FEASIBILITY STUDY OF FUEL REACTOR TO PRODUCE SYNTHETIC GAS AS AN ALTERNATIVE ENERGY

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ABSTRACT

This research is focused on the feasibility of the Fuel Reactor in order to produce synthetic gas. The Fuel Reactor uses ordinary tap water and low voltage electrical energy for producing a synthetic gas. High temperature (3000-4000°C) plasma is generated underwater by an electrical arc between carbon electrodes. The Fuel Reactor produces a mixture of carbon monoxide and hydrogen (COH_2) and this gas can burn very cleanly in oxygen or air. The objective of this research is to produce the Fuel Reactor and to test the feasibility of the Fuel Reactor to produce the synthetic gas. The idea of the project came from the rising of the fuel price and the extinction of the petroleum and the desire to find replacement for this non renewable energy. The Fuel Reactor that has been set up here was not feasible to produce the gas as expected. The main problem was the melting of the wire and the experiment has been continued for 3 times in order to test the Fuel Reactor. Future recommendation after conducting this research will be using the wire that sheathed with silicon which can withstand the heat generated by the high current flow. Another solution will be using the alternative to the copper wire that is aluminum wire which widely used in the power grid system. A sufficient ammeter should be ready in order to measure the current that draws by the Fuel Reactor. The success of this research will be a technological breakthrough in the mechanical field.

ABSTRAK

Penyelidikan ini adalah bertumpu dalam kemungkinan reactor bahan bakar untuk menghasilkan gas synthetic. Reaktor bahan bakar ini menggunakan air paip biasa dan voltasi rendah tenaga elektrik untuk menghasilkan gas synthetic. Plasma dengan suhu yang tinggi (3000 - 4000°C) dijana dibawah air oleh arc elektrik diantara elektrod karbon. Reaktor bahan bakar ini menghasilkan campuran karbon monoksida dan hidrogen (COH_2) dan gas ini boleh bakar dengan sangat bersih dalam oksigen dan udara. Objektif untuk kajian ini adalah untuk menghasilkan reaktor bahan bakar dan uji kemungkinan untuk reaktor bahan bakar itu untuk menghasilkan gas synthetic. Idea projek ini adalah daripada kenaikan harga minyak dan kepunahan petroleum serta hasrat untuk mencari penggantian untuk tenaga yang tidak boleh diperbaharui ini. Reaktor bahan bakar yang dihasilkan ini tidak dapat untuk menghasilkan gas synthetic seperti mana yang diharapkan. Punca utama adalah peleburan dawai dan eksperimen ini telah dijalankan untuk 3 kali untuk menguji reaktor bahan bakar ini. Rekomendasi masa depan untuk mengkaji ujian ini adalah menggunakan dawai yang disarungkan dengan silicon yang boleh tahan kepanasan yang dijana oleh arus yang tinggi. Cara yang lain adalah menggunakan dawai aluminium yang sering digunakan dalam sistem jaringan kuasa dan yang menjadi pilihan kepada dawai kuprum. Ammeter yang sesuai juga adalah perlu untuk mengukur arus yang digunakan oleh reaktor bahan bakar ini. Kejayaan kajian ini akan menjadi satu pemecahan teknologi dalam bidang mekanikal.

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(b) Test the feasibility of the Fuel Reactor.

1.4 Project Background

A simple Fuel Reactor uses ordinary tap water and low voltage electrical energy for producing a synthetic gas. High temperature (3000-4000°C) plasma is generated underwater by an electrical arc between carbon electrodes. The Fuel Reactor produces a mixture of carbon monoxide and hydrogen (COH_2) and this gas can burn very cleanly in oxygen or air, and so it can be used as fuel for an internal combustion engine. When burned, COH_2 produces carbon dioxide and water vapor, so it generates very little, if any, pollution to the environment.

1.5 Problem Statement

Fossil fuel price or so called petrol price is rising in our country or the whole world since we entered this millennium year. Starting from the price of RM1.10 (for the unleaded fuel) in the year of 2000, it soared until RM1.92 last year and the rise will be continuing in the near future. The rising of the fossil fuel price was mainly due to the high price in the international market, soaring above USD90 per barrel.

The fossil fuel on earth has been predicted to be depleted in the near 2 – 3 decades. What will happen to the world when that day arrives? However, fossil fuel has encountered a big issue to all of us but the dependence on it cannot be ignored.

Our automobiles, trains and planes are fueled almost exclusively by petroleum products like gasoline and diesel. A huge percentage of our power plants use oil, natural gas and coal for their fuel.

If the flow of fossil fuels to us were ever cut off, the economy would come to a halt. There would be no way to transport the products that factories produce. There would be no way for people to drive to work. The whole economy, and in fact the whole society, currently depends on fossil fuels.

