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LASER FUSION FOR GENERATION OF ELECTRICAL POWER

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Abstract

The utilization of nuclear fusion energy for commercial pro-diction of electric power is under active consideration the dive. Lament of nigh power lasers. The laser fusion method has been studied so far only theoretically and requires a lot of further. Developmental work in laser systems adds laser materials technology. Use of lasers for fusion plasma studies appears to be more convenient to produce stable containment of the~ plasma than by the existing magnetic field methods. Here, the methods of using lasers for fusion are described, their advantages over conventional methods presented, the problems an:1 prospectus of this type of generation of electricity are also discussed.

INTRODUCTION

It is. Well known that electrical power can b~ generated from nuclear energy sources. There are two general types of nuclear sources: fission and fusion. In the contemporary nuclear power plants, uranium is the primary fuel and fission reactions provide the nuclear energy. Fusion reactions between the heavy isotopes are center source of nuclear energy, one! Whose~ utilization for generation of electricity' lies in future.

The possibility of obtaining energy from J the fusion of the heavy isotopes of hydrogen, I deuterium and tritium according to the follow- 1929

The associated energy liberated is con-sidereal. Compare; with the fission process, fusion process has several potential advantages.

1. Deuterium is a heavy isotope of hydrogen and although its isotopic abundance is on]y one part in six thousand, reserves of deuterium in the form of 'heavy water' m the sea are appreciably greater than the uranium or thorium.
2. Fussier reactor would not produce radioactive visage, which is one of the main residual problems in the fission reactor programmed. .

However, the controlled fusion research is, even to-day at an initial stage and requires a lot of developmental work to be done before it can go into commercial production.

During the past 25 years. The controlled fuse. Studies were made mainly with magnetic containment technique in which a very low density gaseous fuel, deuterium (D) and tritium (T) is heated to extremely high tem-prelatures. The resulting plasma is contained by a magnetic field for a time sufficient to con-velrt4 by fusing the deuterium and tritium (D - T) nuclei, an appreciable fraction of the fuel .to helium (He) plus high energy neutrons. Unfortunately, it is very difficult to produce sufficiently stable plasma by the magnetic field.

During the last twenty years, the thrust of controlled fusion research has been towards magnetic confinement of plasmas heated sufficiently 00 (to temperature of 'about 108 °K) ° to achieve fuel ignition.

Large agnatic fields were required for this purpose, Large magnetic fields can be produced economically by per conducting coils, In order to achieve ~ super conductivity the super conducting alloys must be maintained at temperatures near to absolute zero, (3° K). Thus in the same system both highest and lowest temperatures, are to be produced. So far, with the magnetic confinement systems available it has not been possible to build up plasma densities and plasma containment times to within orders of magnitude required.

The basic idea of laser fusion was conceived somewhere in 1960, It was felt at that time that typically hundreds of mega joules, would be required before the thermonuclear energy released could exceed the laser energy and the laser fusion appeared to be Just an- th~r;g.00d idea. These early estimates of input energy were prohibitively large because the possibility of achieving very high densities had, z not been appreciated. In 1972, the United " States Atomic Energy Commission (USAEC) declassified and published the results of extensive computed simulations which predicted that the densities as high as 1 Kg/cm s could be achieved at center of an imploding pellet; as a consequence of the high densities, energy gain ~ as predicted with laser energies as low as a few kilo joules. i,

The development of lasers and laser sys- teems having' very high energies have made la- ser i1. Sion confinement possible, caned inertial confinement. And severla1 organizations an over the world are concentrating in this area of research, Here, a brief survey is presented on the use of lasers in fusion plasma methods employed for generation of electrical power,

LASER FUSION TECHNIQUES -

Laser fusion techniques can be broadly divided into two types, namely,

a) pellet implosion fusion technique and

b) Linear or solenoid fusion technique.

In the former method laser is used for the implosion of the pellet and no external con- firemen is necessary, However, in the flitter method an external magnetic field is essential to confine the plasma during fusion. The principle of operation of echo type of technique is described in detail below.

Pellet Implosion Fusion Technique

A cryogenic pellet of thermonuclear fuel, a mixture of deuterium and tritium, is uniformly irradiated by a high power pulsed laser. The fuel gets heated and expands, thus imploding the central region,5 of the pellet, which when compressed, reaches thermion- clear temperatures and reacts. In this process, neutrons are also produced. The released energy is absorbed~ and used to raise steam and generate electricity.

Compulsions as high as 2000-10,()OO fold are necessary for. an efficient burn and a temperature of 4 Ke V r;=: 4x 101 OR) is required for ignition. Under these conditions, an appreciable fraction of the fuel will burn before disassembly can take place, hence the term inertial containment.' Therefore, densities of the order of I Kg/cm3 are required. To compress the fuel to this density a pressure of 1011-1012 atmospheres may be essential.

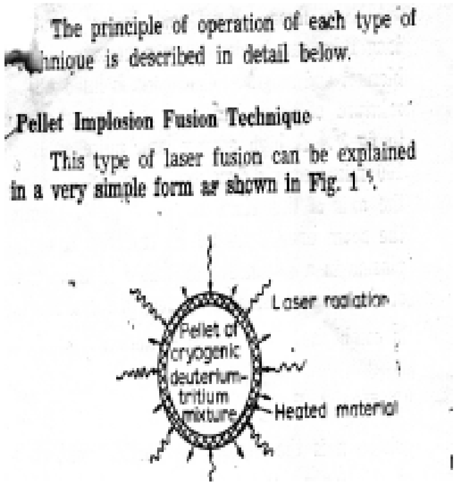

FIG 1. , The concept of laser fusion: heated by laser radiation the exterior of the pellet expands..thus Imploding the central region which. Compresses and reaches thermonuclear temperatures.

