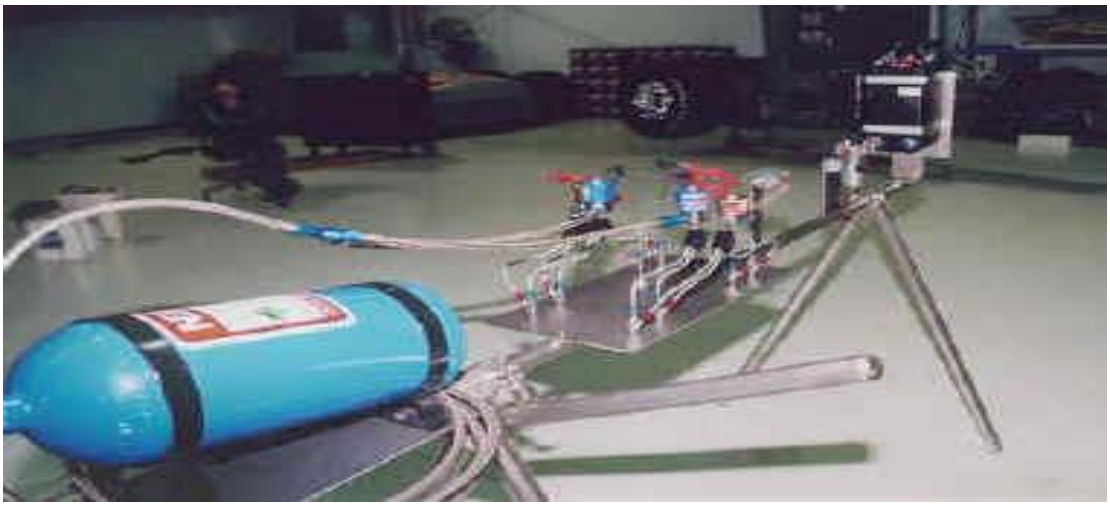


Figure 11. ”Nos” system with cables and pressure vessel

2.5 Additional energy

Moreover, there are plants of new technologies to use as additional energy, as the example “transparent solar cells”. "Transparent luminescent solar concentrator" (Figure12) as it was called by creators, can be used on buildings, cars, gadgets and any other devices that have a transparent surface. And the key word here is "transparent".

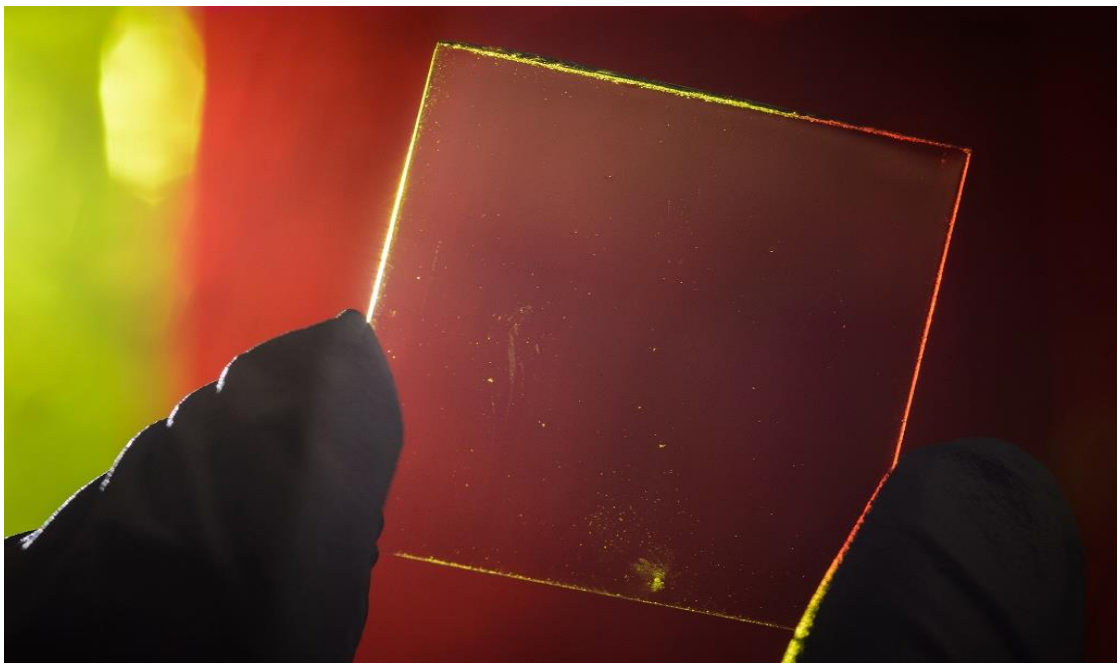


Figure12. Transparent solar concentrator[ix]

Research in the field of energy from the solar panels has been going for many years, but until now the used materials were coloured view of the design features. ”Nobody ever wants to sit at the stained glass - it's like trying to work in a disco. Fortunately, now we have managed to make the active luminescent layer transparent”, - says Richard Lunt, assistant professor of chemical engineering and materials science.