While fossil fuels have played an important role in getting society to the point it is at today, there are four big problems that fossil fuels create:

- Air pollution
- Environmental pollution
- Global warming
- Dependence

There is many researches through all the decades to figure out a long lasting and yet leaving the least side effects alternative energy to replace the fossil fuel. However, every source has their pros and cons. The ongoing and possible solutions including Hydrogen, Hybrid, biodiesel, fuel cell, solar cell and many others. There are also researches on some future energy technologies that are not categories as the conventional way. One of these future energy technologies is the Fuel Reactor that can produced synthetic gas to replace the fossil fuel.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Probably in this century, it is believed that crude oil and petroleum products will become very scarce and costly to find and produce. Although fuel economy of engines is greatly improved from the past and will probably continue to be improved, increase in number of automobiles alone dictates that there will be a great demand for fuel in the near future. Gasoline and diesel will become scarce and most costly. Alternative fuel technology, availability, and use must and will become more common in the coming decades.

All these years there have always been some IC engines fuelled with non-gasoline or diesel oil fuels. However, their numbers have been relatively small. Because of the high cost of petroleum products, some developing countries are trying to use alternate fuels for their vehicles.

Another reason motivating the development of alternate fuels for the IC engine is concern over the emission problems of gasoline engines. Combined with other air – polluting systems, the large number of automobiles is a major contributor to the air quality problem of the world. Quite a lot of improvements have been made in reducing emissions given off by an automobile engine. If a 35% improvement made

over a period of years, it is to be noted that during the same time the number of automobiles in the world increases by 40%, thereby nullifying the improvement. Lot of efforts has gone into for achieving the net improvement in cleaning up automobile exhaust. However, more improvements are needed to bring down the ever – increasing air which control the larger oil fields. As of now many alternate fuels have been used in limited quantities in automobiles. Quite often, fleet vehicles have been used for testing (e.g., taxies, delivery vans, utility company trucks). This allows for comparison with similar gasoline – fuelled vehicles, and simplifies fuelling of these vehicles.

The engines used for alternate fuels are modified engines which were originally designed for gasoline fuelling. They are, therefore, not the optimum design for the other fuels. Only when extensive research and development is done over a period of years will maximum performance and efficiency be realized from these engines. However, the research and development is difficult to justify until the fuels are accepted as viable for large numbers of engines.

Some diesel engines have started appearing on the market which use dual fuel. They use methanol or natural gas and a small amount of diesel fuel that is injected at the proper time to ignite both fuels. Most alternate fuels are very costly at present. This is often because of the quantity used. Many of these fuels will cost much less if the amount of their usage gets to the same order of magnitude as gasoline. The cost of manufacturing, distribution, and marketing all would be less.

Another problem with alternate fuels is the lack of distribution points (service stations) where the fuel is available to the public. The public will be reluctant to purchase an automobile unless there is a large-scale network of service stations available where fuel for that automobile can be purchased. On the other hand, it is difficult to justify building a network of these service stations until there are enough automobiles to make them profitable. Some cities are starting to make available a few distribution points for some of these fuels, like propane, natural gas, LPG and methanol. The transfer from one major fuel type to another will be slow, costly, and sometimes painful process.

2.1 The pros and cons between conventional energy and alternative energy

2.1.1 Fossil fuels

Fossil fuels, in terms of energy, involve the burning of coal or hydrocarbon fuels, which are the remains of the decomposition of plants and animals. Steam power plant combustion heats water to create steam, which turns a turbine, which, in turn, generates electricity, waste heat, and pollution. There are three main types of fossil fuels: coal, petroleum, and natural gas.

Pros

- Because it is based on the simple process of combustion, the burning of fossil fuels can generate large amounts of electricity with a small amount of fuel. Gas-fired power plants are more efficient than coal fired power plants.
- Fossil fuels such as coal are readily available and are currently plentiful. If more energy is required, more coal can be strip-mined. The transport of coal is by rail, especially if the plant is located close to the fuel source.
- Excluding external costs, coal is less expensive than most other sources of energy. Because there are large deposits of coal in the world, the per-unit cost is relatively low.
- The technology already exists for the use of fossil fuels, meaning consumers do not have to spend money switching to other technologies, except for oil and natural gas, as they approach peak production.
- Commonly used fossil fuels in liquid form such as light sweet crude, gasoline, and liquefied propane gas are easy to distribute.

Cons

- The combustion of fossil fuels leads to the release of pollution into the atmosphere. A typical coal plant produces:
    I. 3,700,000 tons of carbon dioxide (CO2), the primary human cause of global warming.

