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NEW CONCEPTS REGARDIN POLLUTION REDUCTION THROUGH THE USE OF RIGID SAILS IN ORDER TO DECREASE THE POWER OF THE MAIN PROPULSION ENGINES

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Abstract: *Several studies regarding wind assisted propulsion have been carried out before. The most common reasons for those studies have been high or increasing bunker prices. Most of the research was never realized since the benefits, at that time, did not have a great significance. Due to environmental laws, public opinion and costs of modern shipping, firms are obliged to reduce their fuel consumption.*

Introduction

For thousands of years, wind energy has been used for various purposes, from active propulsion of ships and military shipping, to the new farms installed in areas with wind potential. With the oil crisis, prices for fuel have gone up and the polution of the environment with huge quantities of carbon dioxide and other compounds from combustion of was increased (nitrogen oxides NO_x and SO_x sulfur). Therefore, there has been a substantial development of wind energy intakes and thus the wind energy technology is growing, both through the development of turbine building, which became effective with installed capacity, growing and enjoying an electronic developed and by introducing the various shipping powertrain rigid active sailing or using high altitude balloons, in which the current velocity is substantially higher. Based on these considerations, the evaluation of these natural, completely clean and economic energy sources is solicitated more and more. Thus, with an increased systematic use of vessels as primary means of transporting goods around the globe, this matter implies that a part of the propulsion energy is provided by the sails. This paper presents design solutions currently used to capture a portion of the propulsion energy by using wind energy.

1. Investigation into the sail system

The propulsion force is derived from the lift force of sail L. The mechanism is described as fig.1.

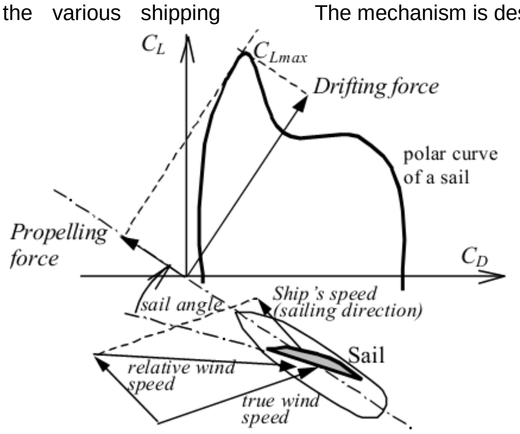

Fig.1 Schematic diagram of the propelling force by a sail

Lift force L of sail is described as the following form, which depends on the lift coefficient: CL as well as sail area: and the square of relative wind velocity:

$$L=\rho U^2 A C_L/2 \quad (1)$$

As the higher C_{Lmax} promises the large propelling force, most of the designers in 1980's were seeking after the higher CLmax of sail. Indeed the rotor and turbo-sail produces high C_{Lmax} , but these sails were not used in actual ships. One reason is the high cost, and the other is the weight of the sail. If the heavy sail is installed on deck, the center of gravity: CG of ship becomes higher, which causes the poor stability. In order to avoid this, the large ballast weight shall be installed to cancel the rise up of CG. This arrangement makes the ship heavier, the payload smaller and the construction cost higher. Then, the merit of the sail is lost. Consequently, it is clear that the weight and cost of sail are most important than the higher C_{Lmax} , particularly for a small ship like a fishing boat.

2. The classification of wind collecting devices

Obtaining wind energy requires lift force or drag force induced by wind that propels the vessel. People have been developing the lift or drag generating devices, searching for effective and easy-handling systems. As for the results, a series of types of devices have been proposed up until now. Those devices are shown in Fig.2, being arranged by their mechanisms.

