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Extraction of Helium-3 Implying Cyclotron and Its Usage as a Propellant in Ships

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Human race has triggered the economy to harvest a renewable energy source which would satisfy its needs in all aspects with concern to all environmental problems. Helium -3 is found in abundance on moon but scarcely on earth. The process follows the extraction of liquefied He-3 from sea water. Deuterium and oxygen are rifted from sea water by the process of electrolysis. By bombarding deuterium isotope, He-4 can be obtained. Injecting He-4 into a cyclotron, a neutron is eliminated which results in the formation of gaseous He-3 and its liquefied form is bought in by the simple process of condensation. The steam which is released in the process of electrolysis can be utilised for a steam working process. Ejaculation of a neutron from He-4 by the means of cyclotron results in a energy output of 3.268 MeV, which can be directed as a power source for further economical uses. Since Helium is a main ingredient in the reaction happening in sun, usage of its isotope (He-3) in ship engines provide more thrust than the present fuel forms. As the temperature output of He-3 is higher than the other fuels when burnt, alloy mixture of iron (Fe),titanium (Ti), and niobium (Nb) should be used in the manufacture of engines running on Helium-3.He-3 can be defined as pollution free fuel as it is carbon free and gives out hydrogen when burnt. This implies that the above process not only results in the outcome of liquefied He-3 but also paves way for an economical extraction process which is 100% pollution free.

Field of Research: Renewable Energy-(Naval Architecture).

Introduction

Energy Source in Geological Hypothesis

The inadequacy of numerous geological hypotheses trying to explain the endogenic process of Earth is based on lack of suitable energy sources and their carriers, such as to produce an immortal fuel which is eco-friendly and also to maintain the increasing carbon content in the atmosphere and thereby decreasing it. The inquisitive of renewable sources to the present generation can be unveiled by

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producing He-3 by means of sea water. Through which we can obtain everlasting renewable source without causing any harm to the atmosphere.

Literature Review

1. Helium-3:

Helium-3 is the isotope of Helium. It is the most lighter and non radioactive element among the other products of Helium. It is also called as Thralphium. Helium-3 is compressed with two protons and one neutron. This element is rare and found at a percentage level of 0.000137% in earth crust. Helium-3 is found to be 10000 times rarer than the Helium-4 from the gas wells. It is rare and sought for use in nuclear reactions. Helium-3 has very long half life period (billions of year).It is neucleogenic and cosmogenic neucleoid and also terrestrial.

Helium3	
General	
Names & Symbols	Helium-3,He-3,He^3
Neutrons	1
Protons	2
Nuclide Data	
Natural Abundance	0.000137% (He on earth)
Half-Life	Stable
Parent isotopes	^3H(Beta decay of tritium)
Isotope mass	3.0160293u
Spin	+1/2

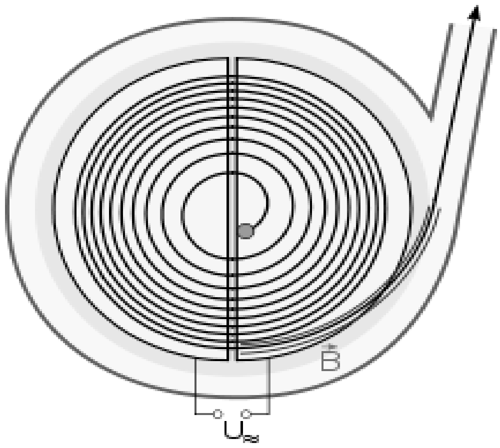
Properties of liquid helium	**Helium-4**	**Helium-3**
Critical temperature	5.2 K	3.3 K
Boiling point at one atmosphere	4.2 K	3.2 K
Minimum melting pressure	25 atm	29 atm at 0.3 K
Super fluid transition temperature at saturated vapour	2.17 K	1 mK in the absence of a magnetic field

2. Helium-3 Source:

In our solar system no other planet except Earth has the presence of atmosphere; this is the main reason for the absence of Helium3 on earth. Helium -3 is found in abundance on moon but scarcely on earth ,So there are no direct sources for the production of Helium-3 and hence it is possible only by artificial method.Helium-3 can be extracted in earth by means of seawater. Seawater contains Deutrium and Oxygen. Hydrogen, Deuterium and tritium are very close cousins. They have quite similar chemical properties but not their physical properties. Deuterium is found in sea water at the concentration of 33 milligrams per litre.