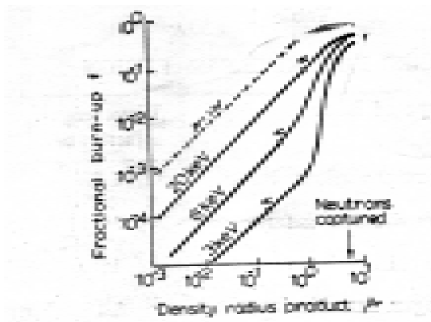

FIG.2 Fractional burn-up ver5us the density-radius. Product for uniform D-T spheres free to expand initial temperatures ore 3 keV , 6keV and 2OkeV

The density radius (~ R) is the most important single parameter in laser fusion and is evident to the Lawson number in magnetic confinement fusions. From the detailed model- ling it is possible to estimate the fractional burn top of the material. Fig. 2 shows the fraction 3.l burn up for different density radius products with initial temperature

as a Para- meter under the condition that uniform D – ,T spheres are free to expan[5]. It is seen from this figure that if the value of density radius product is greater than one and the initial? Temperature is also more than 3 keV then the, 0-' fue~ turn up is approximately 40% .It is de- ;{ sired to work at low initial temperatures, as! 1 this r ('quires lesser input energy; Low temperature with high 9. R **(,** R > 1) will also give high yields of thermonuclear energy as longs there is central hot spot in the pellet which can produce sufficient alpha particles to to i1eat the surrounding D -T to fusion temperatures The high power lasers currently avai1able are having wavelengths greater than 1 micron, but optimum wavelength required for laser fusion is generally estimated to be ap- proximately 0,3 micron. The lasers that are at present. used for such studies with their corresponding wavelengths are given, In addition to the above existing lasers, several other types of lasers4 are also bring developed for this application. For economic production of fusion power, the laser system must fulfill the following requirements.

Energy efficiency =10% Power output' 1015 W

Energy output > 10^6 J

Repetitive rate > 1 pulse per second

LASERS USED FOR NUCLEAR FUSION

Sr.	Type of Laser	Wavelength
1.	Neodymium glass laser	1.06
2.	Carbondioxide laser	10.6.
3	Iodine laser	1.3
4	Hydrogen fluoride laser	2.7

Linear or Solenoid Fusion

The laser heated solenoid7 approach places less strain on laser technology than pellet implosion because it depends upon reasonable extrapolations of existing long wave

Length carbon dioxide or carbon monoxide laser rather than on a type as yet undeveloped. One of the fundamentals requirements of the reactor scheme is the ability of the plasma to contain the laser beam in a long, thin, linear plasma column.

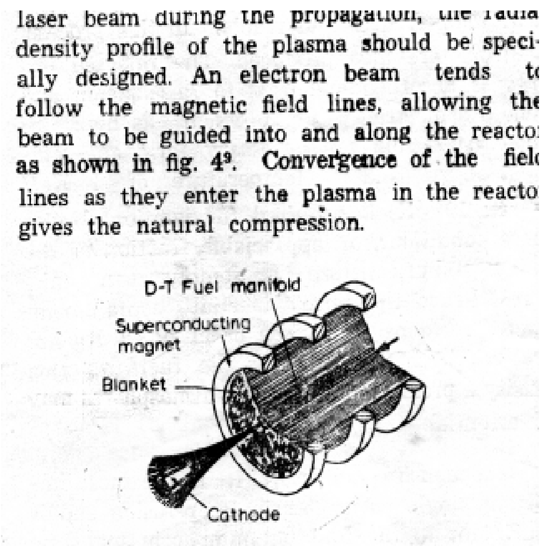
laser beam during the propagation, the radia density profile of the plasma should be speci- ally designed. An electron beam tends to follow the magnetic field lines, allowing the beam to be guided into and along the reacto as shown in fig. 4[9]. Convergence of the fiel lines as they enter the plasma in the reacto gives the natural compression.

Fig. 3 In laser- heated the pinch top a pulsed magnetic field removes the plasma from the reactor walls. In steady field solenoid bottom a cool plasma blanket insulates the reactor wall from the laser heated core.

In a linear or solenoid fusion react long tube surrounded by a neutron blanket and magnetic field coils is filled with a mixture of deuterium and tritium as shown in fig 37. A high-energy laser pulse of 10 to 100 micro second's duration is directed along the axis of this tube. In this type of reactor, the beam energy should be transferred to the plasma in a distance comparable to the length of the reactor. Break-even length for a reactor is established by Lawson Criterion [9]

n. = 1014 = 2V

Where n is the density in particles/cm3. 1 is the reactor length in centimeters and 't is the confinement time in seconds required for the plasma to flow out of the ends of the reactor at a velocity V in centimeters per second.

CONCLUSION -

The paper briefly reviews the state of two types of reactors under consideration for the -laser fusion. The work is still at the initial stages and a lot of developmental work is needed before a model for the commercial reactor is built. In spite of the various difficulties, laser fusion offers the possibility of a greater range of applications than is provided by other methods.

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REFERENCES-

1. Atkinson, R d' E. and Houtermans, F. G. 'Zur Frage der Avfbaumoglichkeit der E1emente in Sternen', Z. Physik, 1929, Vol. 54" p. 656.

2. Hunt, S. E. 'Fission, Fusion and the energy crisis', Paragon Press, U. K., 1974.

3. Hafele, W. and Starr, C. 'A perspective on fusion and fission breeders', J. Br. Nucl. Energy Soc., 1974, Vol 13, p. 131.

4. Boyer, K. 'Status of laser fusion re-search', IEEE Trans. Nuclear Science, 1975, Vol. NS-22, Feb. p. 18.