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## Factors Affecting the Pace of Development Of Source of Nuclear Fusion Energy

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### Abstract

The fuel for a fusion reactor is heavy hydrogen and helium that is found in abundance in the seawater. It has been estimated that the heavy hydrogen (deuterium) obtainable from the sea water will give the fusion energy which will suffice for the whole world for the next ten thousand years. An intense effort is underway to develop the use of fusion energy as a virtually inexhaustible energy resource. The primary perceived use of fusion is for the commercial production of electricity. There are other potential uses, however for example, fusion can be used the production of fissile material or for the production of synthetic fuels. The principal factors affecting the pace of world fusion development are costs, technical progress and management. Costs are of two types: the inherent costs of the research and development and the money that governments are willing to make available. Technical progress can accelerate the pace if it is “positive” but can slow pace if results are “negative”. Management affects pace by the nature of national or regional decisions but also through cooperative international agreements.

**Keywords:** fusion reactor, inexhaustible energy resource, heavy hydrogen.

### 1. Introduction

Nuclear Fusion, where two lighter nuclei moving at very high speeds fuse together to form a single heavier nuclear, then this phenomenon is called ‘nuclear fusion’. The mass of the nucleus obtained after fusion is less than the sum of the masses of nuclei which are fused together. The lost mass is obtained in the form of energy. The energy output in a fusion reaction (21.6 Mev) is very much less than the energy released in the fission of a  $U^{235}$  nucleus (200 Mev). But this does not mean that fusion is a weaker energy source than fission. The number of hydrogen nuclei in gram of heavy hydrogen is much larger than the number of  $U^{235}$  nuclei in 1 gram of Uranium. Therefore, the energy obtained by the fusion for a certain

mass of heavy hydrogen is much larger than the energy obtained by the fission of equal mass of Uranium.

## **2. Difficulties in Nuclear Fusion**

In practice, the nuclear fusion is a very difficult process. This is so because when (positively charged) nuclei come very close for fusion, the force of electrical repulsion between them becomes very strong. For fusion against this force, they require very high energy ( $\approx 0.1 \text{ MeV}$ ). To impart so much energy to them, very high temperature ( $\approx 10^8 \text{ K}$ ) and very high pressure is required. These conditions of temperature and pressure are not available on earth. These are available either in the sun or are produced when a nuclear-fission bomb is exploded. Therefore, nuclear fusion is possible only by the explosion of a nuclear-fission bomb. The fusion of nuclei is an uncontrolled process. To carry out controlled nuclear fusion, it is necessary to set up and maintain a temperature of the order of  $10^8 \text{ K}$  in a limited volume. At such a high temperature the atoms are entirely freed of their electrons so that the fusible substance is a completely ionized gas called plasma. The main problem is the design of a container for the hot plasma. No vessel of any substance can be a container because it would immediately evaporate. Attempts are being made to retain the plasma in a circular magnetic field created by means of a current pulse of the order of million amperes. In India, the Institute for Plasma Research (IPR), Ahmadabad operates Aditya Tokamak (1989) for the studies on high temperature magnetically confined plasma. To address nuclear Fusion reaction Technology issues related to advanced Tokamak, configurations SST-I (2013), one of the world's first super-conducting steady state Tokamak with elongated diverter plasmas and 1,000 second operation capability, is being setup at IPR. Despite being a developing economy with its attendant's problems, India has effectively involved in conducting nuclear fusion reactor's research at various institutes like CAT (Indore), BARC (Mumbai) and IGCAR (Kalpakkam). An intense effort is underway to develop the use of fusion energy as a virtually inexhaustible energy resource. The primary perceived use of fusion is for the commercial production of electricity. There are other potential uses; however for example, fusion can be used for the production of fissile material, for the production of process heat or for the production of synthetic fuels.

The scientific development of fusion has been an international undertaking. Major programs have existed in the United States, the Soviet Union, and the European Community (EC) since the early 1950s. Early experiments established that fusion development would not be easy. The complexity of the fusion problem and the potentially enormous pay off have motivated a

continuing world wide effort. A major breakthrough came in 1969, when Russia showed that the tokamak concept has excellent potential for confining the hot fusion plasmas. During the decade of 1970's, the world fusion programs began to make rapid progress based on the Tokamak concept. By the end of the 1970's, major results had required for net energy production had been demonstrated. A consensus then emerged in the international fusion community that fusion was scientifically ready to proceed towards engineering development and practical application. A number of other fusion concepts also more developed to the stage that they were perceived as potential reactor concepts (e.g. tandem mirrors, bumpy torus, and stellarator). By the end of the decade, significant scientific progress has been making and the focus of international fusion R&D began to move more rapidly toward advanced reactor design and engineering development. The engineering development of fusion has already begun. The International Tokamak Reactor (INTOR) design study is just being completed. This study was carried out under the auspices of the international Atomic Energy (IAEA) and involved all major fusion development countries. If the individual countries in the fusion community believe in developing fusion, then given suitable management, fusion can be the first effort in which a major problem, facing the whole of mankind, was resolved through international cooperation.