Methodology

1. Cyclotron



Cyclotrons accelerate charged particle beams using a high frequency alternating voltage which is applied between two "D"-shaped electrodes (also called "Dees"). An additional static magnetic field B is applied in perpendicular direction to the electrode plane, enabling particles to re-encounter the accelerating voltage many times at the same phase.[1] To achieve this, the voltage frequency must match the particle's cyclotron resonance frequency

$$f = \frac{qB}{2\pi m},$$

with the relativistic mass *m* and its charge *q*. This frequency is given by equality of centripetal force and magnetic Lorentz force. The particles, injected near the centre of the magnetic field, increase their kinematic energy only when recirculating through the gap between the electrodes; thus they travel outwards along a spiral path.

$$f = \frac{qB}{2\pi\gamma m_0} = \frac{f_0}{\gamma},$$

where

$\gamma = 1/\sqrt{1-\left(\frac{v}{c}\right)^2}$ is the Lorentz factor

m_0 is the particle rest mass

f_0 would be the cyclotron frequency in classical approximation.

The gyro radius for a particle moving in a static magnetic field is then given by

$$r = \frac{\gamma\beta m_0 c}{qB},$$

Where $\beta = v/c$ is the relative velocity.

A synchrocyclotron is a cyclotron in which the frequency of the driving RF electric field is varied to compensate for relativistic effects as the particles' velocity begins to approach the speed of light. This is in contrast to the classical cyclotron, where the frequency was held constant, thus leading to the synchrocyclotron operation frequency being

$$f = \frac{f_0}{\gamma} = f_0 \sqrt{1-\beta^2},$$

where f_0 is the classical cyclotron frequency, and $\beta = v/c$ again is the relative velocity of the particle beam.

The rest mass of an electron is 511 keV/c^2, so the frequency correction is 1% for a magnetic vacuum tube with a 5.11 keV/c^2 direct current accelerating voltage. The proton mass is nearly two thousand times the electron mass, so the 1% correction energy is about 9 MeV, which is sufficient to induce nuclear reactions

Recalling the relativistic gyro radius

$$r = \frac{\gamma m_0 v}{qB}$$

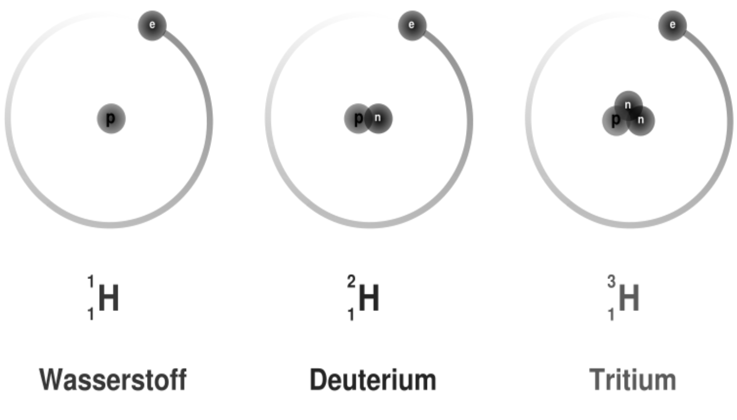
and the relativistic cyclotron frequency $f = f_0/\gamma$, one can choose B to be proportional to the Lorentz factor, $B = \gamma B_0$. This results in the relation