The system uses solar panels small organic molecules developed by a team of scientists to absorb certain wavelengths of sunlight. "We can customize these materials so that they absorb only ultraviolet rays, near-infrared wavelength and highlight a different wavelength in the infrared range", - says Richard.

"Luminous" infrared light is converted into electricity by means of thin strips of photovoltaic solar cell battery. "Due to the fact that our materials do not absorb and emit light in the visible spectrum, they appear completely transparent to the human eye," - boasts Lunt.x

3 HYDROGEN STATION

Hydrogen station (Figure13) is a storage and filling station for hydrogen, usually located along a road or highway, or at home as part of the distributed generation resources concept. The stations are usually intended to power hydrogen vehicles, but can also be used to power small devices. Vehicles use hydrogen as fuel in one of several ways, including fuel cells and mixed fuels like HCNG. The hydrogen fuel dispensers dispense the fuel by the kilogram. HyGen believes the hydrogen infrastructure is mostly in place. With electricity and water universally available, the missing piece is on-site equipment to extract hydrogen from water using electricity.

Major automobile manufacturers have hydrogen fuel cell vehicles ready for mass production with expected volume sales to begin in 2015. Vehicles need fuel like people need food. It's a commodity that will always be required and will always be in demand. Supplying hydrogen fuel is a profitable business with predictable long-term revenues. Long-term revenues attract capital and capital expenditure is all that required for the hydrogen infrastructure. There is no need for new pipelines, just the installation of profit-generating equipment. If the business model works in low volume, it will work even better as equipment costs reduce with mass production.

As developer of several Southern California renewable hydrogen fueling stations, including the world's first in Los Angeles, HyGen has the necessary experience to oversee the planned rollout of hydrogen stations to meet California and the nation's goals for an alternate solution to fossil fuels.

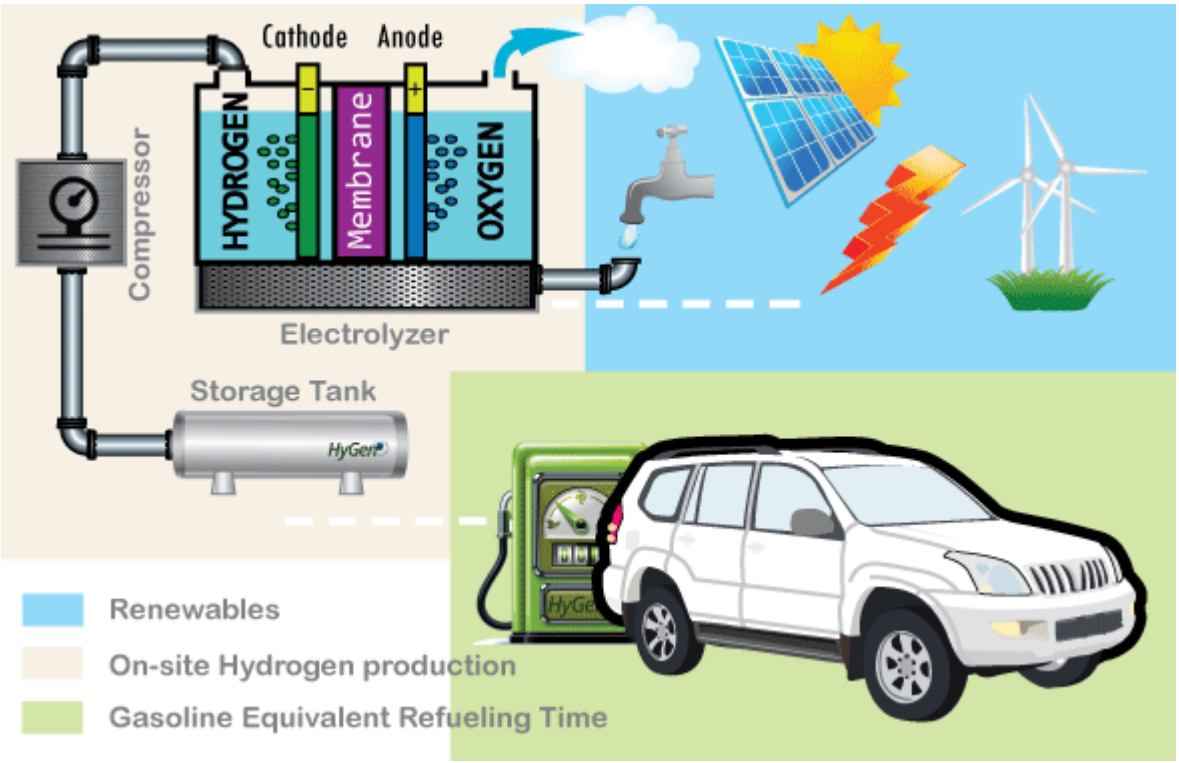


Figure 13.Power station, simple model[xi]

