Concept Study Of Savonius Keel & Wind Turbine Darrieus (SKWID) Coupled With Carbon Capture Storage (CCS) To Produce Fuel In On-Board Ships

Arpit Jajoo [1], SK. Rakibuddin [2]

[1] B.Tech, Marine Engineering, First Year

Indian Maritime University, Chennai-600119

Phone Number: +91 8015570941, E-mail: arpit.jajoo001@gmail.com

[2] B.Tech, Marine Engineering, First Year

Indian Maritime University, Chennai-600119

Phone Number: +91 8015346037, E-mail: skrakibuddin07@gmail.com

[1.] Arpit Jajoo - Presenting the paper

[2] SK. Rakibuddin - Responsible for Correspondence

1. Abstract

This paper deals with the coupled study of Savonius Keel & Wind Turbine Darrieus (SKWID) and Carbon Capture Storage (CCS) to produce fuel in on-board ships. CCS aims to utilize CO_2 and H_2 present in water to produce fuel by electrochemical acidification that can be used to run ships. It reduces the consumption of gallons of fuel, global warming, is highly cost- effective and eco-friendly. SKWID aims to provide renewable and cost- effective energy. This energy will be required as an input to drive CCS system. The system has the potential to be very sustainable in the long-term.

2. Keywords

CCS, SKWID, Electrochemical Acidification Cell, Alternative Fuel, Coupled of CCS and SKWID

3. Introduction

The seas and the oceans cover two thirds of the Earth's surface and contain different amount of energy, and its possible resources are far beyond the energy needed by the humanity. The energy resources came from two types of phenomenon: solar energy and gravity variations due to changes in positions of Earth, Moon and Sun. The planetary ocean contains numerous forms of renewable energies, who, in absolute, deliver enough energy to meet the needs of the entire planet.

Carbon capture and storage (CCS) is the process of capturing carbon dioxide (CO_2) from large-point sources (such as power stations, seawater and industrial facilities). In addition to H_20 and salt, ocean water is rich in carbon dioxide (CO_2 concentration is 140 times that of air). So a hybrid system of CCS with a catalytic converter should be built that extracts hydrogen and carbon dioxide from the water with approx. 92 percent efficiency and then -- via a reaction with a metal catalyst - transforms those gases into a liquid hydrocarbon fuel that the ship's existing engines can burn.

SKWID is a floating wind and current hybrid power generation system capable of converting two inexhaustible ocean energy sources into abundant power. By harvesting the renewable energy from never-ending currents and strong and continuous ocean winds, the pioneering technology of the SKWID provides cost-effective power generation with minimal environmental impact.

In this study we intend to show how to produce fuel in on-board ships from CO_2 and H_2 present in seawater. To run CCS technology in ships a large amount of electrical energy is needed which is produced using SKWID technology.

4. Principles Involved

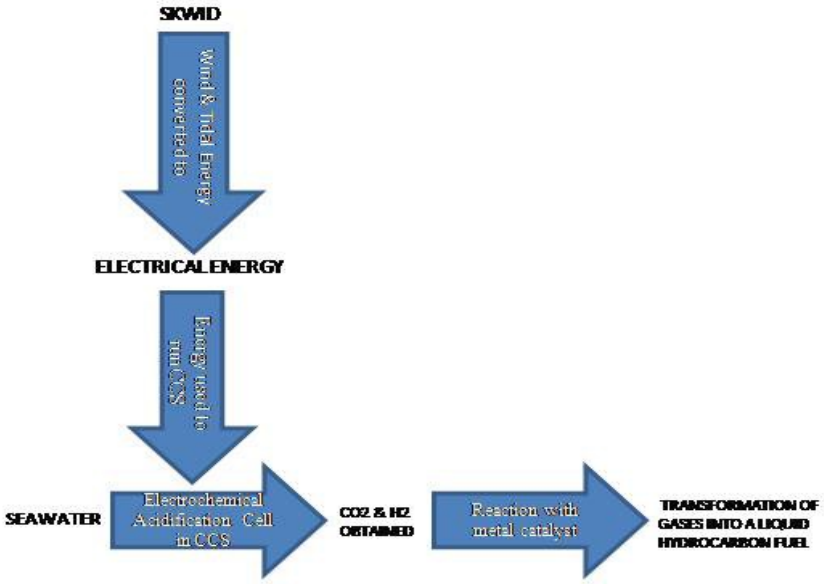
4.1 CCS TECHNOLOGY: -

This technology is used to remove CO_2 from seawater with a concomitant production of hydrogen (H_2), which are the building blocks of hydrocarbons. They achieved this through the use of **Electrochemical Acidification Cells**

4.2 SKWID :-

This technology works on the principle of Vertical-axis wind turbines (VAWTs) VAWTs are the type of wind turbine where the main rotor shaft is set vertically and the main components are located at the base of the turbine. This arrangement allows the generator and gearbox to be located close to the ground, facilitating service and repair. VAWTs do not need to be pointed into the wind, which removes the need for wind-sensing and orientation mechanisms.