$$r = \frac{m_0 v}{qB_0}$$

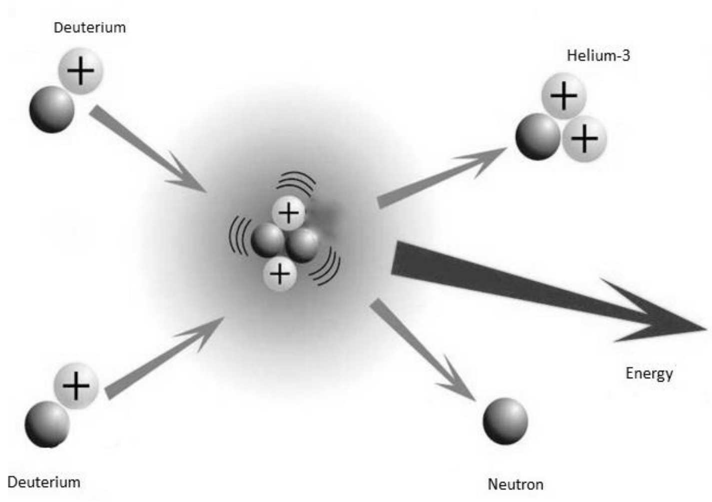
which again only depends on the velocity v, like in the non-relativistic case. Also, the cyclotron frequency is constant in this case.
The TRIUMF cyclotron mentioned below is the largest with an outer orbit radius of 7.9 metres, extracting protons at up to 510 MeV, which is 3/4 of the speed of light. The PSI cyclotron reaches higher energy but is smaller because of using a higher magnetic field

2. Extraction of Helium3:

Deuterium and oxygen are rifted from sea water by the process of electrolysis.

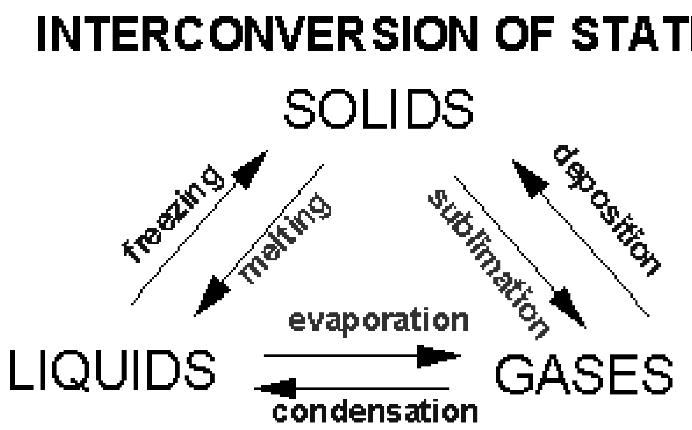


By bombarding deuterium isotope, He-4 can be obtained. Injecting He-4 into a cyclotron, a neutron is eliminated which results in the formation of gaseous He-3.



3. Formation of Liquefied Helium-3:

By the above process we can obtain the product in gaseous form.He-3 and its liquefied form is bought in by the simple process of condensation, which is shown below



4. Economical Usage of Extraction Process:

The steam which is released in the process of electrolysis is diverted into a steam turbine, there by producing energy which can be used in further extraction process. Ejaculation of a neutron from He-4 by the means of cyclotron results in a energy output of 3.268 MeV, which can be directed as a power source for further economical uses.

