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FUSION RESEARCH IN THE REPUBLIC OF KOREA

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ABSTRACT

This paper reviews the status of fusion research in Korea and works done for the last 10 years. A few experiments are given. The paper also includes a preliminary future program in progress. Necessity of international cooperation is accentuated.

1. INTRODUCTION

Korea, with its dense population and poor resource, has changed itself to an industrialized country from early 1960's. In the process of industrialization, elctricity has been one of the most important contributors to the rapid economic growth. During 1961-1987, the installed capacity became multiplied by 52 times and consumption rate per capita expanded itself by 33 times.(1)

In the beginning,electricity generation was mainly shared by hydro and coal fired plants. In 1960's and 1970's KEPCO introduced many oil fired plants. But the oil shock followed by the energy crisis forced Korea to give up the new oil fired plants and to increase nuclear power plants of which the first unit was built in 1978. Today 8 nuclear plants are supplying more than 50% of demand.[2]

All nuclear power plants in operation and under construction are conventional water reactor plants. For the next century, a combined study in progress is seeking the most viable path to energy security.[3] Two new concepts, the liquid metal fast breeder reactors and fusions, are briefly stated in the study. So far the fusion is not treated as a real reactor to be introduced, rather it is considered as a way of possible alternative energy source.

2. FUSION RESEARCH ACTIVITIES IN KOREA

There are several organizations involved in fusion research. Two institutes, Seoul National University (SNU) with its medium scale experimental Tokamak SNUT-79 and Korea Advanced Energy Research Institute (KAERI) with its small scale Tokamak KAERIT, have steered most of the experimental activities. Other institutes are involved in theoretical study for educational purposes. Table 1 is a list of the important works done in SNU and KAERI since 1979.[3]

Table 1. List of Important Works During 1979 - 1989.

- Design of Tokamaks
- Plasma Focus Experiments
- Fabrication of Plasma Chamber
- Magnetic Field Control Test for Plasma Confinement
- Fabrication of Toroidal Magnets

- High Voltage Switching System Test
- Completion of Tokamak Main Bodies
- Establishment of High Vacuum
- Development of Large Current Crowbar Switch for Magnetic Field Coil Power Supply
- Establishment of Preionization and Toroidal Plasma Production Technology
- Development of Discharge Cleaning
- Set up of Basic Diagnostic System

It is worth while to note that all of the software work and much of the hardware work were done by the young researchers. Main bodies of the two devices were completed in 1984. Though they still need to be equipped with higher power supply and more accurate detectors in order to operate at full power, researchers accumulated quite a bit of experiences in plasma generation and concentration. The current topic is to maintain a uniform plasma column as long as possible.

Among the various experiments, the following three tests from SNUT-79 may give some idea to see the status of fusion technology in Korea.

2.1 Toroidal Field Measurement(4)

16 D-Shape toroidal coils which can generate the magnetic field of 3T in the center of plasma were designed as in figure 1. Design was done by use of computer code DSHAPE and prediction of experiment results were done by TFIELD code. Both computer codes were developed by the researchers.

The measured parameters were toroidal field, field ripple, electromagnetic forces, coil current, ohmic loss, time-space dependence of temperature, etc.