5. APPLICATION



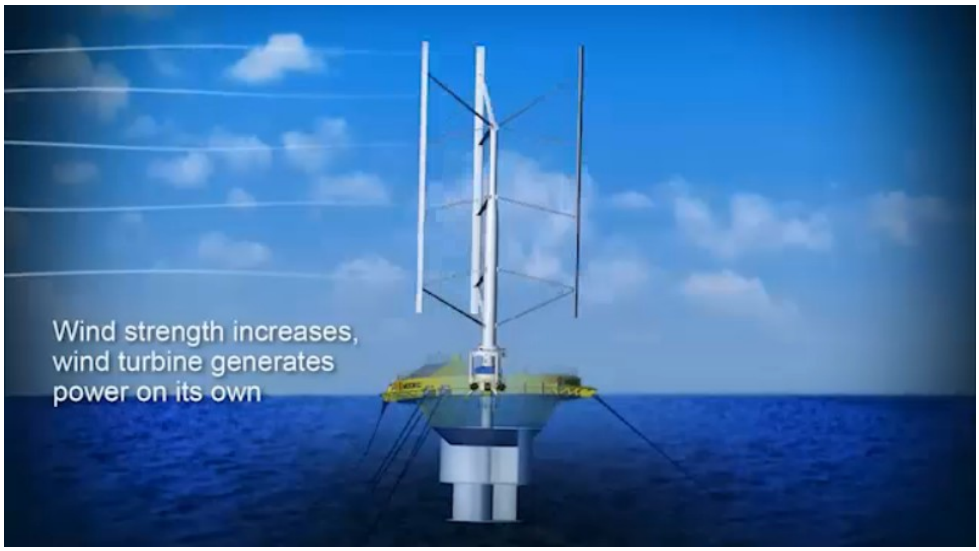
Flow Chart representing production of fuel using SKWID & CCS

5.1 Production Of Electrical Energy Using SKWID To Drive CCS:-

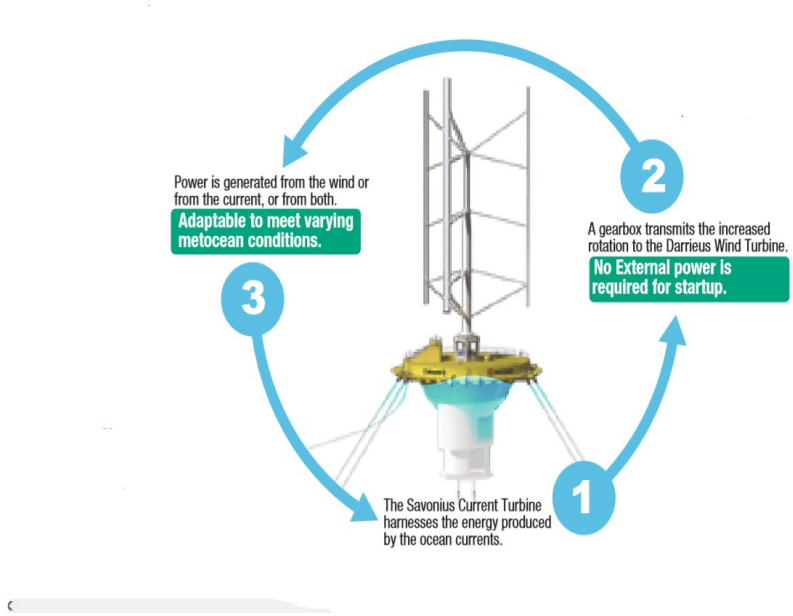
Savonius Keel & Wind Turbine Darrieus

Darrieus Wind Turbine :-

The Darrieus wind turbine efficiently harnesses the ocean wind. The unidirectional Darrieus turbine rotates regardless of the wind direction. Due to the location of the generator, the system has excellent stability with a low center of gravity, as well as excellent maintainability with easy access. The Darrieus' rectangular swept area catches twice as much wind when compared to the circular swept area of typical onshore wind turbines of the same diameter and is therefore capable of delivering twice as much power from a single installation - far more power from the same wind farm area.