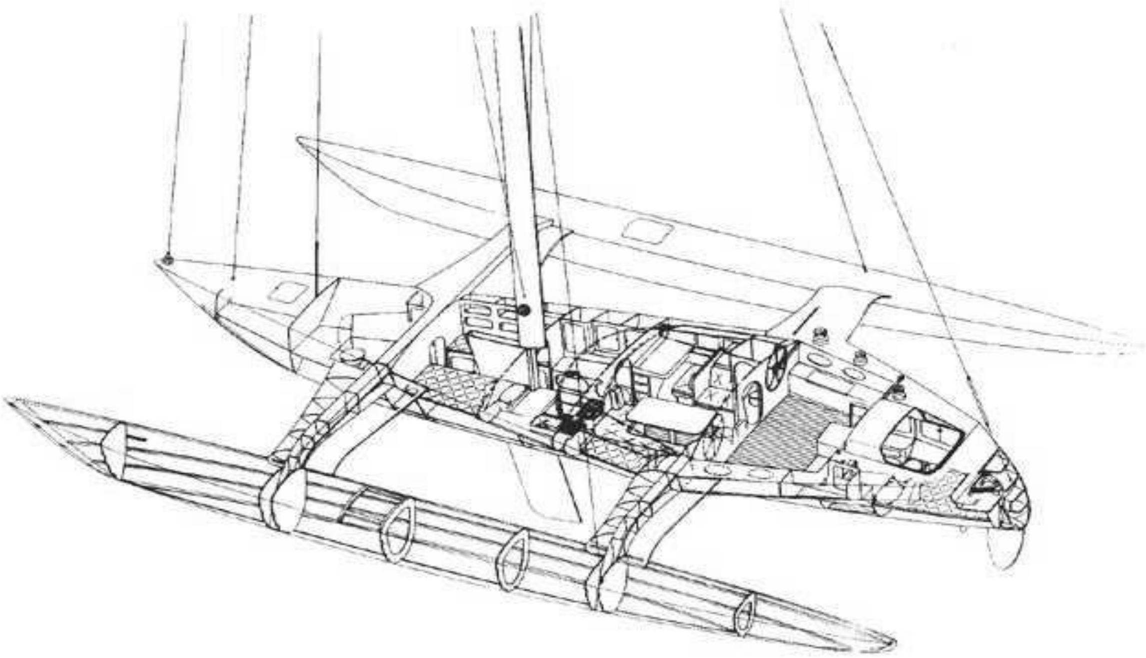
FUSION REACTION FUSION OF DEUTERIUM INTO HELIUM-3				
Reactants		Products	Q	n/MeV
Second-Generation fusion fuels				
$^{2}_{1}H$ + $^{2}_{1}H$ (D-D)	→	$^{3}_{2}He$ + $^{1}_{0}n$	3.268 MeV	0.306
$^{2}_{1}H$ + $^{2}_{1}H$ (D-D)	→	$^{3}_{1}H$ + $^{1}_{1}p$	4.032 MeV	0
$^{2}_{1}H$ + $^{3}_{1}H$ (D-T)	→	$^{4}_{2}He$ + $^{1}_{0}n$	17.571 MeV	0.057

Findings/Discussion

1. Why Helium-3 for Ship Propulsion?

The major source of fuel to the present shipping industry is diesel. The usage of liquefied He^3 in ship engines can provide more thrust than diesel. Know fact is that shipping industry is the profitable one in means of trade. By introducing liquefied He^3 as a fuel for ship engines, we can make it even more profitable in the globe.

2. Trimaran:



A **trimaran** is a multihull boat consisting of a main hull (vaka) and two smaller outrigger hulls (amas), attached to the main hull with lateral struts (akas).

The design and names for the trimaran components are derived from the original proaconstructed by native pacific islanders.

Two types of trimaran exist: the regular trimaran and the open trimaran, which features a trampoline between the hulls instead of plating.

Trimarans have a number of advantages over comparable monohulls (conventional, single-hulled sailboats). Given two boats of the same length, the trimaran has a shallower draft, a wider beam, less wetted area, and is able to fly more sail area. In addition, because of the righting moment provided by the wide beam, trimarans do not need the weighted keel that is required in monohulls, often resulting in unsinkable designs. As a result of the wide beam, the trimaran offers much better straight-line performance than a monohull, is able to sail in shallower water, and maintains its stability in stronger winds. However, its wider beam requires more space to maneuver, so tacking and gybing can be trickier in confined areas. Also, the narrower hulls provide less living space than an equivalently-sized monohull. Finally, trimarans require more docking space in marinas, unless the ama can be folded to reduce the beam.