II. 10,000 tons of sulfur dioxide (SO2), the leading cause of acid rain
III. 500 tons of small airborne particles, which result in chronic bronchitis, aggravated asthma, and premature death, in addition to haze-obstructed visibility.
IV. 10,200 tons of nitrogen oxide (NOx), leading to formation of ozone (smog) which inflames the lungs, burning through lung tissue making people more susceptible to respiratory illness.
V. 720 tons of carbon monoxide (CO), resulting in headaches and additional stress on people with heart disease.
VI. 220 tons of hydrocarbons, volatile organic compounds (VOC), which form ozone.
VII. 170 pounds of mercury, where just 1/70th of a teaspoon deposited on a 25-acre lake can make the fish unsafe to eat.
VIII. 225 pounds of arsenic, which will cause cancer in one out of 100 people who drink water containing 50 parts per billion.
IX. 114 pounds of lead, 4 pounds of cadmium, other toxic heavy metals, and trace amounts of uranium.

- Dependence on fossil fuels from volatile regions or countries creates security risks for dependent countries. Oil dependence in particular has lead to monopolization, war, and socio-political instability.
- They are considered non-renewable resources, which will eventually decline in production and become exhausted, with dire consequences to societies that remain highly dependent on them. Fossil fuels are actually slowly forming continuously, but we are using them up at a rate approximately 100,000 times faster than they are formed.
- Extracting fossil fuels is becoming more difficult as we consume the most accessible fuel deposits. Extraction of fossil fuels is becoming more expensive and more dangerous as mines get deeper and oil rigs go further out to sea [3].
- Extraction of fossil fuels can result in extensive environmental degradation, such as the strip mining and mountaintop removal of coal.

- The drilling and transportation of petroleum can result in accidents that result in the despoilation of hundreds of kilometers of beaches and the death or elimination of many forms of wildlife in the area.
- The storage of these fuels can result in accidents with explosions and poisoning of the atmosphere and groundwater.

2.1.2 Alcohol

Alcohols are an attractive alternate fuel because they can be obtained from both natural and manufactured sources.

Pros

- It can be obtained from a number of sources, both natural and manufactured.
- It is a high octane fuel with anti-knock index number of over 100. Engines using high-octane fuel can run more efficient by using higher compression ratios. Alcohols have higher flame speed.
- It produces less overall emissions when compared with gasoline.
- When alcohols are burned, it forms more moles of exhaust gases, which gives higher pressure and more power in the expansion stroke.
- It has high latent heat of vaporization (hfg) which results in a cooler intake process. This raises the volumetric efficiency of the engine and reduces the required work input in the compression stroke.
- Alcohols have low sulphur content in the fuel.

Cons

- Alcohols have a low energy content or in other words the calorific value of the fuel is almost half. This means that almost twice as much alcohol as gasoline must be burned to give the same energy input to the engine. With equal thermal efficiency and similar engine output usage, twice as much fuel

would have to be purchased, and the distance which could be driven with a given fuel tank volume would be cut in half. Automobiles as well as distribution stations would require twice as much storage capacity, twice the number of storage facilities, twice the volume of storage at the service station, twice as many tank trucks and pipelines, etc. Even with the lower energy content of alcohol, engine power for a given displacement would be about the same. This is because of the lower air-fuel ratio needed by alcohol. Alcohol contains oxygen and thus requires less air for stoichiometric combustion. More fuel can be burned with the same amount of air.

- Combustion of alcohols produce more aldehydes in the exhaust. If as much alcohol fuel was consumed as gasoline, aldehyde emissions would be a serious exhaust pollution problem.
- Alcohol is much more corrosive than gasoline on copper, brass, aluminum, rubber, and many plastics. This puts some restrictions on the design and manufacturing of engines to be used with this fuel. Fuel lines and tanks, gaskets, and even metal engine parts can deteriorate with long-term alcohol use (resulting in cracked fuel lines, the need for special fuel tank, etc). Methanol is very corrosive on metals.
- It has poor cold weather starting characteristics due to low vapor pressure and evaporation. Alcohol fuelled engines generally have difficulty in starting at temperature below 10 degree Celsius. Often a small amount of gasoline is added to alcohol fuel, which greatly improves cold-weather starting. The need to do this, however, greatly reduces the attractiveness of any alternate fuel.
- Alcohols have poor ignition characteristics in general.
- Alcohols have almost invisible flames, which is considered dangerous when handling fuel. Again, a small amount of gasoline removes this danger.
- There is the danger of storage tank flammability due to low vapor pressure. Air can leak into storage tanks and create a combustible mixture.
- Because of low flame temperatures there will be less NOx emissions but the resulting lower exhaust temperatures take longer time to heat the catalytic converter to an efficient operating temperature.

- Many people find the strong odor of alcohol very offensive. Headaches and dizziness have been experienced when refueling an automobile.
- There is a possibility of vapor lock in fuel delivery systems.