The above diagram outlines the HyGen process. Renewable energy is purchased from the utility company and is used to split water to obtain pure hydrogen which is held in a buffer tank. Oxygen is the by-product of this process and is currently released to the atmosphere in the majority of on-site hydrogen stations.

The next stage is to compress the hydrogen from x bar to x bar and pump the gas to storage vessels for delivery to the fuel pump. FCEVs are designed to accept 350 or 700 bar with the greater pressure adding to the cost per kg. 700 bar gives greater range at additional cost, leaving the choice to the consumer. HyGen uses a booster pump to achieve the 700 bar. Fueling time is 3 to 5 minutes and the current cost for 700 bar hydrogen is $3.00-$3.50 GGE (Gallon Gasoline Equivalent).

Depending on production capacity requirements, a HyGen system can be installed for as little as $1.5 mil. This can fuel up to 100 vehicles/week. This will be a starter system for the first 20 stations (Green flags on Figure 14) that HyGen plans to install in its next venture. Given low initial volume, this figure represents a surprisingly low capital cost over the lifespan of the equipment.

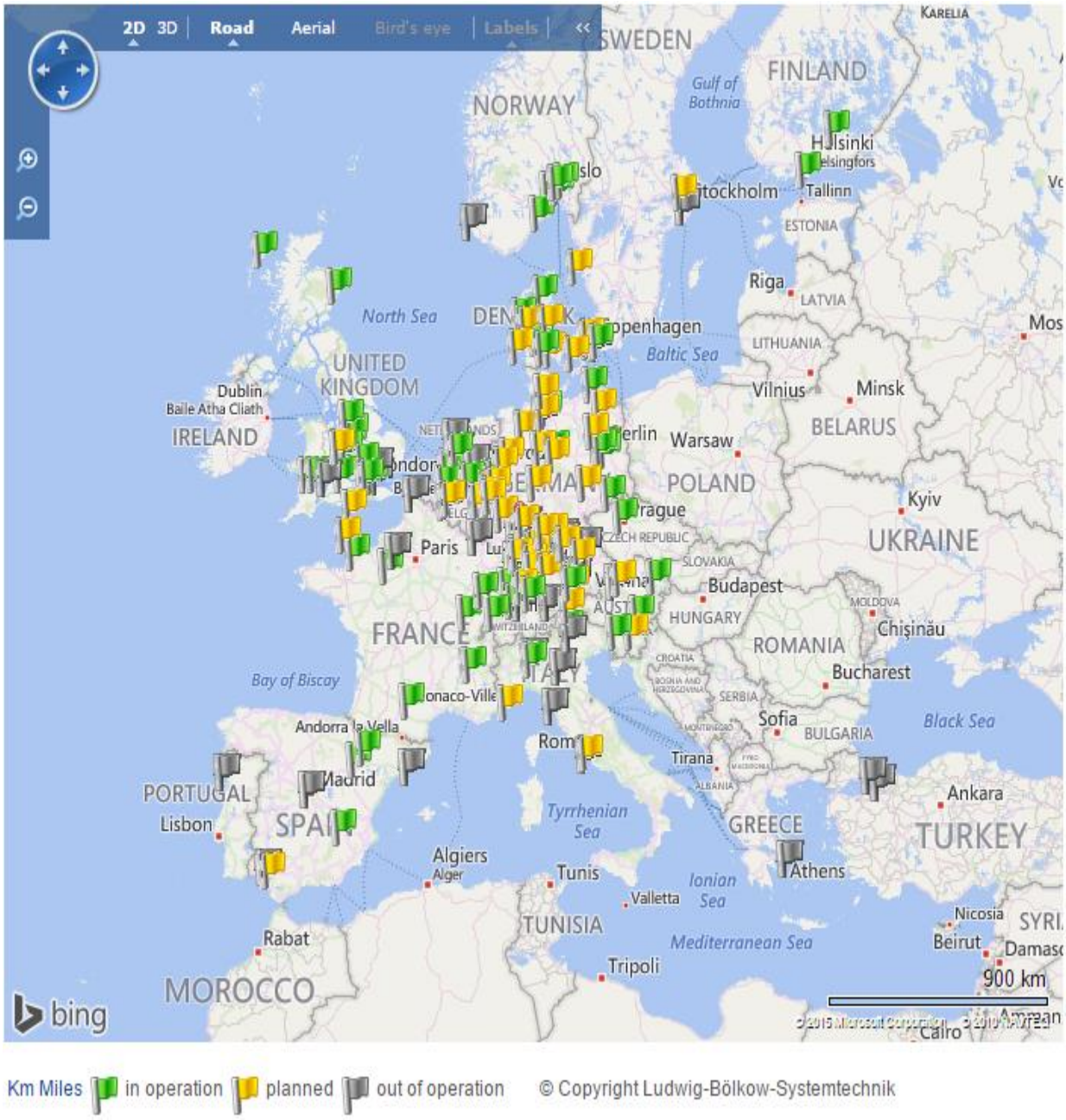


Figure 14. Map of hydrogen fuel stations in Euro Union

4 3D MODEL

For design, size, style and volume checks were made of 3D model of Volkswagen golf mk5 (Model was chosen by online survey)
All modeling work was split into four parts:

4.1 The beginning – 2D sketches and 2D sizing (Figure 15).

For making 2D sketch (Figure 15.) Profile photos and basic sizing were used. Coloured lines and dimensional plans were chosen for every axis.

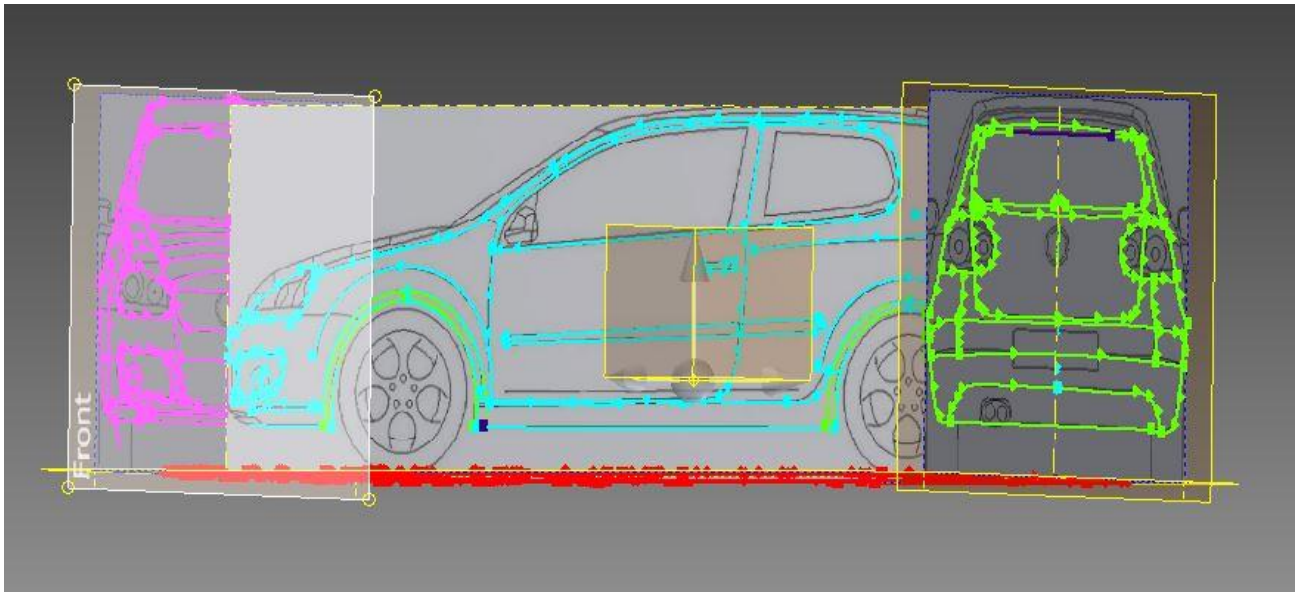


Figure 15. Basic sketch with profile pictures

4.2 3D sketches and 3d sizing

Connection of intersection (Figure 16) and geometry were added.