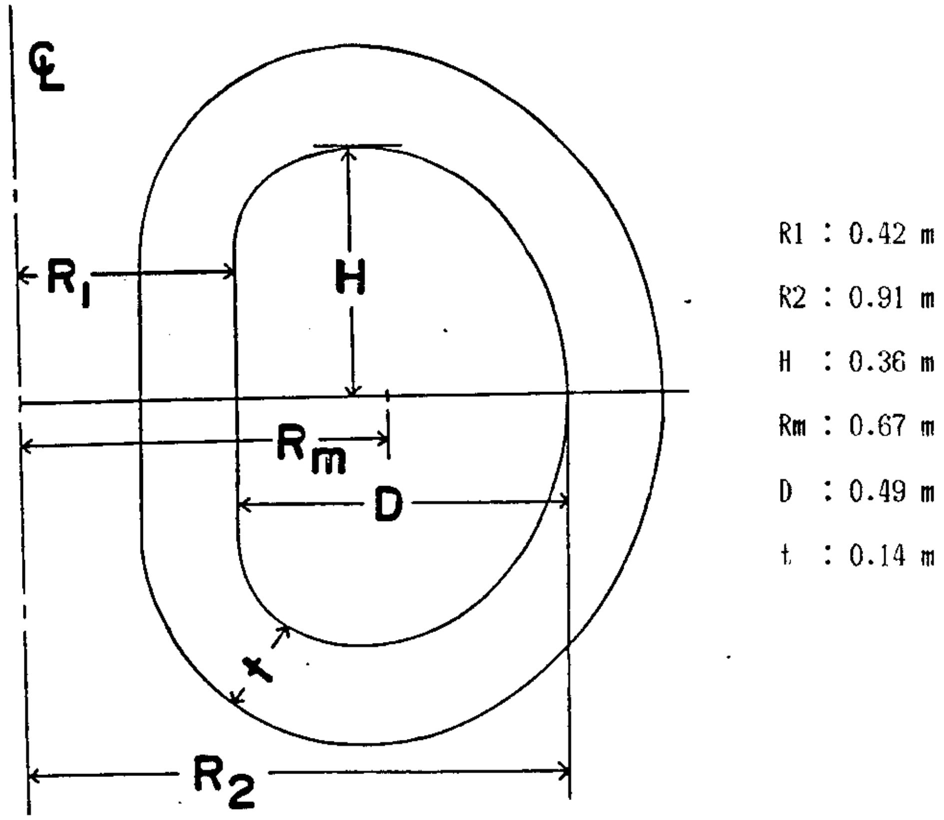

Fig 1. D-Shape Toroidal Field Coil

The results verified simplicity and good approximation of DSHAPE and TFIELD codes.

2.2 Plasma Control and Diagnostics[5]

In 1984, SNUT-79 system became ready for operation and diagnostic instruments were provided to make a basic system as shown in figure 2.

The following data came out from the operation experience.

• The ultimate pressure of the torus after 24 hour glow discharge cleaning with 6 - 7 amp in hydrogen atmosphere of 10^{-2} torr resulted in 1.4 X 10^{-6} torr.

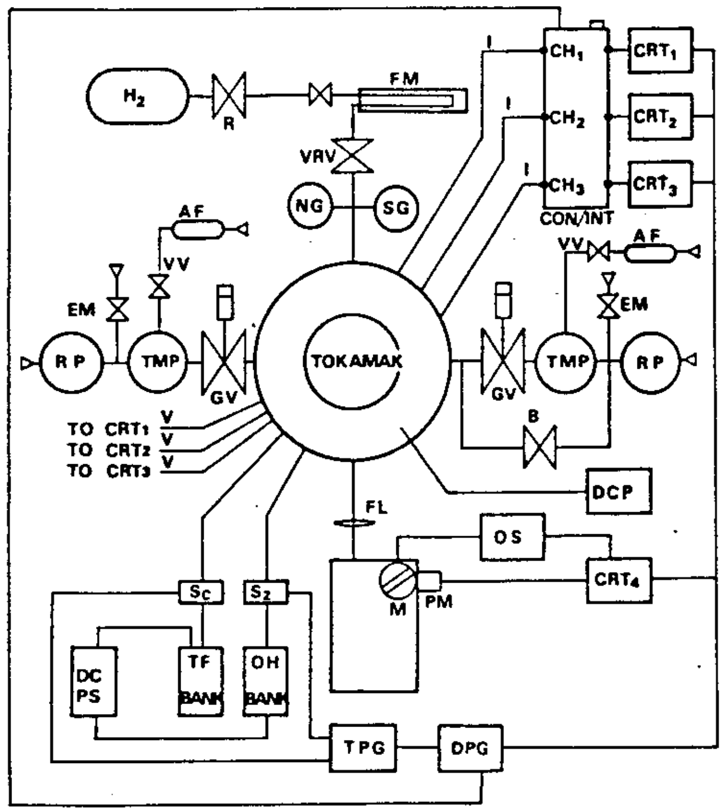

Fig 2. Layout of SNUT-79 Tokamak System
for Operation and Diagnostics

• Through a low current test, the toroidal magnetic field per coil current along main radius was measured to be 0.95 KG/KA which was very near to the design value 0.98 KG/KA.