As the righting moment (the force that resists the opposite torque of the wind on the sails) is produced by a float on either side called an ama and not a heavy protruding keel, trimarans are lighter and faster than a monohull of equivalent length. A lightweight retractable keel or foil, referred to as a centerboard or Daggerboard is often employed to resist lateral movement, making many models easily beachable. Most trimarans are difficult to flip sideways given a reasonable degree of caution, however, trimarans can reach speeds so great in high winds that they can plow into the back of a wave and flip end-over-end (Pitchpole). This hazard is especially dangerous for a multihull that is using a spinnaker in high winds and large seas. To avoid this unfortunate scenario trimaran sailors are advised to reduce sail and to always have all sails easily released. The use of trampolines with a large weave, to allow water to easily pass through, and the deployment of parachute anchor drogues and sea anchors whenever appropriate should reduce the risk to an acceptable degree.

The father of the modern sailing trimaran is Victor Tchetchet, a Russian émigré and a strong proponent of multihull sailing. Mr. Tchetchet, who was a fighter pilot during the First World War in the Czar's Air Force, lived in Great Neck, New York from the 1940s until his death. He built two trimarans while living in the US, Eggnog 1 and 2. Both boats were made of marine plywood and were about 24 feet long. Mr. Tchetchet is credited with coining the name trimaran. Aside from boat design Mr. Tchetchet earned his living as a landscape and portrait painter. About the same time,Arthur_Piver was also building trimarans in the USA and created many early plywood designs to which amateurs built their boats. Many successfully crossed oceans despite being relatively heavy and inferior compared to those of more modern design. The homebuilt cruiser movement survived his death in 1968, with designers Jim_Brown, John Marples, Jay Kantola, Chris White, Norman Cross and Richard Newick bringing the trimaran cruiser to new levels of performance and safety.