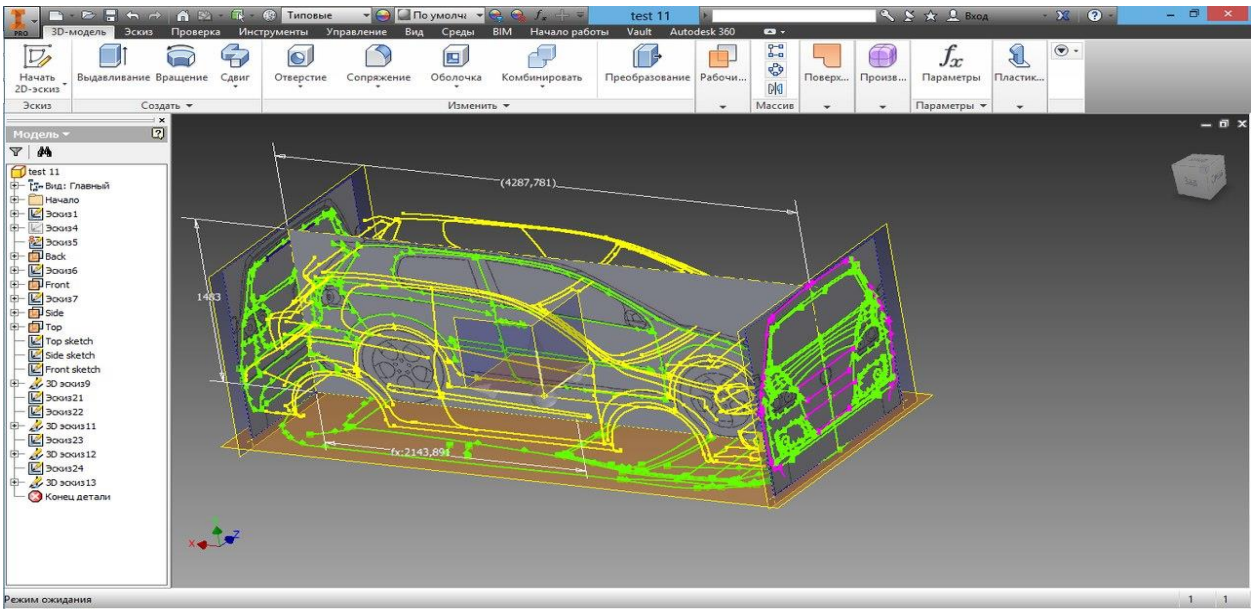


Figure 16. 3D basic sketch

4.3 Finishing and solidification

At this stage sub-geometry and small parts were added, Solidification and structuring (Figures 17-18) were done via Autodesk inventor.

