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RESEARCH ON CHOOSING THE BEST GAS FOR THE FLETTNER BALLOON, AN UNCONVENTIONAL POWER GENERATOR ENERGY DEVICE

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In the last 30 years, the degree of pollution has been continuously increasing and the chemical structure of the atmosphere has changed due to large amounts of polluting emissions such as NO_x, SO_x, CO_2 and other particles resulting from combustion, which lead to the destruction of the ozone layer, climate change, greenhouse effect or acid rain. Because the price of oil is continuously increasing, the atmosphere is degrading due to emissions of exhaust gases and the general degree of pollution of the Earth is increasing day by day, various solutions for the generation of non-conventional energies have begun to arouse the interest of parties involved in maritime transport. Non-conventional propulsion systems, which use wind energy or solar energy, are currently making a comeback after being ignored for a long time. By using an unconventional power generator energy devices, like Flettner Balloon, ship owners can save a great amount of fuel, thus making substantial savings and not least, reducing pollution, making environmentally friendly ships. In this article you can discover six major points, which are: 1) Flettner Balloon description, 2) Flettner Balloon components, 3) Determination of the gas with which to fill the Flettner Balloon, 4) The principle of operation for the Flattner Balloon, 5) Energy balance, 6) Conclusions.

Keywords: Flattner balloon, environment, gas, helium, hydrogen.

ИССЛЕДОВАНИЯ ПО ВЫБОРУ ЛУЧШЕГО ГАЗА ДЛЯ НАПОЛНЕНИЯ ВОЗДУШНОГО ШАРА ФЛЕТТНЕРА, НЕТРАДИЦИОННОГО ГЕНЕРАТОРА ЭНЕРГИИ

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За последние 30 лет степень загрязнения атмосферы постоянно увеличивалась, а ее химический состав изменился из-за большого количества загрязняющих выбросов, таких как NOx, SOx, CO2 и других частиц, образующихся в результате горения, которые приводят к разрушению озонового слоя, изменению климата, парниковому эффекту или кислотным дождям. Поскольку цена на нефть постоянно растет, атмосфера ухудшается из-за выбросов выхлопных газов, а общая степень загрязнения Земли увеличивается день ото дня, стали вызывать интерес различные решения для получения нетрадиционных источников энергии. участниками морских перевозок. Нетрадиционные силовые установки, использующие энергию ветра или солнечную энергию, в настоящее время возвращаются после того, как долгое время игнорировались. Используя нетрадиционные энергетические устройства-генераторы, такие как Flettner Balloon, судовладельцы могут сэкономить большое количество топлива, тем самым существенно сэкономив и, что не менее важно, уменьшив загрязнение окружающей среды, сделав суда экологически чистыми. В этой статье вы можете найти шесть основных моментов, а именно: 1) описание шара Флеттнера, 2) компоненты шара Флеттнера, 3) определение газа, которым нужно заполнить шар Флеттнера, 4) принцип работы шара Флеттнера, 5) Энергетический баланс, 6) Выводы.

Ключевые слова: воздушный шар Флаттнера, среда, газ, гелий, водород.

1. Introduction

Wind is the fastest source of energy in the world and one of the cheapest renewable energy technologies today. Wind is a completely renewable energy source.

The Flettner balloon is a device that generates electricity at high altitude. The device is an electrical power generator, filled with a lighter-than-air gas – initially helium that rotates around a horizontal axis and sends the electrical power through cables. The electricity generated can be used immediately or stored in a battery. The Flettner balloon has an aerodynamic profile, with two stabilizers, with the role of maintaining its position in the air. It is positioned in an air current at a certain altitude, at which the wind direction and speed are approximately constant. The balloon remains in a fixed position relative to the ship to which it is attached, regardless of the different angles from which the wind blows and the direction of movement of the ship. During all this time it will generate electric current. The stronger the wind, the faster the balloon will spin and generate more electricity. The balloon rotates around a horizontal axis in response to the wind, efficiently generating renewable, clean electricity at a lower cost than all competing systems. The generation of electricity from wind energy takes place in several stages. The system consists of: a rotor with 2-3 blades, mounted on a tower, cables and other auxiliary components (converters, inverters, batteries/accumulators). Due to the high altitudes at which the Flettner rotor rises, the power generated by it is at least double the power generated by a classic wind turbine.

