§24. Evaluation of Fusion R&D — Cost Reduction of Fusion Plants —

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The most important issue in realization of a commercial fusion power plant is the reduction of the capital cost. In the case of a fission power plant, the capital cost of one GWe power plant is about 4000×10^8 yen (gross weight of power plant is about 15,000 ton). The power plant consists of a core reactor and surrounding facilities such as buildings and electric power generator. The former costs about 1500×10^8 yen (5,000 ton in weight), and the latter costs about 2500×10^8 yen (10,000 ton in weight). Since the energy density of the magnetic fusion power plant is extremely low, the core volume of the fusion reactor is bigger than that of the fission reactor by about 20 times, and its weight is heavier by about 10 times. The cost of the power plant is in proportion to weight. Therefore the cost of a fusion reactor might be 1500×10^8 yen , which is 10 times more expensive than that of the fission reactor.

On the other hand, a driver system is most expensive in an inertial fusion power plant. For example, the cost of a future semiconductor laser is estimated to be 3000×10^8 yen /MJ. Since the required output of the laser driver is 4 MJ in a commercial power plant, the cost of the driver might be 12000×10^8 yen, which is also extremely expensive. Recent proposals for cost reduction of nuclear fusion reactors are as follows.

○Magnetic fusion reactor

Recently current start-up by radio-frequency has been experimentally realized in tokamaks. If CS coils can be removed, the aspect-ratio of the tokamak can be reduced. An inner wall blanket can be removed in a low-aspect-ratio system, because its effective area as a tritium breeder is small. In addition, the current density of the toroidal coil can be increased by the re-examination of coil support structures without CS coils. Then the total magnetic stored energy becomes smaller than that in a standard tokamak reactor by more than 10 times. In a low-aspect-ratio tori, the ratio of the surface area of plasma facing wall and the plasma volume can be increased with elongation. Then a compact reactor can be designed without increasing neutron wall loading

○ An inertial fusion reactor

Since a laser system is expensive, the cost of inertial fusion power plant is also high. Therefore required driver output should be reduced to attain a reasonable cost. On the other hand, even if a laser system raises the number of the repetition, the cost may not be influenced very much. In other words, the cost of 1MJx 16Hz becomes about one fourth of that of 4MJx 4Hz. Expected pellet gain is 200 at maximum, and possible repetition rate for one chamber is several Hz at maximum. Therefore in the case of a driver of one MJ, we can expect only a small output reactor with one chamber system. Then a set of several reactor chambers and one laser system might give a reasonable cost.

In late years an idea of the fast ignition gives excelent experimenal results. The most attractive advantege of the fast ignition is that we can expect a small output reactor chamber. Today's estimation gives a reasonable cost of power plant of 1GWe as 5500x108 yen. In this case, the cost of the laser sysrem of 1MJx 16Hz and 4chambers is estimated to be about 3000×10^8yen.

A fusion power plant can be a future alternative of energy source, if it's capital cost is around 5×10^8yen, because the fuel expense is very cheap .

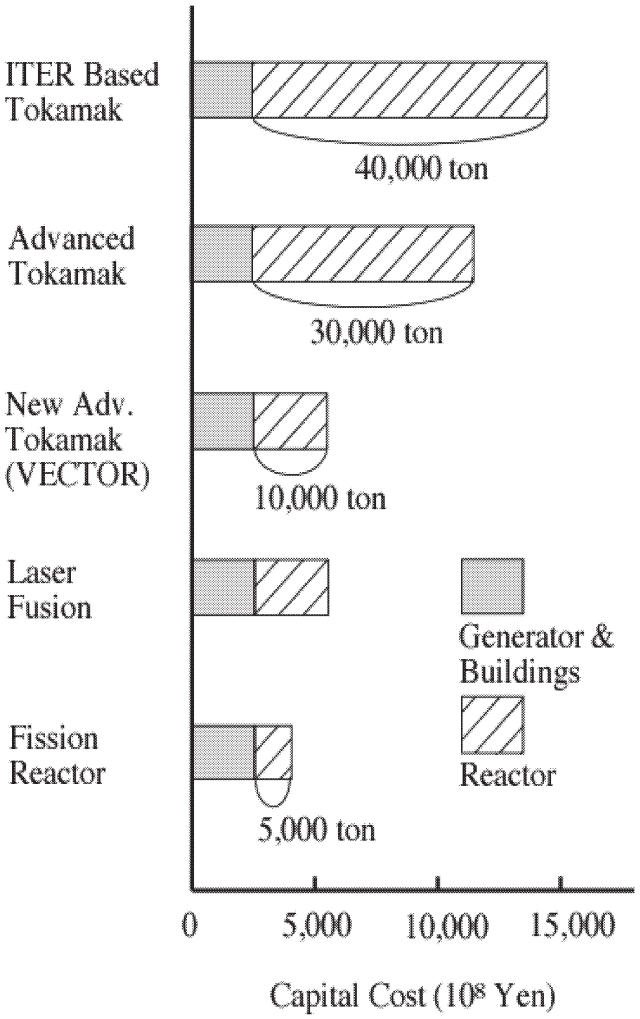

Fig.1 Capital costs of various power plants.