A. General Arrangement (GA) of trimaran:

B. Lines Plan:

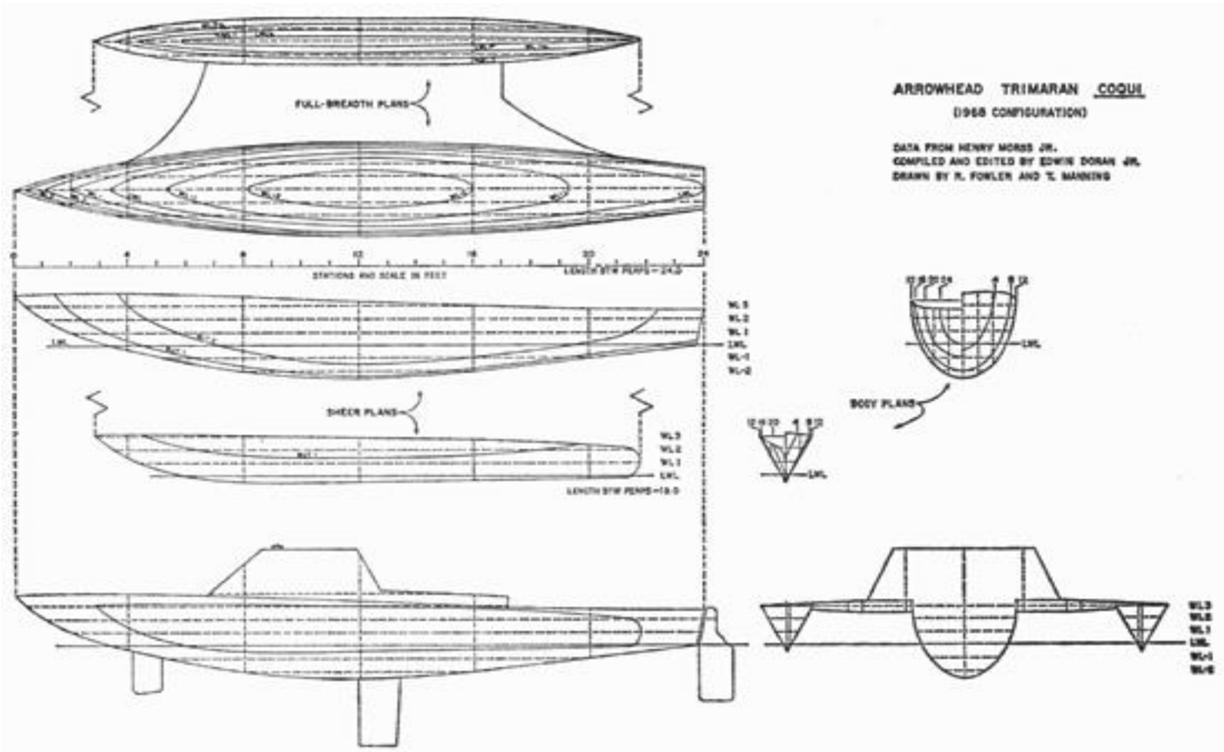
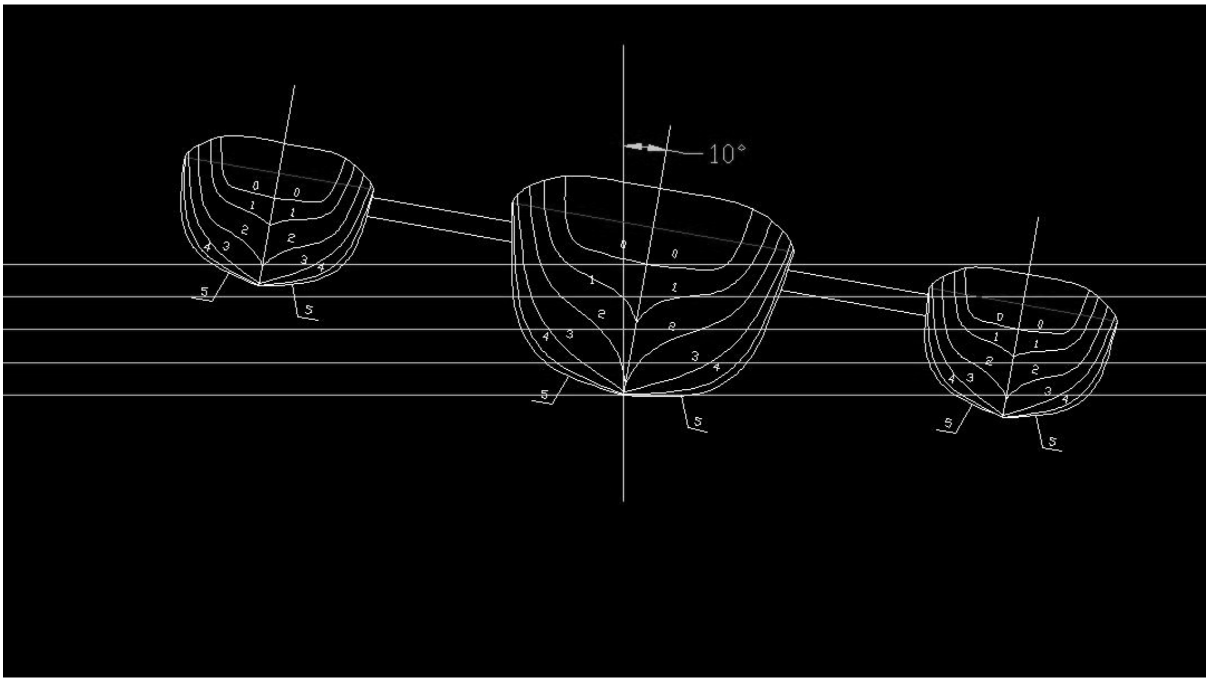