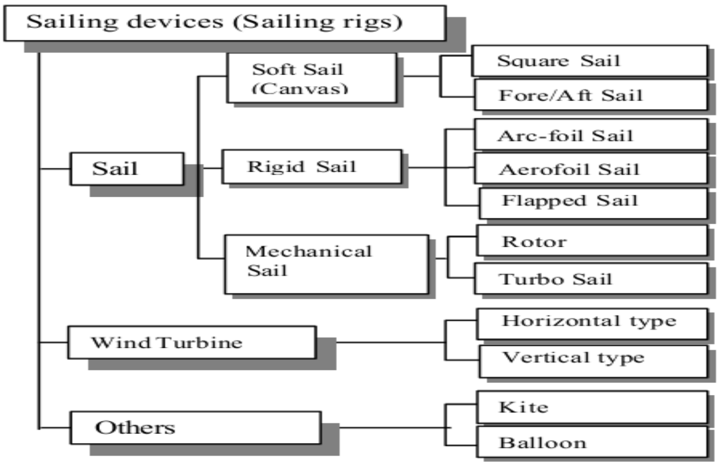

Fig. 2 The classification of wind collecting devices

Soft Sail
This device is the most popular and has been utilised for the classic tall ships. In 1955, the "Dynaship" project in Germany, commenced to develop a semi-rigid squire sail, as shown in Fig.3 This sail however, was not realized at all, but the concept might succede in JAMDA's rigid sail. However, for the fore and aft sail, the traditional gaff sail has been well used for topsail schooners. Bermuda sail that is more of a simplified loose-foot sail is still useful for sailing yachts and dinghies. Wartsila Ab. designed the automatic sail driving system and then sketched the modern sail cruising ships "Wind Star", "Wind Song" and "Wind Sprits" from 1986 to 1988, as seen in Fig.4.

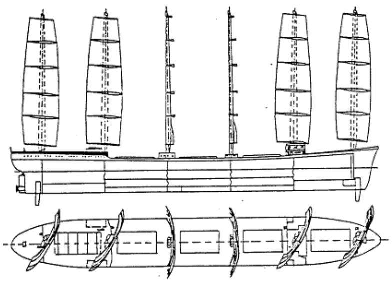

Fig.3 General Plan of "Dynaship"

Fig 4 Modern sail-equipped cruising ship "Wind Star"

Rigid Sail
JAMDA and NKK designed the rigid type square sail. The expansion and setting of the sail angle were automatically conducted by hydraulic units as seen in Fig.5. In 1980, the world's first modern sail equipped ship "Shin-Aitoku-Maru" was built using the above presented sail, as shown in Fig 6. After "Shin-Aitoku-Maru" was constructed, 17 ships were equipped in a similar way, with the JAMADA's sail in Japan.

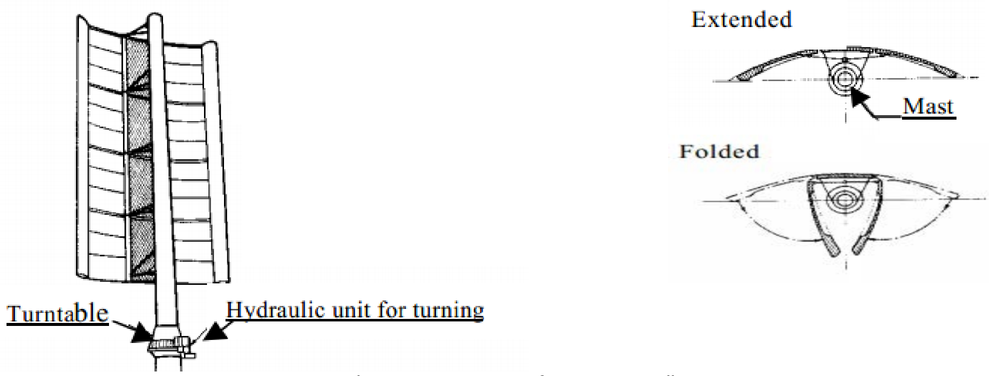

Fig.5 Arrangement of JAMDA's sail

Fig.6 Sail-assisted tanker "Shin-Aitoku-Maru"

Mechanical Sail

Mechanical navigating can produce a higher lift coefficient than a conventional sail. In any case, the ail weight generally becomes heavier. The rotor system was designed by Flettner in Germany. This principle is that the rotating cylinder in wind releases the lift force using the Magnus effect. Equipping these rotors, the 455GT cargo ship "Buchau" and 2,077GT cargo ship "Barbara" was actually built in 1924 and 1926. In any case, the rotor ship has never been released, because the merit was for Flettner Rotor was too small. The principle of a spinning rotor using the Magnus effect was tested on a ship as early as in 1924, but was never considered to be an efficient choice since the oil taxes were too low and the profits too small. However, the shipping industry has reconsidered this matter. As a result, the wind mill building company Enercon is at the moment building a ship with auxiliary propulsion of 4 large Flettner rotors of 25 meters height, as it is shown in Fig. 7

Fig. 7 The E-ship ordered by Enercon is a 130 m freighter that will be equipped with four 24m high rotors that uses the Magnus effect.