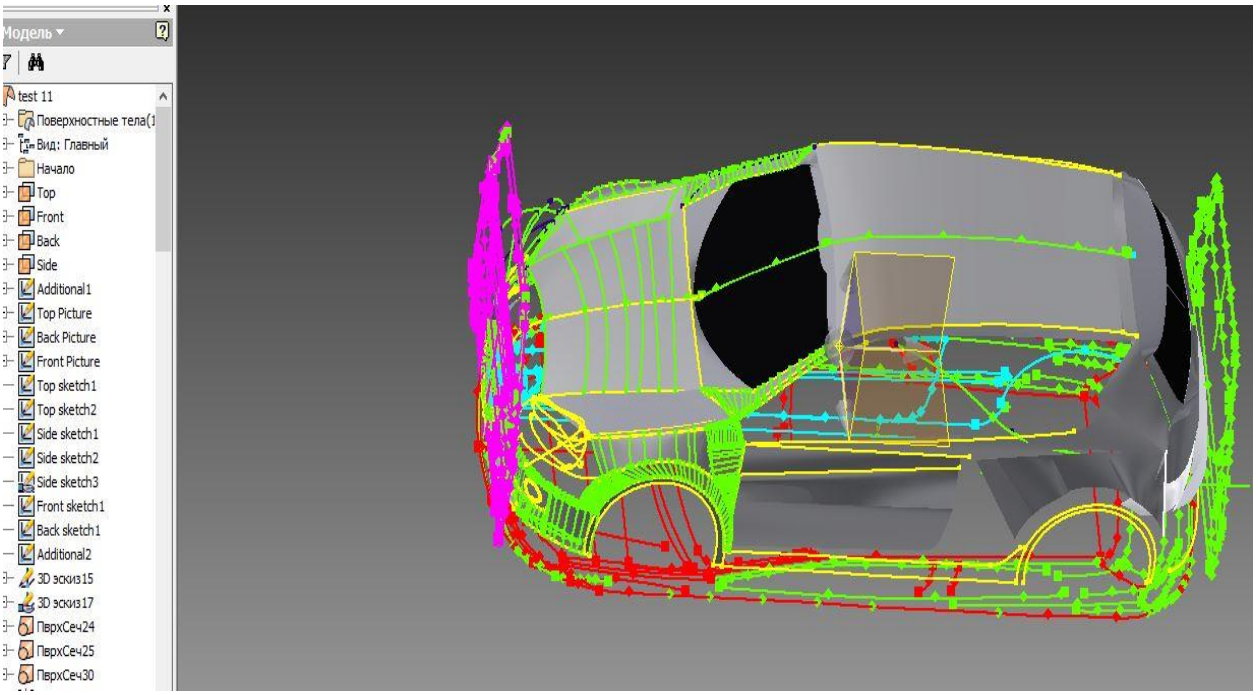


Figure 17. Process of making solid model

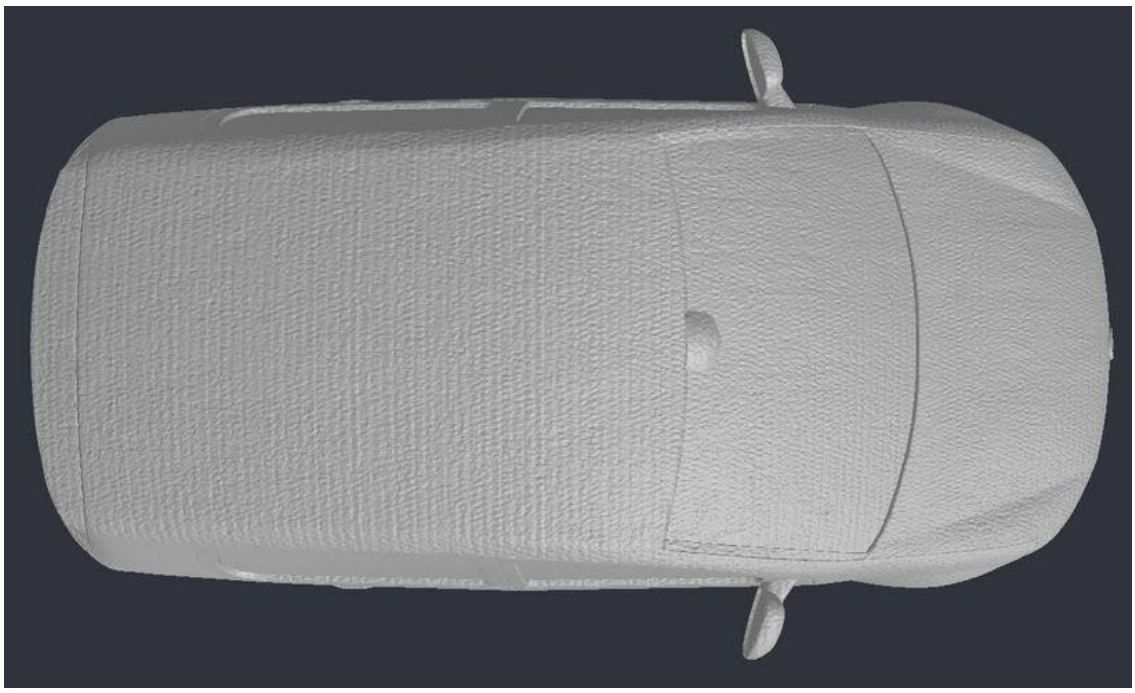


Figure18. Solid model upper side view

4.4 Final version

Final model (Figure 20) was processed via photo redactor (Adobe Lightroom and Picasa) to add more detailed outlook and rise sharpness and shadows.

Figure 20. Final model

4.4.1 Note

Also were made many additional car models, models of rims, models of batteries and style parts which participated in online surveys as part of social research.
For all modeling Autodesk 2015 Student version was used.