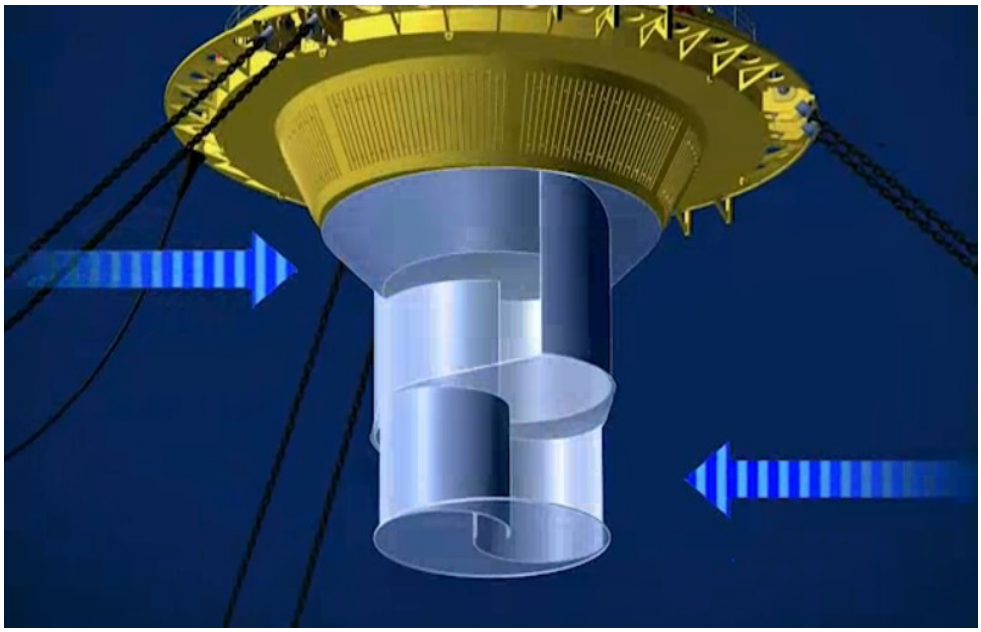
Darrieus Wind Turbine-Converting Wind Energy to Electrical Energy



Working of SKWID

Savonius Current Turbine:-

The Savonius current turbine harnesses the current. The split-cylinder-shaped buckets of the Savonius current turbine can harness any weak current and will rotate in one direction regardless of current direction. This turbine is insensitive to marine growth on the buckets and is harmless to the marine ecosystem, as it rotates slowly at the speed of the current.