2. System components

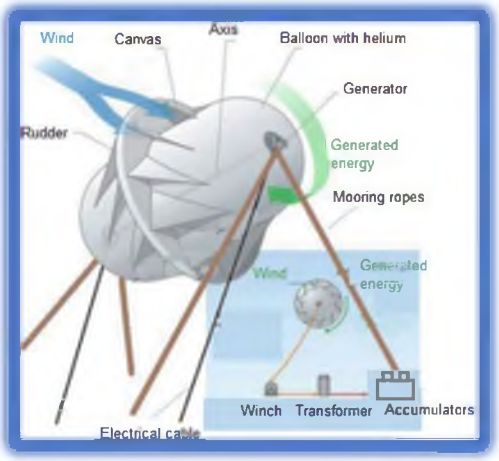

Figure 1.1: Flettner balloon components [1]

2.1 Mooring ropes / mooring lines

The mooring ropes are used to anchor the Flettner balloon to the ship.

2.2 Electricity transmission cables

The power generated by the aloft system is sent to the ship via cables. The generated electric current travels through the cables to a transformer located on the ship, and is then redirected to the grid.

2.3 The balloon filled with a gas lighter than air

After the research carried out, we chose helium as the filling gas. The balloon remains suspended in a vertical position. The helium gas supports the Flettner balloon which can climb to maximum 300 m, for the best performance. [2]

2.4 Helium

Helium is the chemical element with atomic number 2 and an atomic weight of 4.002602, which is represented by the symbol He. It is an inert, colorless, odorless monoatomic gas that leads the group of noble gases in the periodic table.

2.5 Rotor blades

Blades are relatively thin, which means they have a higher surface-to-volume ratio and thus are more affected by the wind. They are curved for increased efficiency.

The blades are made of fiberglass reinforced polyester because this makes the blades light and yet strong enough to withstand the force of the wind.

As the blades move, they cause the shaft located in the turbine body to start rotating. The turbine blades rotate at a speed of between 10-50 revolutions per minute and are equipped with regulators that shut down the system in dangerous weather conditions to prevent them from going out of control. The longer, thinner and lighter turbine blades can increase power output. Current blades range from 40-145 meters.

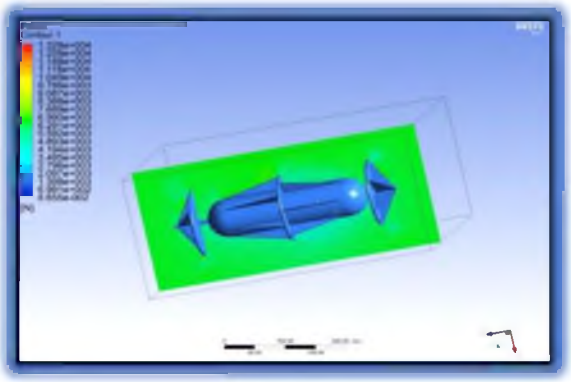

Figure 2.1 – Force distribution on the plan where is situated the Flettner Balloon, in XOZ at a wind speed of 10 *m/s* and a wind direction of 0° design in Ansys Fluent [3]

In the figure it can see the force distribution on the plan where is situated the Flettner Balloon, in XOZ at a wind speed of 10 *m/s* and a wind direction of 0° . The force is bigger near the balloon. The arrows are showing the rotation way of the balloon.

2.6 Turbines

The turbine is located on the horizontal axis and has the ability to transform the mechanical energy of the wind into electrical energy.

2.7 Generator

The turbine generator converts mechanical energy into electrical energy. Turbine generators are different compared to other generating units commonly found attached to electrical grids. The generator must work with an energy source that provides highly variable mechanical power (torque). A generator located 300 meters above ground level enjoys a strong wind, which is why the Flettner helium balloon plays such an important role.

The generator is positioned at the back of the device to ensure stability. This is done with the help of massive rotor blades, which form the visible part of a turbine.

2.8 Stabilizers

The Flettner Balloon was 2 wind stabilizers, at each end of the balloon, with the role of maintaining it in a controlled area, keeping the balloon's position constant.

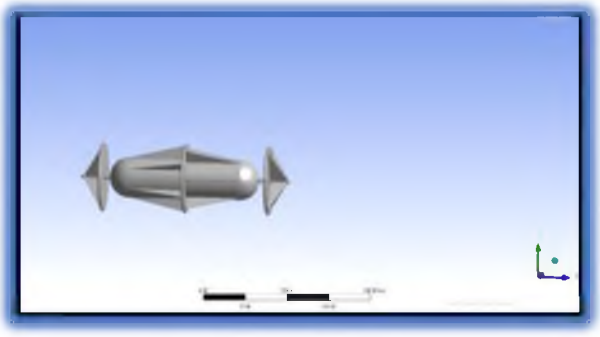

Figure 2.2 – Projection of Flattner Balloon design in Ansys Fluent

2.9 Cooling

Generators need cooling while they are working. This is done with air. The generator being encapsulated, it is cooled with the help of large fans.