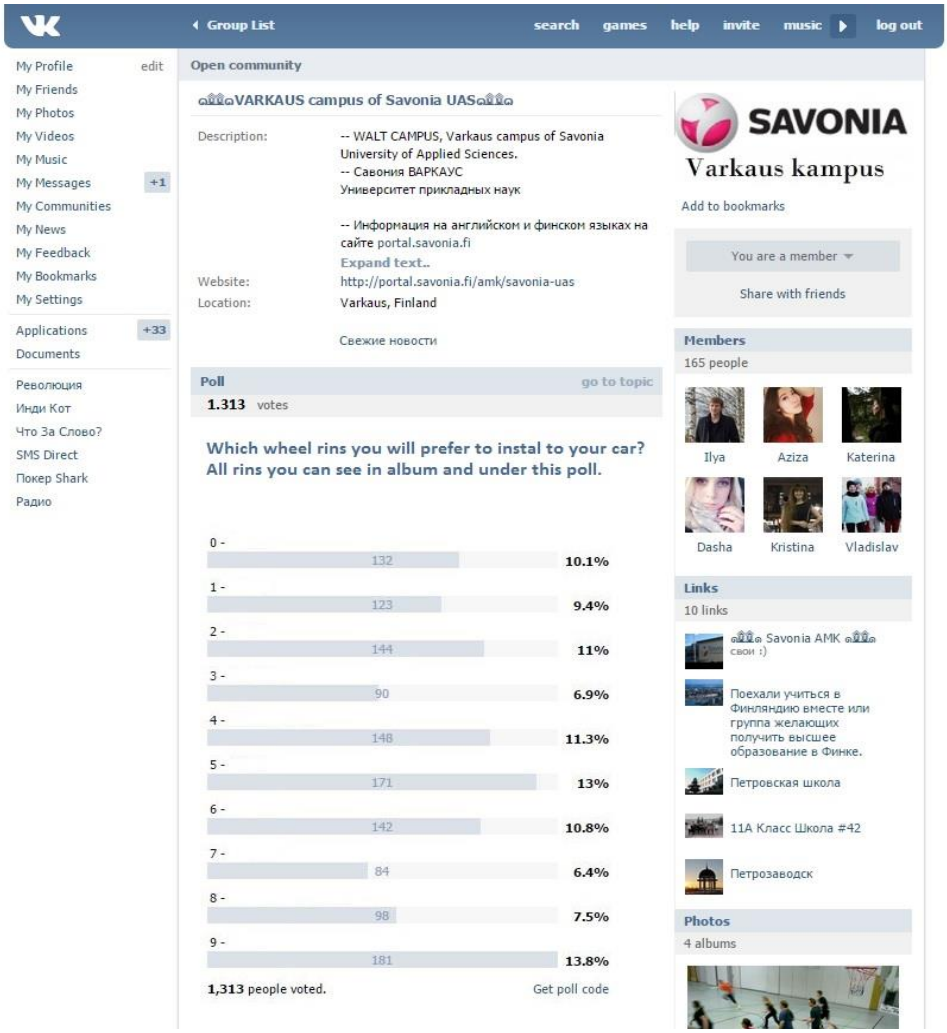
5 SEASONS VERSIONS

In order to be sure, that fuel-cell car would be as good as regular car, the internet survey was made to get a social opinion about perfect car for each season.

5.1 Social research

Some discussions about additional parts in vehicle, design and outlook were suggested to interviewees.

Main questions were about style of driving (Usage of gasoline per 100 km), design, music in car (subwoofer and etc.), wheel rims (Figure 21) and other nuances.



xii

Figure 21. Public pool in social network "Vkontakte"

Respondents preferred the design of 3-components rims (Figures 22-23)

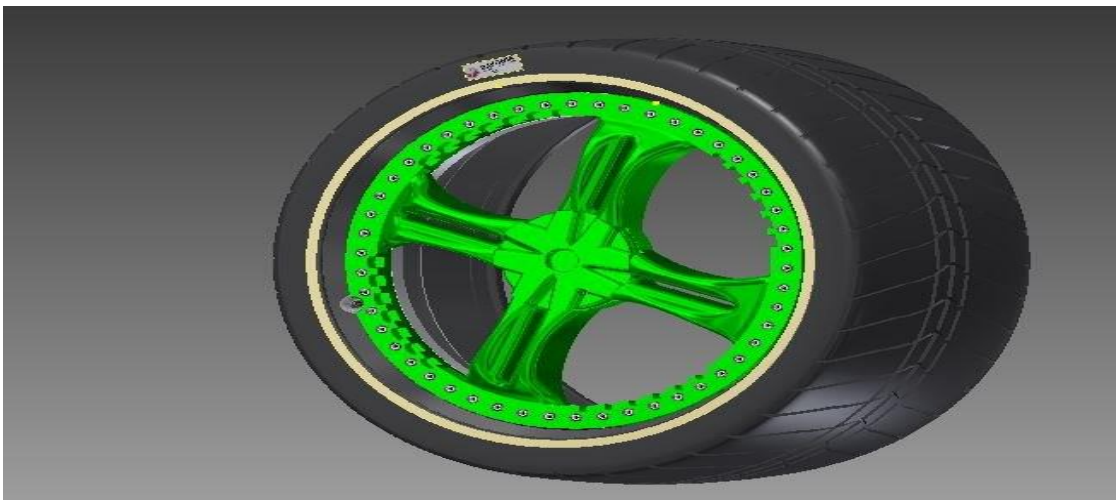


Figure 22. – 3D model of car rim with tire

Figure 23. – 3D model of car rim with tire

5.1.1 Summer version

In summer version (Figure 24), it was suggested to upgrade the view of car - changing style of body wheel's rims and tyres. By public pool it was decided to change music inside car, painting, tone, lights and suspension.

Figure 24. 3D model, final version

5.2 Winter version

For northern countries winter is a big challenge – a lot of snow, extreme temperatures and ice.

Best decision for snow-fighting is tracks (Figure 25). Normally they are used in snow scooters, but now a few options for car are available (Figure 26) and there is no need to change suspension.