FIGURE 8
Lines and sections of the trimaran *Coqui*



C. Why Trimaran?

Although it is possible for a trimaran to capsize, this is less frequent than with monohull boats because of the greater resistance to rolling that the amas offer. Most trimaran designs are considered nearly unsinkable because even when filled with water, the flotation of one ama is enough to keep the entire vessel afloat. Because of their stability and safety, special trimarans such as the Challenger, have become popular with sailors who have restricted mobility.The greater speed compared to monohulls can also become important for safety when weather conditions are bad or threaten to deteriorate because the boat can leave the area of danger faster.Potential buyers of trimarans should look for one that is designed with amas with multiple sealed partitions, controls that all run to the cockpit, a collision bulkhead, partial or full cockpit coverings or windshields, and drain holes in the cockpit that can adequately drain the cockpit quickly, among other things.

D. Modifications to be made for Using Helium-3 as Propellant:

Since heat output of helium-3 is higher than the other fuel forms, modifications has to be made in engines/turbines and the engine room. They have to be sealed with heat insulator with high resistance to heat. Metal composition of the engines/turbines has to change such that it withstands the heat. Piping arrangement and the boiler has to be modified in the engine room.

3. Cost Factor:

It takes nearly 50 lakhs rupees (USD$ 91000) to refuel the tank of a ship (say container) per trip. If we use He^3 for refuelling the tanks of the ships it takes only 20 lakhs rupees (USD$ 36300) (estimate) for us to spend, which makes us a sum of 30 lakhs (USD$ 54500) profit per trip.

4. Efficiency Factor:

A. Carnot Cycle:

The present day diesel engine in the ships, run by the principle of Carnot diesel cycle. The **Carnot cycle** is a theoretical thermodynamic cycle proposed by Nicolas Léonard Sadi Carnot in 1823 and expanded by in the 1830s and 40s. It can be shown that it is the most efficient cycle for converting a given amount of thermal energy into work, or conversely, creating a temperature difference (e.g. refrigeration) by doing a given amount of work.Every single thermodynamic system exists in a particular state. When a system is taken through a series of different states and finally returned to its initial state, a thermodynamic cycle is said to have occurred. In the process of going through this cycle, the system may perform work on its surroundings, thereby acting as a heat engine. A system undergoing a Carnot cycle is called a Carnot heat engine, although such a 'perfect' engine is only a theoretical limit and cannot be built in practice.
Evaluation of the above integral is particularly simple for the Carnot cycle. The amount of energy transferred as work is

$$W = \oint PdV = (T_H - T_C)(S_B - S_A)$$

The total amount of thermal energy transferred between the hot reservoir and the system will be

$$Q_H = T_H(S_B - S_A)$$

and the total amount of thermal energy transferred between the system and the cold reservoir will be

$$Q_C = T_C(S_B - S_A)$$

The efficiency η is defined to be:

$$\eta = \frac{W}{Q_H} = 1 - \frac{T_C}{T_H} \qquad (3)$$

where

W is the work done by the system (energy exiting the system as work),
Q_H is the heat put into the system (heat energy entering the system),
T_C is the absolute temperature of the cold reservoir, and
T_H is the absolute temperature of the hot reservoir.
S_B is the maximum system entropy
S_A is the minimum system entropy

This efficiency makes sense for a heat engine, since it is the fraction of the heat energy extracted from the hot reservoir and converted to mechanical work. A Rankine cycle is usually the practical approximation.