### **3. The Pace of World Fusion: Affected By Costs, Technical Progress and Management Costs**

The higher the cost of fusion development either is, or is perceived to be the more slowly it will tend to be developed. Costs are of two types:-

1. The Inherent costs of the Research and development.
2. The money that governments are willing to make available.

Unfortunately both aspects are today tending to slow the pace of fusion development. As more scientific progress has been made, the size and cost of the next generation experimental facilities have increased. Test reactors needed to test engineering and power handling will cost several billion dollars each. At the same time, the world-wide economic recession and 'oil glut' have made governments less willing to increase funding for fusion research. The impact of this circumstance is not yet felt on the pace of the fusion program because we are still benefiting from commitments made several years ago. Failure to make commitments to new and improved facilities now will be seen to slow the pace of fusion development. Thousands of engineers and scientists have contributed to design of ITER since the idea for

an international joint experiment in fusion was first launched. This is till date world's largest scientific project (more than 20 billion dollars) ever to be taken. India is also expected to contribute about 9000 crores over the next decade to the project.

### **3.1 Technical Progress**

Technical results have a strong impact on pace and can sometimes be independent of, or even inversely proportional to, costs. Usually technical progress occurs more or less on an anticipated schedule and the out coming to fruition of past successes or failures occur. New ideas can also lead to unexpected successes which impact pace world leaders at this time are bringing past commitments to fruition but seem stymied on when and how to make future major facility commitments. In southern France ,35 nations including, China, European Union, India, Japan, South Korea Russia, United States collaborating to build the world's largest tokamak. ITER will be the first fusion device to maintain fusion for long periods of time and ITER will be the first fusion device to maintain fusion for long periods of time And ITER will be first fusion device to test the integrated technologies, materials and physics regimes necessary for the commercial production of fusion based electricity. the ITER fusion reactor currently being built in France will achieve its first plasma in 2005. With the first plasma now expected in 2025, delayed by 7 years, the first experiments using burning fusion fuel-a mixture of deuterium and tritium (D-T) will have to wait until 2032. China ranks as a member country of the ITER project which aims to produce 500 megawatts of fusion power for 400 seconds. China overtakes Germany to make nuclear fusion breakthrough in December 2015. Reactor creates conditions three times hotter than the sun so called artificial sun (49.99 million degree Celsius) keep it there for 102 seconds at Experimental Advanced Super Conducting Tokamak (EAST). The EAST was invented by soviet scientists to control nuclear fusion for power generation. Mean while, physicists in Japan and Europe have been able to reach the same temperature as Chinese team, but only up to 20 second. It would still take years to build a commercially viable plant that could operate in stable manner for several decades.

### **3.2 Management**

Management decision and procedures also influence pace. Strong management action to allocate and redistribute funds can accelerate pace. Weak management can allow programs to "drift". National management in Europe, Japan, U.S. and including India are in large part

responsible for the vigorous pace of fusion development today. Due to cost factors, however, these leaders are looking increasingly to international cooperation as a means to maintain pace. A primary justification for encouraging extensive international cooperation is the general consensus that the international sharing of scientific information will reduce individual program risks and expedite progress towards the program goal of achieving practical fusion energy.

Joint projects/programs will enhance progress; reduce information cost, and lower development risk. Political infighting among different nations about the ITER project's budget, personnel appointments and other issues are hampering the pace of project. The U.S. congress is divided over the future of U.S. contributions to the ITER. Now U.K.'s role will also hamper the pace of development after withdrawn from European Union.

#### **4. Conclusions**

Fusion reactor shall provide many facilities compared to fission reactor. For example, no radioactive substance shall be produced in the fusion- reactor and so there will be no danger of atmospheric pollution. Also, there will no problem of the disposal of the radio-active substance. At present, the unwanted radio-active substance is sealed in stainless- steel drums and thrown into the sea or buried deep in the ground in deserts. Besides this, the people working on fission-reactor have to take many precautions to protect themselves from radioactive radiation. The fusion reactor will provide one more and important advantage. The main fuel for a fission reactor is uranium whose quantity few hundred years. On the other hand, the fuel for a fusion-reactor is heavy hydrogen and helium which is found in abundance in the sea water. It has been estimated that the sea water will give fusion energy which will suffice for the whole world for the next ten thousand years.

#### **5. References**

1. J. A. Bittencourt, Fundamentals of Plasma Physics, 3<sup>rd</sup> Edition, Springer, 2004.
2. S. B. Bhatt et al. Aditya-The First Indian Tokamak, Indian J. Pure Appl. Physics 27, 710, 1989.
3. Dhiraj Bora et al. SST and Aditya Tokamak Research in India, Brazilian Journal of Physics 32,193, 2002.
4. Aparajita Mukhaerjee, Indian Fusion Programme and Contribution for ITER Project, 4th World Conference on Applied Sciences, Engineering and Technology, Japan, 2015.