New Technologies in Navigation (the use of wind force)

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Summary: The course of the vessel in relation with the wind is an angle between the direction of the wind and the midship line of the vessel. One of the most widespread use of the wing is its application in the wind-driven ship. But these ships are not so fast. But there also is an alternative way to use wind for ship movement despite wind speed and stream force – the application of Magnus Effect, which is the result of mutual impact of the physic phenomenon, such as Bernoulli effect and creation of border layer around streamlined object. Using this effect, the first rotor vessel was created. In 1980s more complicated form of turbo sail was developed by French engineers under supervision of oenologist Jacques Yves Cousteau. In comparison with the best of the usual sails, the turbo sail provided 3,5-4 larger propulsive coefficient. It was supposed to install turbo sails to the tankers, bulkers and the large ships to decrease fuel consumption rate. Nowadays there are attempts to put rotor sails into mass usage. The rotor sails give possibility to save 30-40% of fuel at 16 knots speed. The experience of German shipbuilders will show if it is useful to develop the sails, working in application of Magnus effect. We hope, that in future the world navigation will apply the principle, described by the talented German scientist more than 150 years ago.

Key words. Magnus Effect, Bernoulli effect, rotor vessel, comfortable navigation.

We want to touch on the topic of maritime navigation and express our opinion about its nearest future, whose roots lie in the 20-s of the last century. In general, all types of sailing vessels are quite similar, almost all of them have at least one mast for sail maintenance, rigging and Kiel. In modern ships of this type, the sailing structure is folded by means of electric motors - freeing a person from physical work, and new lighter and more durable synthetic materials make it possible to significantly simplify the design. Based on the previous effect, we created a complete operational prototype. This shows the efficiency and practicality of the application of the Magnus Effect.

The Magnus Effect

An alternative way of using the wind for the movement of a ship, regardless of its speed and flow strength, is realized with the help of the Magnus Effect, a physical phenomenon discovered in 1853 by Henry Magnus. The essence of the Magnus Effect is as follows: Imagine a ball or a cylinder that rotates in a gas or liquid flow around them. In this case, the cylindrical body must rotate along its longitudinal axis. During this process, a force appears, the vector of which is perpendicular to the direction of flow. On the side of the body where the direction of rotation and the flow vector coincide, the velocity of the air or liquid medium rises, and the pressure, according to Bernoulli's law, decreases. On the opposite side of the body, where the rotation and flow vectors are multidirectional, the velocity of the medium's motion decreases, as it were, and the pressure increases. The pressure difference arising on opposite sides of the rotating body generates a transverse force. So, The Magnus effect is the result of the combined effect of such physical phenomena as: 1) the Bernoulli Effect; and 2) the formation of a boundary layer in the medium around the streamlined object. Let us explain the latter: the air that touches the surface of the cylinder forms on it a so-called boundary layer in which the closer to the surface, the less its velocity relative to this surface. On the very surface, the air is relatively immobile; it seems to stick to it. As the cylinder rotates, the "adhered" to it the boundary layer rushes towards the external flow, breaks away from the surface of the cylinder, and pressure appears directed perpendicular to the flow washing the cylinder. The same force arises both on the sail and on the wing of the aircraft. But the cylinder is about 10 times larger. Therefore, rotating cylinders (rotors) were used by the German engineer Fllettner instead of the sails of the vessel "Bukau".

Fluttner's rotating sails

The described physical phenomenon was used by the German engineer Anton Flettner when creating a new type of marine engine. Flettner installed a paper cylinder rotor about a meter in diameter and 15 cm in diameter on a meter test boat. To adjust it, he adjusted the clockwork and the boat swam. Proving in practice the possibility of using the lateral force resulting from the Magnus effect, Fllettner decided to convert the Bukau three-mast into a rotary ship. In 1922, the inventor received a patent for his device and in 1924 the first ever rotary ship. Its rotor sail looked like a rotating cylindrical wind power tower. On top of the rotor-cylinders, Fllettner placed flat plates for better orientation of the air flows around the cylinder. This allowed to double the driving force. Due to the mentioned "Magnus Effect" the resultant force moved the vessel. This force is approximately 50 times higher than the force of wind pressure on the fixed rotor!

Flettner's turbo-parachute tests proved to be excellent. Unlike a conventional sailboat, a strong lateral wind only improved the running qualities of the experimental vessel. Two cylindrical rotors (with a height of 15.6 m and a diameter of 2.8 m) made it possible to better balance the vessel. At the same time, changing the direction of rotation of the rotors, it was possible to change the movement of the vessel forward or backward. Unlike a conventional sailing ship, a rotary ship was practically not afraid of bad weather and strong side winds, it proved to be more stable than a sailboat that the Bukau was before perestroika. The tests were conducted in a calm, storm, and deliberate overload - and there were no serious shortcomings. Of course, the most profitable direction of the wind for creating thrust was a strictly perpendicular direction to the longitudinal axis of the vessel. Unfortunately, the ships with the rotor Flettner depended on the whims of the wind and were forced out by motor ships.

Turbo-coupler from Cousteau

The idea of a fundamentally new system that uses wind power to create the thrust of the vessel was picked up by the French explorer and inventor Jacques-Yves Cousteau. In the early 1980-s, he began work on the creation of such propulsors for a modern vessel. As a basis, he took the turbo-parachute Flettner, but significantly upgraded the system, making it more complicated, but at the same time increasing its efficiency. Construction Cousteau is a vertically installed hollow metal pipe, which has an aerodynamic profile and acts on the same principle as the wing of the aircraft. In the cross section, the pipe had a drop-shaped or ovoid shape. On each side there are air intake grilles through which air is pumped through the pump system. And then the Magnus effect comes into play. Twists of air create a difference in pressure inside and outside the sail.