• During operation, toroidal magnetic field reached maximum of 2.4 KG, total magnetic flux variation to plasma loop was 0.17 V-sec, initial plasma loop voltage was 47V. But the instantaneous peak plasma discharge current was only 6 KA at 0.8 KG of toroidal field and 35V of loop voltage, because at the time of experiment the time delay operation of magnetic field was in poor condition and equalizing magnet system was not equipped.

From the operation data, the following factors were calculated.

- Safety Factor $q \sim 2.3$
- Plasma Temperature $T_e \sim 7$ eV
- Plasma Density $n \sim 2 \times 10^{14} / cm^3$
- Plasma β $\beta \sim 8.7$ %

2.3 Breakdown Test (6)

These experiments executed in 1988 aimed to find several characteristics related to breakdown phenomena during initial start up of ohmic heating system. The preionization which is essential to overcome the problems due to the limit of power transfer and stray magnetic field was cleared by use of $\vec{E} \times \vec{B}$ drift preionizer illustrated in figure 3.

The experiment allowed to reduce plasma loop voltage as low as 24 V. A computer program describing the spatial distribution of seed electrons of preionizer was also developed.

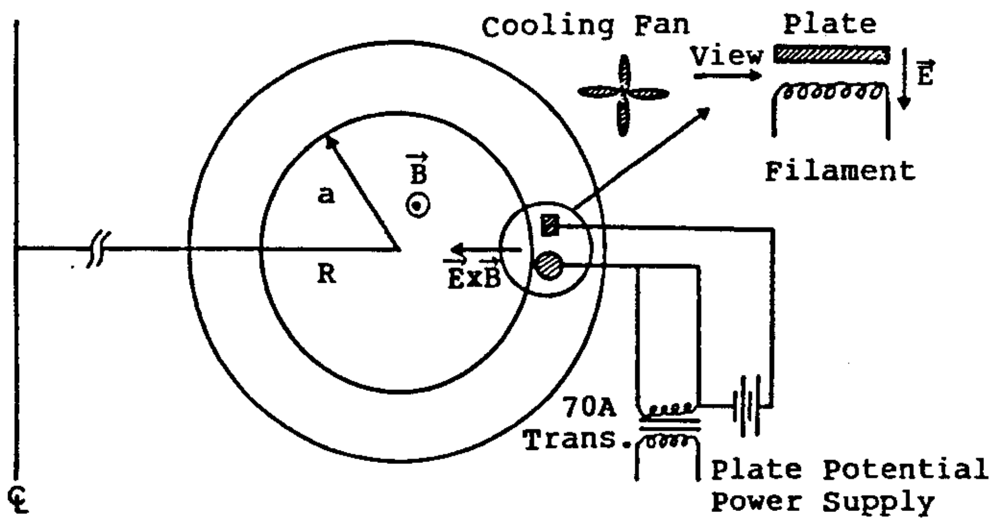

Fig 3. $\vec{E} \times \vec{B}$ Drift Preionizer

Meanwhile, using double probe system researchers measured time-space dependent plasma distribution to investigate plasma characteristics at breakdown phase.

The results showed that at the breakdown phase, electron temperature reduces exponentially along the chamber wall but the spatial plasma density depends on that of initial seed electrons. Computer program proved to be well consistent with measurement.

