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NUCLEAR FUSION ENGINEERING AND TECHNOLOGY

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NUCLEAR FUSION AS AN ALTERNATIVE ENERGY SOURCE

In our world’s history, we have made many great technological advancements built on the use of fossil fuels as our primary source of energy. However, in the near future, we will find ourselves facing the issue of these fossil fuels, which we have relied on so heavily, slowly diminishing, forcing us to find a new means of energy. Many engineers will be and already have been called upon to help tackle this problem by developing more sustainable energy sources. It is my belief that one of the best options for sustainable energy is Nuclear Fusion. Nuclear Fusion naturally occurs in stars and transmutes matter into energy by combining the nuclei of light elements to form heavier elements, resulting in a release in kinetic energy. If engineers are successfully able to harness this energy, the resulting power would be more efficient than any other existing fuel source. So far, the most advanced method of gaining energy from nuclear fusion is magnetic confinement, which uses accelerating plasma in a magnetically confined ring. Nuclear fusion technology is seen as one of the best solutions to our issue of sustainable energy sources, however the debate still circulates around whether or not it is even possible to control the fusion process. Hopefully, with the completion of the ITER tokamak, there will be breakthroughs in the technology, which could aid the progression of nuclear fusion as a viable source of sustainable energy.

THE NEED FOR SUSTAINABLE ENERGY SOURCES

Modern society has built a heavy reliance on the burning of fossil fuels for energy, based upon its ease and great supply in decades past. However, with the growth of the world population as well as the increasing energy use, these fossil fuels will soon run out. Based upon current reserves of coal, gas, and oil (the most commonly used fossil fuels), and the global energy usage data, Ecotricity, a British alternative energy provider projects that fossil fuels will have completely diminished around the year 2088.

FIGURE 1 [1]
Reserves of Certain Fossil Fuels over Time

Though this prediction cannot be taken as a set-in-stone date that our fossil fuel supply will run out, it does suggest the high urgency of this issue. As the Ecotricity website states, “New reserves will be found which will help extend this deadline slightly, but these can’t last forever. New reserves of fossil fuels are becoming harder to find, and those that are being discovered are significantly smaller than the ones that have been found in the past.”[1]. The bottom line is that these fuel sources are running out, and we must prepare for that inevitability.

Why is Nuclear Fusion the Best Option?

The simple answer to this question is that nuclear fusion is more efficient and economical than the use of fossil fuels. According to data presented by the ITER project, “A fusion reaction is about four million times more energetic than a chemical reaction such as the burning of coal, oil or gas. While a 1,000 MW coal-fired power plant requires 2.7 million tonnes of coal per year, a fusion plant of the kind envisioned for the second half of this century will only require 250 kilos of fuel per year.”[2]. Nuclear fusion allows for us to gain more energy out of less fuel, making it a very efficient means of creating energy. If projects such as the ITER tokamak, which will be discussed in further detail, are completed, then nuclear fusion will become a much more viable energy source than fossil fuels ever were.
MAGNETIC CONFINEMENT TECHNOLOGY

Magnetic confinement is not necessarily a specific technology but rather a process used for nuclear fusion to be possible. For nuclear fusion to be possible, two atom’s nuclei must be close enough to each other to negate the repulsion from their charges and remain there long enough for fusion to occur. This requires fuel to be heated to the plasma state, in which the atoms are stripped of their electrons and are able to overcome the repulsion forces. To achieve this, scientists and engineers use confinement to create incredibly high pressure systems in which the atoms can withstand temperatures high enough to change into the plasma state and be confined into controlled spaces as to get the particles close enough for fusion to occur.

One of the properties of the plasma state is that it has very strong electric conductivity. This allows for the particles to be influenced by a magnetic field, which is the basis for magnetic confinement. The goal of this, as presented by the World Nuclear Association is to “prevent the particles from coming into contact with the reactor walls as this will dissipate their heat and slow them down.” Researchers have found that the most effective lay out of these magnetic field forces is toroidal, which rotates about itself and a central axis, creating a ‘donut’ shape with forces creating a helix shape within the confinement, which keeps the particles off of the confinement and accelerates them through the system. The high heat and speed, accelerated by the magnetic fields provides an ideal environment for fusion to occur.

Fuel Sources

One of the greatest features of nuclear fusion is that it has a nearly inexhaustible fuel source. This is because the fuels used in these reactors are two Hydrogen isotopes: Deuterium and Tritium. In every liter of seawater, there is approximately 33mg of Deuterium, making this isotope very abundant in nature. Tritium however is highly radioactive and is hard to find in nature, leaving a global inventory of only about 20kg of the substance. However, by layering the blanket wall of the tokamak with Lithium, which can also be extracted from seawater, “tritium is produced, or ‘bred,’ when neutrons escaping the plasma interact with lithium contained in the blanket wall of the tokamak.” This provides a nearly endless fuel supply, which makes nuclear fusion a very viable sustainable energy source.

THE I.T.E.R. TOKAMAK

Tokamaks have been created and experimented with for decades, however the most current and most advanced of any is the ITER reactor in Saint-Paul-lès-Durance, France. This reactor will be ten times larger than the current largest tokamak in operation today. Projected to be completed and operating by the year 2025, the ITER tokamak is planned to produce 500 MW of fusion power, shattering the previous record of 16 MW. This is just one of the goals outlined by the project. Another important aspect of this project is the testing of the efficiency of the Tritium ‘breeding’ highlighted earlier. By observing this process, scientists and engineers working on the reactor will be able to assess a reactor’s ability to create its own tritium, which would then be recycled as fuel. Perhaps one of the most important goals that engineers hope to achieve is for the system to sustain a deuterium-tritium reaction. The main issue with earlier reactors is that the reaction could not be sustained long enough to create more energy than it took to conduct the reaction. Scientists hope that the increased size of the tokamak will allow for longer reactions, which would create more energy. I feel that engineers should make this project a priority as its success could mean creating a stable and sustainable global energy source for the next 1,000 years. Developments in nuclear fusion could mean more energy and cheaper energy, and its implementation into society should be a goal of all engineers working on sustainable energy.
CONCLUSION

Nuclear fusion as of right now is not a perfect science. There are many issues surrounding containing the fusion reaction and sustaining the reaction for a long enough period of time as to generate more energy than is needed to conduct the reaction. However, it is my belief that with the completion of the ITER tokamak, many insights into fusion reactions will be made that could help create larger fusion reactors in the near future, which would replace our diminishing supply of fossil fuels. If the ITER project is successful, we will have a sustainable energy source that is more cost effective than fossil fuels ever were, which would last for at least the next 1,000 years. If more focus is put into nuclear fusion, perhaps after deuterium-tritium reactions are perfected, a more renewable deuterium-deuterium reaction can be developed (which due to technological limits is not feasible) [6]. It is important for engineers to pursue nuclear fusion for the future of our energy sources, which impacts nearly the entire population. There is a shortage of fossil fuel energy coming, and I believe that nuclear fusion is the answer.

SOURCES


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