The Turbo Sail system is unique as it could be seen in Fig.7, in which the stalled air is drawn behind the sail-body with the help of a powerful electric fan. It was hopped as a high-lift sail, but not used in actual ships, except prototypes.

The Wind turbine

A wind turbine can be seen as an alternative way to produce electric power in order to reduce the generator requested output. Mainly, there are two categories of turbines which will be considered, the Vertical Axle and VAWT the Horizontal Axle Wind Turbine HAWT. In any case there are certain differences that are of interest when these systems are set onboard a moving vehicle. The location could be turbulent and this means that the wind direction is unstable. The HAWT is obliged to constantly yaw to find the right direction for the wind. Meanwhile, the VAWT could take advantage of the wind coming from all directions without having to yaw, as shown in Figure 8a,b. The VAWT makes less noise than the HAWT because the blade tip-speed is much lower, which also might be a valuable strong point.

Fig 8.a Vertical type

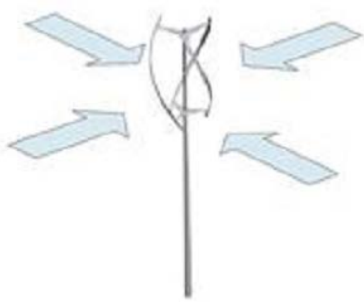

Fig 8.b Horizontal type

The kite

The kite represents a new concept with the leading developer being the German enterprise, Skysails. The company claims to have a working product of 640 m kite, and that their purpose is to design kites almost as big as 5000 m. The kite is released and then recovered from a bridge controlled panel and it is otherwise totally autonomous. Figure 9 is a photo of a demonstration in which Skysails tests a kite launch on a ship.

Fig. 9. Skysails

The wing profile

Ships have used sails for decades. However, the wing profile has more power than a conventional sail. It utilizes a similar technique as sail navigation, but it is created with a sort of rigid material rather than soft cloth. In conlusion, it generally offers more efficient profiles. Figure 10 describes a bulk carrier with possible mount of wing sails.

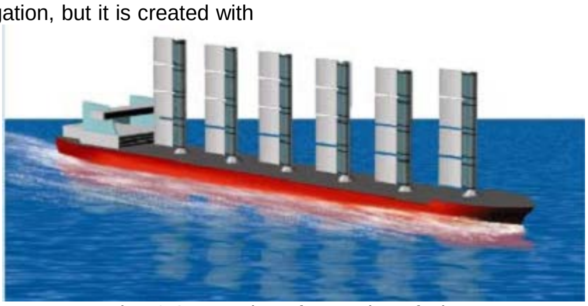

Fig 10 Suggestion of mounting of wings

3. Conclusions

This article is an analysis of the means that can make the usage of wind energy to be taken at a time of energy potential of the marine environment, with the aim to replace some of the installed propulsion power on board ships, which is produced most often by diesel engines. Thus, the replacement of a part of the power board is installed in a triple effect, the first one represents the reduction of the flue gas, especially nitrogen oxides, NO_x, carbon dioxide CO_2 and sulfur dioxide SO_2 and so on. The second one refers to the reduction of the quantities of fossil fuels used to produce electricity for main engines of internal combustion. Finally, the third one extends the life of the main propulsion by increasing length of time between periodic inspections and routine repairs. The key question is: could wind energy can compete with conventional energy produced in power plants? We do have an affirmative answer to this question based on the following considerations:

- Elimination / reduction of pollution, noise and vibration produced by the main propulsion;
- Increasing the energy autonomy in relation to fuel embarked on board;
- Stimulating research and development of technologies for equipment which has the ability to capture clean environmental energy, both at sea and on land;
- Increased safety when operating through the existence of two propulsion systems, independent of each other;
- Longer reliability for the propulsion system, using implicitly classical systems with lower maintenance costs;
- Environmental harm reduction during voyages and easily obtainable entry requirements of international legal standards relating to emissions of combustion gases into the atmosphere;
- reduced costs for equipping the vessel with facilities to capture wind energy;
- saving a part of the fuel that would have been used for conventional navigation;
- reducing the amount of exhaust gases discharged into the atmosphere;
- increasing the reliability and life of the main propulsion system;
- reducing the maintenance costs of the main propulsion machinery by making their time intervals larger;
- increasing the on board comfort, using the main propulsion at lower load factors, as is the noise level and lower vibration;

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