3. Determining the gas with which to fill the Flettner balloon (helium or hydrogen)

From the tables above we can see that both hydrogen and helium are gases that were or are used to fill balloons, due to their lower density than air

$\rho_H = 0.0899\ kg/m^3$ respectively

$\rho_{He} = 0.1785\ kg/m^3$.

Although hydrogen has a lower density than helium and requires a smaller volume of gas than helium to fill and keep the Flettner balloon afloat, it is much more dangerous, because after a mixture of hydrogen with air, it creates an explosive gas, which would endanger the balloon and the ship.

For this reason, we chose to fill the Flettner balloon with helium. The last one being lighter than air, giving the balloon buoyancy in the air and due to its inert gas properties, it cannot explode, in the case of mixing the gas in the balloon with the air, if it is to lose the gas from the balloon.

Table 3.1: Hydrogen - helium comparison

	Hydrogen (dihydrogen or molecular hydrogen) **1H; 2H; 3H**	**Helium**
Symbol	H	He
Atomic No.	1	2
Chemical series	nonmetals	Noble gas
Group, Period, Block of the Periodic Table of Elements	1	18, VIII-A, 1, s
Density	0.0899 kg/m^3	0.1785 kg/m^3
CAS number	1333-74-0	7440-59-7
EINECS number		231-168-5
Auto-ignition point/flammability	500 ^{0} C	-
Melting point	-259.14 ^{0} C	-272.2 ^{0} C
Boiling point	-252.87 ^{0} C	-268.9 ^{0} C
Fusion energy	0,05868 kJ/mol	5,23 kJ/mol
Evaporation energy	0,44936 kJ/mol	0,0845 kJ/mol
Critical temperature		-268 ^{0} C
Critical pressure		2,27 x 10^5 Pa
Molar volume	22,42 x10^{-3} m^3/kmol	21 x 10^{-3} m^3/kmol
The speed of sound	1270 m/s la 20^0 C	970 m/s la 20 ^{0} C
Vapor pressure	-	-
Electronegativity	2.2	-
Specific heat	14,304 J/(kg x K)	5193 J/(kg x K)
Electrical conductivity	-	-
Thermal conductivity	0,1815 W/(m x K)	0,142 W/(m x K)
First ionization energy	1312 kJ/mol	2372,3 kJ/mol
Second ionization energy	-	5250,5 kJ/mol
Atomic mass	1,00794 u	4,002602 u
Atomic radius	25(53) pm	128; (31) pm
Convalescence radius	37 pm	32 pm
Van der Waals radius	120 pm	140 pm
Electronic configuration	$1s^1$	$1s^2$
Electrons per energy level	1	2
Oxidation number	-1,+1	0
Oxide	Amphoteric	-
Crystal structure	hexagon	hexagon

4. The principle of operation

The wind turns the turbine blades, which in turn causes the generator to turn.

The vanes change the mechanical energy of the wind into an energy transmitted to the rotating shaft. The shaft is connected to a transmission box. The role of the shaft is to rotate the blades, thus leading to the rotation of the magnets in the generator and the production of mechanical energy. Mechanical energy is transmitted to the shaft in the turbine hub thus causing a torque to develop on the shaft. At the other end of the shaft is a transmission box that transfers power to a secondary shaft. Intensification of the transmission causes a high RPM in the secondary shaft and consequently, the torque is reduced. A generator or alternator is mounted on the secondary shaft and converts the initial mechanical energy supplied by the wind to the turbine. Under a protective cover are the shaft, drive unit and generator.