Efficiency of Real Heat Engines

The known fact is that the efficiency factor of carnot cycle is always less than 50%.Carnot realized that in reality it is not possible to build a thermodynamically reversible engine, so real heat engines are less efficient than indicated by Equation 3. In addition, real engines that operate along this cycle are rare. Nevertheless, Equation 3 is extremely useful for determining the maximum efficiency that could ever be expected for a given set of thermal reservoirs.
Although **Carnot's cycle** is an idealisation, the expression of Carnot efficiency is still useful. Consider the average temperatures,

$$\langle T_H \rangle = \frac{1}{\Delta S} \int_{Q_{in}} T dS$$

$$\langle T_C \rangle = \frac{1}{\Delta S} \int_{Q_{out}} T dS$$

at which heat is input and output, respectively. Replace *TH* and *TC* in Equation (3) by <*TH*> and <*TC*> respectively.
For the Carnot cycle, or its equivalent, <*TH*> is the highest temperature available and <*TC*> the lowest. For other less efficient cycles, <*TH*> will be lower than *TH*, and <*TC*> will be higher than*TC*. This can help illustrate, for example, why a reheater or a regenerator can improve the thermal efficiency of steam power plants—and why the thermal efficiency of combined-cycle power plants (which incorporate gas turbines operating at even higher temperatures) exceeds that of conventional steam plants.

B. Efficiency Factor on Using Helium-3

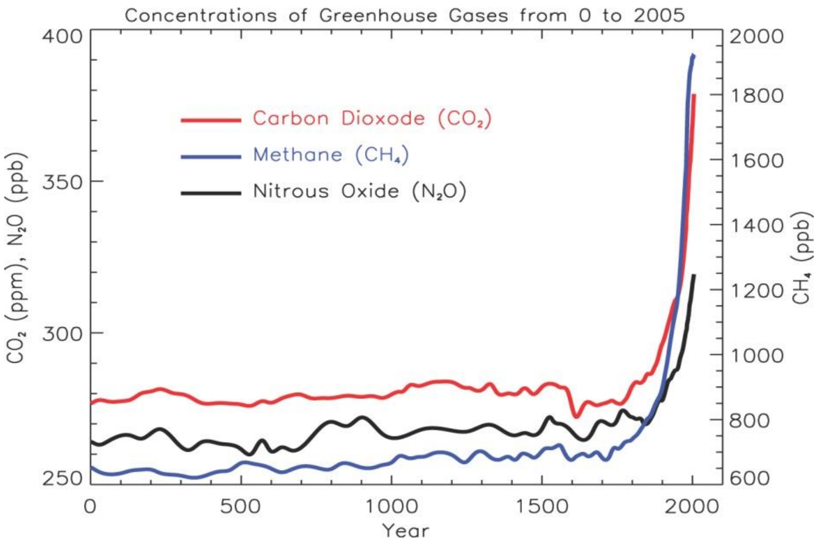
Fuel efficiency is a form of thermal efficiency, meaning the efficiency of a process that converts chemical potential energy contained in a carrier fuel into kinetic energy or work. Overall fuel efficiency may vary per device, which in turn may vary per application fuel efficiency, especially fossil fuel power plants or industries dealing with combustion, such as ammonia production during the Haber process. Since thermal efficiency of helium-3 is more, it can provide efficiency up to 80%.

5. Refuelling Process:

Ships usually come to the port for refuelling. Since idea proposes the production of He-3 from the sea water, we can place He-3 reservoirs on the offshore platforms. By doing so, the frequency of the ships coming to the port for refuelling decreases, which eventually clears the ship traffic along port side.

6. Effects on Atmosphere:

Today, Hydrocarbon fuels on burning yield CO_2 and CO into the atmosphere, which is becoming one of the prime factors for green house effect. Whereas liquefied He-3, which has zero carbon content, on burning yields out Hydrogen gas which can further be recycled.



Conclusion

- Using He-3 as fusion fuel:
  -More efficient electrical conversions
  -Low (negligible) levels of radioactivity
- Only neutrons from chance D-D fusion in D-3He fuel
- Little to no activation of nearby structures
- No radioactive fuel needed (No Tritium!)
- If priced at ~$1 Billion/ton, He-3 has Energy cost ~equal to oil at $7/barrel
- In terms of stored energy, He-3 on the Moon has ~10x as much as all economically viable supplies of fossil fuels on the Earth

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