3. FUSION PROGRAM

As a matter of priority, fusion has always remained in one of future options rather than an objective of real project. Last year, the situation changed a little. KEPCO established a mid-term research program with assistance of various other organizations. This program declares KEPCO's intention to invest in fusion research as a way to evaluate the so called new concept reactors. It means that attentions are paid by goverment, utility and industries. This 12 year program consists of 3 phases as follow.

Phase I starts this year and lasts 3 years. KEPCO-SNU-KAERI will collaborate for the project. The project aims primarily to add experimental data and put the existing Tokamaks in design capacity. The numeric goals of the parameters are,

- Power Supply by Motor Generator Set to Toroidal Field Coil ≧ 30MW
- Max Plasma Heating : 400 - 600 eV
- Plasma Density : $10^{13}/cm^3$
- Ultimate Pressure : 1×10^{-9} mbar
- Sustain Time : 5 msec

At the termination of this phase, the control of plasma in those two Tokamak will be possible, as hoped.

Phase II will be dedicated to the design of large scale Tokamak. The specification will depend on the results of phase I, international cooperation and technical level of advanced large Tokamaks. Some people think in mind that the scale would be similar to PLT (Princeton Large Tokamak). Related institutes will be integrated to the design project and a part of components fabrication will be attempted. During this period, cooperation with other countries will be available and much of the work will be done on international basis. This phase will cover the years 1993-1996.

Phase III doesn't give a clear vision but is regarded as a period of large Tokamak construction. Newly developed technologies will be applied, and development of super conducting coil will have a high priority. The phase will probably start around 1997.

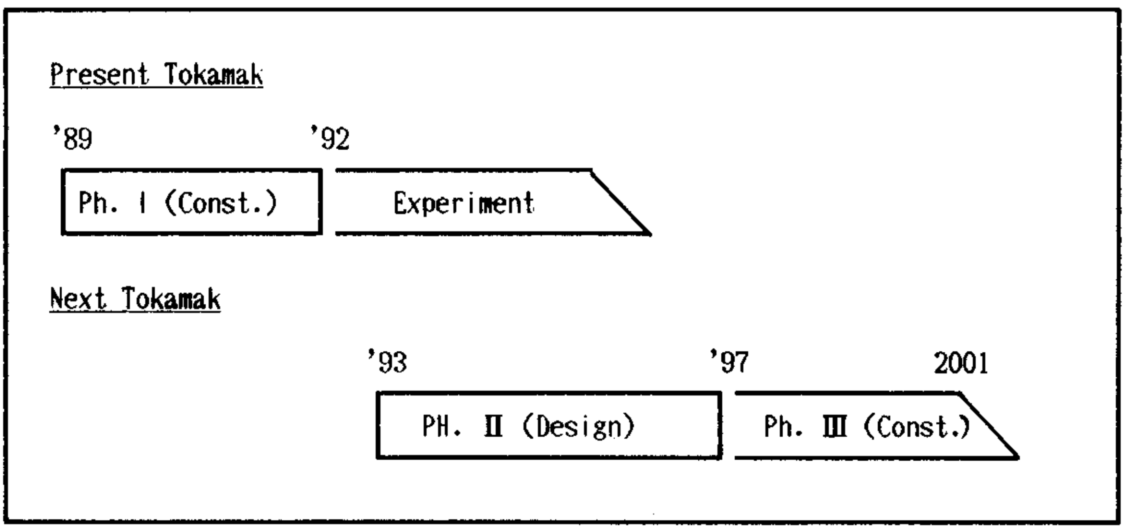

Fig 4. Mid Term Fusion Program

CONCLUSION

The research people in Korea want to raise their level of technology by the end of this century to that of advanced countries in late 1970's. It's not an easy task and present situation is not so promising. But most of all they have confidence in the will of development and econo-technical potentiality.

A good international cooperation is one of the vital requisites. Korea strongly believes that a fair cooperation will be beneficial to all participants and that every country can contribute to a degree in order to bring earlier use of fusion energy, and the international agency is expected to expand its role for that purpose.

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