Table 3.2: Hydrogen - helium comparison

	Hydrogen (dihydrogen or molecular hydrogen) **1H; 2H; 3H**	**Helium**
Proprierties	Colorless	Colorless
	Odorless	Odorless
	Tasteless	Tasteless
	Vapid	Vapid
	Non-toxic gas	Non-toxic gas
	Very soluble in rare metals	
	Soluble in monocrystalline and amorphous metals	
	Soluble in water	Least soluble in water compared to other gases
	Low density	Low density
	Highest heating point	Low boiling point
		Low solubility
	Low viscosity	Low viscosity
	At high pressures, it turns into snow crystals, thus forming solid hydrogen	
	The highest thermal conductivity of all gases	High thermal conductivity
		High calorie content
	The temperature of the flame at which hydrogen burns can reach 2000 ^{0} C	
		Inert and monatomic gas
	14.5 times lighter than air	Gas lighter than air
	Hydrogen gas H2	
	Highly explosive and combustible substance	
	The most stable isotopes	

Symbol	AN	T1/2	MD	Ed MeV	PD
1_H	99985%	Stable with 0 neutrons			
2_H	0,015%	Stable with 1 neutron			
3_H	syntetic	12,33 years	β^-	0,019	3_{He}

Table 3.3: Hydrogen - helium comparison

	Hydrogen (dihydrogen or molecular hydrogen) 1H; 2H; 3H	**Helium**
Condition	Gaseous	Gaseous (at 26 atm)
	Liquefied	Liquefied
	Grease	It can be found in the plasma state
	Solid	
	Metallic shapes	
Use	Hydrogen agent	Filling balloons and airships
	As a protective shield in various atomic hydrogen welds	Filling weather balloons
	For cooling in the power generation industry	For cooling (temperatures below -434^0 F)
	In the chemical, aerospace, telecommunications, food industries	To maintain controlled atmospheres
		Used as an inert gas
		For detecting gas leaks
		Used in the rocket building industry
		For deep diving
		When cooling some nuclear reactors
		When creating some hard disks
		On the manufacture and use of solar telescopes
		Cryogenesis
Hydrogen 2	It is used for nuclear fusion	
Hydrogen 3	Produced in nuclear reactors to create hydrogen bombs	
Burn	With ultraviolet flame, imperceptible to the human eye	

The generator converts the mechanical energy of the wind into electrical energy using electromagnetic induction, which involves using the opposite charge of a magnet to form the electric current.[4]

The generators have a direct output connection with cables at each end of the rotor. Outside the generators at each end of the rotor are wind stabilizers in the form of bevel gears.

The deviation is caused by the Magnus force. It is in the direction of rotation of the rotor and results

from the pressure differences created during the rotation process. The Magnus effect is maximum when the wind direction is perpendicular to the axis of rotation of the rotor. The Magnus effect associated with rotor rotation provides additional lift and stabilizes the rotor position.

The wind causes the balloon to spin. The motion is converted into electrical energy and then transferred to the ship.

Flettner helium rotor blades are a component of the three-dimensional balloon. The blades catch the wind, causing the entire balloon to rotate. After the generator converts this motion into electricity, it is transferred to the ship.

The Flettner helium rotor can capture winds from 183 to 305 meters above the ground. Winds at these upper levels are significantly faster than lower level winds.[5]

Research shows that with every doubling of height, there is a 12% increase in wind speed and with every doubling of wind speed, there is an eightfold increase in power generated by the Flettner helium rotor.

Wind pushes the rotor blades, converting kinetic energy into rotary motion. This turns a shaft, which goes into a gearbox. The transmission, in turn, drives a high-speed shaft that passes through the generator housing.[6]

A magnetic rotor located on the high-speed shaft produces electromagnetic induction through the coils, which generate an electric current. The current must be regulated for grid power or routed into a battery rack for later use.

In order to have a long life, the inflatable part of the turbine is made of an extremely durable fabric used in aeronautics. The outer part of the fabric is lined with a specially treated layer for protection against UV rays and abrasion.

The inner side is covered with a Mylar film (the silver part that you see in the helium balloon), which has the role of preventing the helium gas from escaping. Because the Flettner helium rotor is located at such high altitudes, it was also specially designed to withstand high winds.[7]

The Flettner helium rotor can operate at speeds greater than 28 m/s. At the other end of the spectrum, the Flettner helium rotor turbine can convert wind energy into electricity even at wind speeds of 3 m/s.[8]

5. Energy balance

From the research carried out, it was found that the Flettner balloon, positioned at 300 m altitude, can generate approximately 1000 kWh.[9]

6. Conclusions

By using the Flettner balloon, filled with helium, we can capture the winds from 183 to 305 meters altitude, generating up to 1000 kWh.

The Flettner balloon can generate electricity both at low wind speeds of 3 m/s and at high speeds of 28 m/s.

We can reduce pollution as a result of replacing conventional energy, produced in the classical way, with non-conventional energy captured from the marine environment, green energy.

Shipbuilders are aware that ship engines emit harmful exhaust gases and certain chemical compounds dangerous to human health and also to the environment.

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