Savonius Current Turbine-Converting Tidal Energy to Electrical Energy

5.2 Obtaining CO_2 And H_2 From Seawater Using Electrochemical Acidification Cell In CCS:-

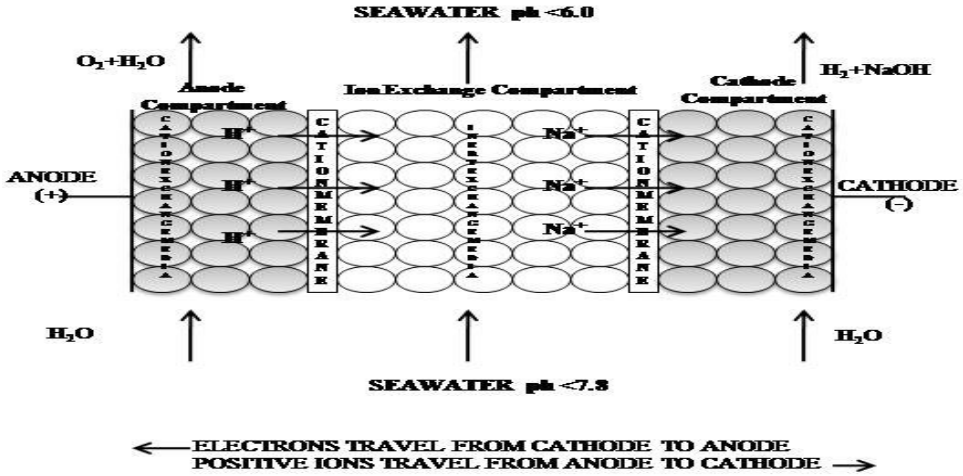


Figure 1. Electrochemical Acidification Cell Schematic Diagram

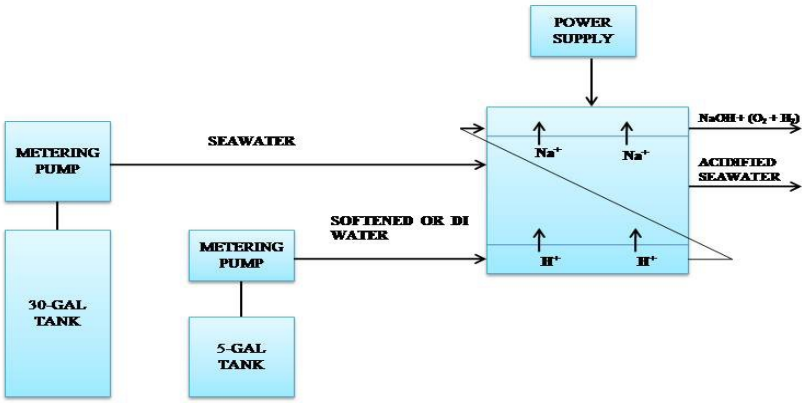


Figure 2. Schematic Showing The Acidification Cell Experiment Layout

Cell Reaction:-

The amount of H^+ generated by the anode is proportional to the applied electrical current, which follows Faraday's constant. Faraday's constant is defined as the amount of electricity associated with one mole of unit charge or electron, having the value 96,487 ampere-second/equivalent. For the anode reaction, 96,487 A-sec will produce ¼ mole O_2 gas and 1 mole H^+ and for the cathode reaction, 96,487 A-sec will produce ½ mole H_2 gas and 1 mole OH^- This allows the theoretical amount of H^+, OH^-, H_2, and O_2 produced per amp-second of current passed through the electrodes to be determined:

ANODE REACTION :-

CATHODE REACTION :-

Therefore, seawater with a HCO_{3^-} concentration of 142 ppm (0.0023 M) and a flow rate of 1 liter per minute, will require a theoretically applied current of 3.70 A to lower the pH to less than 6.0 and convert HCO_{3^-} to H_2CO_3.

The theoretical amount of CO_2 that can be removed from the acidified seawater is 0.0023 moles per liter. Removal efficiency can be defined as the ratio of the theoretical amount of CO_2 removed to the actual amount of CO_2 removed in the acidified seawater. The theoretical amount of H_2 gas generated at 3.7 A is

5.3 Production Of Hydrocarbon Fuel:-

The production of hydrocarbons, which are compounds solely made up of hydrogen and carbon, from the recovered gases is a three-step process.

- Firstly, CO_2 and H_2 is collected from seawater by the process of electrochemical acidification cell in CCS.
- Secondly, the CO_2 and H_2 obtained are converted into unsaturated hydrocarbon starter molecules called **olefins** using an **iron-based catalyst**.
- Thirdly, these olefins are converted into a liquid containing larger hydrocarbon molecules with a carbon range suitable for use in ship engines by polymerization.
- C9-C16 range hydrocarbons are obtained.

6. Benefits

- CCS technology removes CO_2 at 92% efficiency. Obviously energy will be required as an input to drive the system, and this energy is going to come from energy generated by SKWID, thus preserving eco-system.
- The energy produced by SKWID is large enough to light 100000 houses, this huge amount of energy is sufficient to meet the electrical .
- Independency on fossil fuels make this fuel eco-friendly.
- Highly cost-effective.
- Ships need not stop for refuelling during voyages, as a continuous production of fuel takes place.
- It is estimated that CCS would bring a 15 per cent reduction in the wholesale price of electricity by 2030
- 15,000–30,000 jobs would be created per year in the CCS industry by 2030 (range based on the installed capacity of 10 or 20 GW)

7. Conclusion

This paper presents a concept study for the coupled use of SKWID technology with CCS technology to produce sustainable fuel. The paper puts forward the reasons why such a study is welcomed at this moment. With the vast growth in shipping industry, the fuel consumption has increased manifold. Thus Alternate Fuel resource is the need of the hour and as the proverb goes" Necessity is the Mother of Invention" ,a new coupled technology can be developed in which renewable and perennial Tidal & Wind Energy resource is converted into Electrical Energy by SKWID technology. The Electrical Energy thus produced can be used in two ways-

- Firstly, to supply energy to the Electrochemical Acidification Cell in CCS.

- Secondly, to meet ships electricity requirements. Thus captured CO_2 and H_2 is converted to Hydrocarbon by Catalytic Reaction. These hydrocarbons after polymerisation produce long carbon-chain which can be used as fuel to drive ships.

8. Acknowledgement

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