For the first time, Cousteau tested the prototype of his turboparas in 1981 on the catamaran "Windmill" (Moulin à Vent) during a voyage across the Atlantic Ocean. During the trip, the catamaran was accompanied by a larger expedition ship for safety. Experimental turbo-steam produced traction, but less than traditional sails and motors. In addition, by the end of the journey, welding seams due to fatigue of the metal burst under the pressure of the wind, and the design fell into the water. Nevertheless, the idea itself was confirmed, and Cousteau and his colleagues focused on the development of a larger rotary vessel - "Allion". It was launched in 1985 on December 23, 1986, already after the "ALSION" mentioned at the beginning of the article was launched. Cousteau and his colleagues received joint patent No.US4630997. In comparison with the best of conventional sails, turboparas provided a 3.5-4 times higher traction factor. The turbo-steam is capable of saving up to 35% of the fuel. Even 20 years after the death of his creator, "Alcyone" is still on the run and remains the flagship of the flotilla of Cousteau.

Conclusions and prospects

Nowadays there are two types of propellers of the Turboparus system. The usual rotary sail, invented by Flettner at the beginning of the 20-th century, and its modernized version from Jacques-Yves Cousteau. In the first model, the resultant force arises outside the rotating cylinders; in a second, more sophisticated version, electric pumps create a difference in air pressure within the hollow tube. The first turbo-steam is able to give a course to the ship only in the side wind. It is for this reason that Flettner's turbo-parachute has not become widespread in the world shipbuilding industry. The structural feature of the turbo-steam from Cousteau makes it possible to obtain a driving force regardless of the direction of the wind. Equipped with such engines, the vessel can swim even against the wind, which is an indisputable advantage both over conventional sails and over rotary ones.

At present, many attempts are being made to realize the idea of Fllettner. There are a number of amateur projects. There are a number of amateur projects. For example, the famous Hamburg company Blohm + Voss after the 1973 oil crisis began active development of a rotary tanker, but by the 1986, economic factors covered this project. Then there was a whole series of amateur designs. In 2007, students at Flensburg University built a catamaran driven by a rotary sail (Uni-cat Flensburg).

The turboparic can be installed on tankers, bulkers and other heavy vessels to reduce fuel consumption. Turboparus is equipped with automatic sensors and mounted on a turntable, which is controlled by a computer. Computers coordinated the work of turbo-parachutes and diesel engines, launching the latter, when the wind completely subsided and stopping them at a sufficient wind speed. The smart machine has a rotor that takes into account the wind and sets the air pressure in the system. Only 5 people were enough to operate the ship.

It seems that the rising prices for oil and the alarming warming of the climate create favorable conditions for the return of windmills. Today, attempts are being made to revive the idea of Flettner and make rotary sails mass. Many companies began active development of a rotary tanker. In 2010, the third in the history ship with rotary sails appeared - a heavy truck "E-ship 1", which was built by the order of Enercon, one of the largest producers of wind turbines in the world. The vessel is equipped with four Flettner rotors, and of course, a conventional power unit in the case of windlessness and for obtaining additional power.

Located in Singapore, the ship-based company "Wind Again", which deals with the creation of technologies to reduce fuel consumption and emissions, proposes the installation of special Flettner rotors (folding) on tankers and cargo ships. They will reduce fuel consumption by 30-40% and pay off in 3-5 years. The company of marine engineering "Wartsila", operating in Finland, already plans to adapt the turbo-sails and on cruise ferries. This is due to the desire of the Finnish ferry operator "Viking Line" to reduce fuel consumption and environmental pollution. The use of Flettner rotors on pleasure boats is studied by the University of Flensburg (Germany).

In March 2017, Royal Dutch Shell and Maersk announced plans to equip a 245-meter-long oil tanker with deadweight of almost 110,000 tons, sails 30 meters high and 5 meters in diameter, and will be constructed of lightweight composite materials and carbon fiber. It is assumed that the sails will be installed in the first half of 2018 and tested before the end of 2019. According to the Company's representatives, this technology will save on average up to 10% of fuel on standard routes.

Our main purpose was to study this Effect and execute it practically. We created mini sample of the vessel working on the wind force. We used two turbo sails, in the first case it was identical of Cousteau's model, and in the second case it was the mobile rotor constructed by us.

I suppose that besides getting sufficient knowledge and experience I will make a little contribution in the procedure of using wind energy.

Conclusion

In conclusion, we can confidently assume that the introduction of turbo-parachutes has the following prospects:

- Use free and renewable wind energy on ships;
- Save fuel, i.e. money;

- It is possible on the principle of the Magnus Effect to improve the efficiency of coefficient of performance;
- Turbo sails will provide more effective control of the vessel, excluding the problems associated with the weather, i.e. It's a comfortable navigation!
- New workplaces appear, which requires training of new specialists;
- For the training of specialists - it is necessary to introduce new educational programs in higher educational institutions, which will attract more entrants to the Maritime Training Institutions;
- The need for new teachers!
- As a result, you can solve the problems associated with the ecology of the seas and oceans, which in turn has the global significance for all mankind!

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