2.1.3 Natural gas

Natural gas is found in various localities in oil and gas bearing sand strata located at various depths below the earth surface.

Pros

- Octane number is around 120, which makes it a very good SI engine fuel. One reason for this high octane number is a fast flame speed. Engines can operate with a high compression ratio.
- Low engine emissions. Less aldehydes than with methanol.
- Fuel is fairly abundant worldwide. It can be made from coal but the process of making is very costly.

Cons

- Low energy density resulting in low engine performance.
- Low engine volumetric efficiency because it is a gaseous fuel.
- Inconsistent fuel properties.
- Refuelling is a slow process.

2.1.4 Hydroelectric energy

In hydro energy, the gravitational descent of a river is compressed from a long run to a single location with a dam or a flume. This creates a location where concentrated pressure and flow can be used to turn turbines or water wheels, which drive a mechanical mill or an electric generator. An electric generator, when there is excess energy available, can be run backwards as a motor to pump water back up for later use.

Pros

- Hydroelectric power stations can promptly increase to full capacity, unlike other types of power stations. This is because water can be accumulated above the dam and released to coincide with peaks in demand.
- Electricity can be generated constantly, because there are no outside forces, which affect the availability of water. This is in contrast to wind, solar or tidal power, all of which are far less reliable.
- Hydroelectric power produces no waste or pollution.
- Hydropower is a renewable resource; oil, natural gas, and coal reserves may be depleted over time.
- Hydroelectricity secures a country's access to energy supplies.

Cons

- The construction of a dam can have a serious environmental impact on the surrounding areas. The amount and the quality of water downstream can be affected, which affects plant life both aquatic, and land-based. Because a river valley is being flooded, the delicate local habitat of many species are destroyed, while people living nearby may have to relocate their homes.
- Hydroelectricity can only be used in areas where there is a sufficient supply of water.
- Flooding submerges large forests (if they have not been harvested). If such vegetation decayed, it could release methane, a greenhouse gas.

2.1.5 Nuclear energy

Nuclear power stations work similarly to fossil fuel power plants, except for the fact that the heat is produced by the reaction of uranium inside a nuclear reactor. The reactor uses uranium rods, the atoms of which are split in the process of fission, releasing a large amount of energy. The process continues as a chain reaction with other nuclei takes place. The heat released heats water to create steam, which spins a turbine, producing electricity.

Pros

- The process of nuclear fission allows for the production of tremendous amounts of energy from a small amount of fuel. The energy content of a pound of uranium or thorium is equivalent to 3.5 million lbs of coal (1,6 million kilos).
- The cost of making nuclear power is about the same as coal, which is considered very inexpensive.
- Nuclear power plants are heavily guarded with the nuclear reactor inside a reinforced containment building, and thus are relatively impervious to terrorist attack or adverse weather conditions.
- Nuclear power does not produce any air pollution or release carbon dioxide and sulfur dioxide into the atmosphere. Therefore, it does not contribute to global warming or acid rain.

Cons

- Waste produced from nuclear fission of uranium is poisonous, and highly radioactive, requiring maintenance and monitoring at the storage sites. Moreover, the long-term disposal of the long-lived nuclear waste causes serious problems, since (unless the spent fuel is reprocessed) it takes from one to three thousand years for the spent fuel to come back to the natural radioactivity of the uranium ore body that was mined to produce it.
- The operation of an uncontained nuclear reactor near human settlements can be catastrophic, as shown by the Chernobyl accident in the Ukraine (former

USSR), where large areas of land were affected by nuclear fallout. Members of the public are hesitant about the safety of nuclear power.

- Building a nuclear power plant requires a huge investment, and the costs of safe disassembling (called decommissioning) after it reaches end of usable life have to be included into the budget.
- There can be connections between nuclear power and nuclear weapon proliferation, since both require large-scale uranium enrichment facilities. An international organization (the IAEA) supervises all reactors.
- Nuclear fuels are non-renewable energy sources, with unknown high concentration ore reserves. There is a large amount of trace concentration nuclear material in seawater and most rocks, however extraction from these is not economical.
- Uranium mining activities produce greenhouse gases which contribute to global warming (although not nearly as much as coal mining).

2.1.6 Wind power

This type of energy harnesses the power of the wind to propel the blades of wind turbines. These turbines cause the rotation of magnets, which creates electricity. Wind towers are usually built together on wind farms.

Pros

- Wind power produces no water or air pollution that can contaminate the environment, because there are no chemical processes involved in wind power generation, there are no by-products, such as carbon dioxide, left over.
- Wind generation is a renewable source of energy, which means that we will never run out of it.
- Wind towers can be beneficial for people living permanently, or temporarily, in remote areas. It may be difficult to transport electricity through wires from