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Figure 25. - Tracks for winter version

SPECIFICATIONS

Undercarriage	CAMOPLAST ATV T4S	CAMOPLAST UTV T4S
Weight	71 lbs (30 kg)	Front: 95 lbs (43 kg) I Rear: 112 lbs (51 kg)
Offset (front & rear) ❶	Front: 24 in (611 mm) I Rear: 27 in (662 mm)	Front: 26.5 in (673 mm) I Rear: 35 in (889 mm)
Offset (side-toside) ❷	6 in (153 mm)	7 in (178 mm)
Height	Front: 23.8 in (604 mm) I Rear: 23.2 in (590 mm)	Front: 25 in (637 mm) I Rear: 24.7 in (626 mm)
Length	Front: 40 in (1015 mm) I Rear: 42.5 in (1081 mm)	Front: 42.5 in (1081 mm) I Rear: 52 in (1321 mm)
Width	22 in (560 mm)	25 in (635 mm)
Mounting hardware weight	Approx. 6.25 lbs (2.75 kg)	Approx. 6.25 lbs (2.75 kg)
Rubber track		
Width	Front: 11.5 in (292 mm) I Rear: 12.5 in (318 mm)	Front: 12.5 in (318 mm) I Rear: 13.5 in (343 mm)
Length	Front: 93.4 in (2377 mm) I Rear: 98.5 in (2507 mm)	Front: 98.5 in (2507 mm) I Rear: 116.7 in (2964 mm)
Lug height	Front: 1 in (25 mm) I Rear: 1.188 in (30 mm)	Front: 1 in (25 mm) I Rear: 1 in (25 mm)
Performance		
Ground surface	2000 sq. in (1.30 sq.m)	2470 sq. in (1.59 sq. m)
Ground clearance (average)	Increases by 3 in (76 mm)	Increased by 5 in (127 mm)
Maintained speed (average)	2/3	2/3
Specification		
Drive Type	Internal drive	Internal drive
Rubber track	Front: Flex Rear: Flat	Front: Flat I Rear: Flat
Frame	Carbon steel	Carbon steel
Sprocket	15 to 18 teeth	15 to 18 teeth
Wheel / Roulettes **NEW!**	134 & 202 mm encapsulated and sealed wheels including elastomer outer band	132 mm double bearing & sealed mid-roller wheels (width: 50 mm) 255 mm double bearing & sealed flat free tires
Anti-rotation	Redesigned mild steel anti-rotation Spring and progressive damper	Redesigned mild steel anti-rotation Spring and progressive damper
Hub and bearing	Cast steel multi-bolt (4) pattern hub	Cast steel multi-bolt (4-5) pattern hub
Guide	Molded UHMW	Extruded UHMW
Tandem & suspension	Mono front tandem on pivot point	Dual tandem on each pivot point
Maintenance		
Installation time	Approx. 1.5 h	Approx. 1.5 h
Subsequent	Less than 1 hour	Less than 1 hour

Figure 26. specifications of winter tracks[xiii]

6 BUDGET

Budget was made by collecting prices of details and specifications are shown in Table 3 below.

	A	B	C	D	E
1		**Budget:**			
2		**Details:**	**Price:**	**Amount**	
3		Tesla Model S engine	5000	1	
4		DC controller	100	1	
5		Fuel cells	1500	2	
6		Fuel storage	50	2	
7		Subwoofer	100	1	
8		Winter tracks(set)	3200	1	
9		Rims (set)	600	1	
10		Intruments and wires	100	1	
11		Nokian Tyres	600	1	
12		Car	17000	1	
13			Total:	29800	
14					

Table 3 Budget allocation

Because hydrogen fuel efficiency depends on many things and hydrogen price decreases every year - $3.00-$3.50 GGE (Gallon Gasoline Equivalent) was chosen as basic price of fuel-cell vehicle consumption.

7 SUMMARY

There are many problems in the world that can be solved by engineers. However, it was decided to focus on such global points as sustainable development in the field of cars and the use of clean energy as a way of life.

New electric vehicles appear every year (Hyundai, Toyota, BMW, Lamborghini, Tesla, VAZ), and technology of fuel-cells will improve exponentially also as environmental problems (CO_2 emission and greenhouse effect), consumption of petroleum products.

The theme was focused on sustainability and environmentally friendly vehicle is possibilities and technologies.

The basic ideas of the thesis were chosen clearly, with the possibility of realization in case of proper funding. In addition, a sociological survey to identify those things that people want to see in a particular version of the car was made.

So, it was decided to act globally, to split the project into several parts, such as the car itself, fuel cell and filling machine. That is to say, its engine and all related equipment - controller, consumables and fuel cells, which allows the engine to operate. Furthermore Autodesk model, the design and different kit for the summer and winter season were made. The result includes small development, science, and technology without breaking the brands and patents. Combining several developments, addition and some changes could help us achieve this goal.

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