Nuclear Fusion: Past, Present and Future

In the coming years our planet earth is going to face an energy dilemma. There simply are not enough of the non-renewable energy sources to last our growing population forever. There have been many suggestions as to how to solve this problem. One possibly exciting solution that has come up is nuclear fusion. While not possible to use immediately this could present an answer with further research by physicists.

The idea of fusion entails two nuclei joining together, the opposite of fission. However it’s not as simple as that. In order for the two nuclei to join the energy must be enough to overcome the electrostatic force in between. Once the two nuclei fuse to become one the total mass is less. The difference between the masses is released as energy. Now if we were going to pick an element to use for fusion we would want one that has the least nuclear charge. This way it will require a lower temperature to fuse the nuclei together because there is less of an electric barrier to overcome. Hydrogen then becomes the clearest choice. The fusion product of choice is helium because it has an extremely low mass. There would be a higher amount of output energy then because the there will be a greater difference in between the first mass and the second mass.

The exact process of fusion that would produce the highest output of energy involves using the hydrogen isotopes deuterium and tritium. There is also a process where two deuterium nuclei are fused, but the power produced is 68 times less. In the
first fusing process these two isotopes are fused together resulting in helium. This sounds too easy doesn’t it? It isn’t because there are a number of problems. The first is that tritium is normally not a naturally occurring isotope of hydrogen. When it does occur naturally it does in negligible amounts because of its twelve year half life. Because of this tritium must be obtained through a reaction of lithium. While the supply of deuterium is very large the supply of lithium is not as large, but still great enough to provide for hundreds of years. Another issue is the fact that this process results in radioactivity inside the reactor making handling a dangerous task. Design of a suitable reactor becomes an issue also because the rate of the movement of neutrons (neutron flux) is approximately one hundred times greater in a fusion reactor as opposed to a fission reactor.

The first nuclear fusion reactor to successfully create energy using the deuterium and tritium fuel was the Joint European Torus or JET for short. It was constructed to be able to cope with the radioactivity produced by the fusion. To this day it remains the only reactor able to use the deuterium/tritium mix.

The issues that JET needed to overcome where as follows. In order for Nuclei to fuse they must be very close together. This is achieved by extremely high temperatures somewhere around 100,000,000 degrees Celsius. These temperatures were created by ion beams and microwaves. Anything in contact with this high of a temperature would melt so the plasma is kept from the walls using magnetic confinement.

Once fusion occurs the energy is measured in a temperature increase of the lithium inside the reactor. The temperature increase is directed to a sealed water pipe where the presence of a hot spot sets up a convection current. This current would used to
drive a turbine of an electric generator producing electricity. After the JET project attempted all this did it work? Well yes it did, but it wasn’t good enough. In 1997 JET achieved a peak power of 16 megawatts which up to this day is still a world record. Is this enough to produce electricity for our population? Compare 16 megawatts to the average 500-2000 megawatts produced by a nuclear fission power plant. Even if this was enough energy to produce electricity it still would not be usable. The value known as Q measures the fusion power outputted compared to the power it requires to maintain the reaction. The JET reaction achieved a value of 0.7 Q where 1.0 Q would be a self-sustaining reaction. What this means is in order for this reaction to keep going you would need to add more energy than you’re getting out. Therefore at the present time there has not been a nuclear fusion reaction that is capable of providing usable energy.

Although there has yet to be a successful reaction there are plenty of reasons to be optimistic about nuclear fusion. Some of the advantages are the abundant fuel supply. Deuterium is easily extracted from saltwater and tritium is made using a reaction of lithium which can be found in the earth’s crust. The uranium required for nuclear fission is rare and has to be enriched before it is used in a reactor. Fusion is also very safe. While nuclear meltdowns are a very possible threat with fission they are not at all with fusion. The amount of fuel in the reactor at any given time is only enough to sustain the reaction for a couple of minutes. Also the radiation caused by fusion would be less than that of what we encounter in our daily lives. There is no air pollution in any nuclear process because combustion does not occur. In nuclear fission there is a problem with waste management. What is produced is weapons grade nuclear materials making disposal a challenge. With fusion the reactors do not produce high level nuclear wastes making
removal less of a challenge. Lastly the process of nuclear fusion produces a lot more energy than fission or chemical processes do once a successful self-sustaining reaction occurs.

What is the future of Nuclear Fusion. Well it can be summed up into a single project, the International Thermonuclear Experimental Reactor. Designed to show how feasible nuclear fusion can be in the future ITER is a seven country program that is going to be constructed in France beginning in 2008. Its goals are to momentarily produce a reaction that outputs ten times the energy that is put in, to produce a steady-state plasma with a $Q$ value of greater than five and to develop technologies and processes needed for a fusion power plant. If ITER succeeds it will be a huge step in the process that will eventually lead to electricity production. As of now the work should begin on the actual reactor in 2011. Once ITER finishes its tests it will be followed by DEMO a demonstration power plant that would produce electricity from nuclear fusion for the first time. After DEMO a prototype power plant capable of commercial electricity would follow. Most scientists tend to estimate this commercial plant ready in around fifty years with optimists saying as little as thirty years.

As of now nuclear fusion is not a viable option for an energy source nor can it be relied upon as being one in the future. Too many tests and experiments are needed to declare a timetable to when nuclear fusion will be ready for production of electricity. However this does not mean money and resources should not be put into this. Many of our fossil fuels will someday run out, solar energy is not a viable option world wide and wind and water options will most likely never produce enough energy to meet the worlds
demands. This is why we must turn our attention to nuclear energy. Fusion is the safest, most efficient and most promising of the two.
Works Cited


<http://en.wikipedia.org/wiki/Fusion_energy>