# OPERATION EXPERIENCES OF MC50 CYCLOTRON, KIRAMS

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*Abstract*

MC50 is the first cyclotron installed at Korea Institute of Radiological and Medical Sciences, Korea Atomic Energy Research Institute. It has been utilized for basic medical researches and production of radioisotopes in addition to treatment of cancer patients since 1986. Additionally, MC50 has contributed to many nuclear sciences researches, such as SER test for semiconductor chipsets, development of variable species by ion beam irradiation, and so on. Recently, we have been running another cyclotron, which is named KIRAMS-30 and only for production of radioisotopes. Therefore, MC50 has become placed more weight on the nuclear sciences researches. It is available to support some researches which use proton, deuteron, He-3, and He-4 beam about 18 » 50MeV.

## OBJECTIVE AND IMPORTANCE OF THE MC-50

MC50 is the first cyclotron installed at Korea Institute of Radiological and Medical Sciences(KIRAMS), Korea Atomic Energy Research Institute.[1] It is a variable energy isochronous cyclotron for the acceleration (up to 50 MeV) of light particles, which can be used in the fields of nuclear medicine, physics, biology and engineering. MC-50 cyclotron has been used for neutron irradiation, radioisotope production, cyclotron application research, and preventive maintenance since 1986. MC-50 will be used for cyclotron development, construction of fundamental science technology and collection of basic data. Operation of MC-50 cyclotron is very important because it has produced many radioisotopes for medical uses and developed new nuclear isotopes. In the result, MC-50 has contributed to the neutron radiography, development of cyclotron application researches and the nuclear science researches. In addition, MC-50 cyclotron, which is the facility for producing fast neutron, is unique in Korea. It is a cornerstone of the accelerator development in Korea. In 2003, MC-50 cyclotron performed 9 research projects including the production of radioisotopes, new radioisotope develop-ment(specific research project given by Ministry of Science and Technology ), neutron irradiation and so on. In addition, MC-50 has performed total 23 research projects. Among these projects, 14 research projects was performed by 11 other institutes, such as Samsung electronics, Chun-gang university, KAERI, etc. As the results of these researches, we published 19 domestic presentations, 6 abroad presentations and 1 abroad publication. Additionally, 2 articles are expected to publish now.[2] KIRAMS equiped new cyclotron named Cyclone-30. This is a cyclotron only for the production of radioisotopes. Because cyclone-30 takes full charge for radioisotope production, MC-50 will be able to be utilized for fully research propose in 2004. In the future, MC-50 will be an important basis for cyclotron development, activation of a basic sciences and construction of a technology foundation.

## SCOPE AND CONTENTS OF THE MC-50 OPERATION

Cyclotron has contributed to various fields, such as neutron irradiation, radioisotope production, localization of radioisotope, invention of new nuclear isotope, cyclotron application research, and nuclear experiment of industry and academy cooperation. Moreover, we built the foundation of basic science and technology by construction of ion beam line for nuclear science researches. In addition, we have tried to improve maintenance technology and record data. We believe that the information would be useful to operate new cyclotrons which will be built in the future. The MC-50 cyclotron has been used the various beam energy from 18.0 MeV to 50.5 MeV, and made various beam current from 2 nA to 60 $\mu$A.

## RESULTS AND PROPOSAL FOR APPLICATIONS

The operation results of the MC-50 cyclotron in 2003 are as follows:

1. Except 65 holidays, actual operation days were 261 in 300 days which could be operated a year and the rest were 16 days for preventive maintenance, 4 for repairing glitches and 19 for non-operation due to no-task.

2. Total beam extraction time was 2,739 hours. 1,760 hours were used for the radioisotope production and 451 for the application research.

The total operation time of 2003 was 2,739 hours which is 18% increased quantity in comparison with 2,312 hours of last year. 1,760 hours were used for radioisotope production, 149 hours for cooperative group related our research and 302 hours for various users. MC-50 has made various radioisotopes for those researches. Beam extraction time for each radionuclides is shown in fig.1.

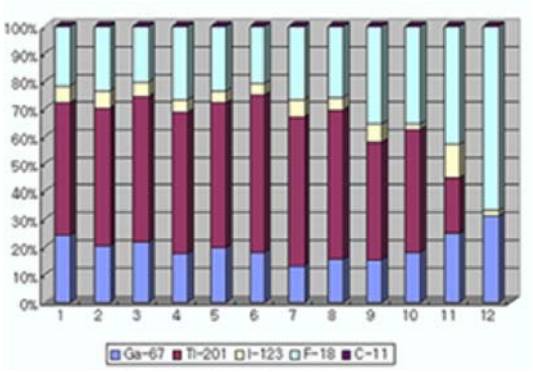


Figure 1: Beam Extraction time by Radionuclides Kinds

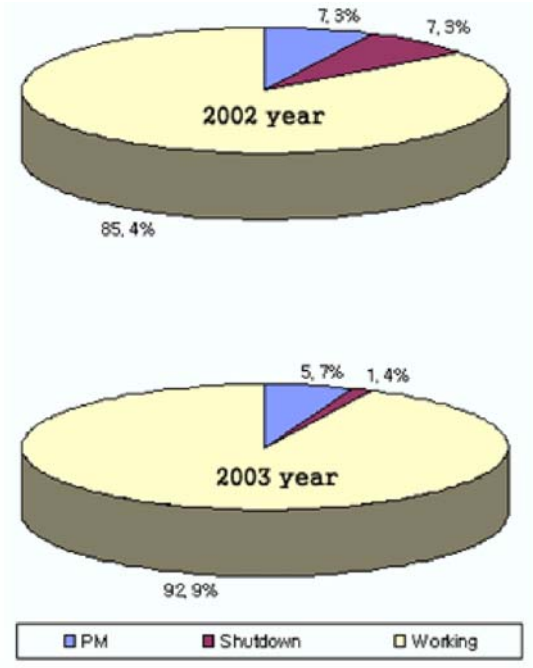


Figure 2: Percentage Comparison of Cyclotron maintenance

From the data mentioned above, we can know that operation time for nuclear science experiment was increased by much because of construction of nuclear science ion beam line. The average operation rate of 2003 was estimated at 98.5% which was increase quantity in comparison last year's 92.9%. In this year, the period for repairing is 4 days, and that of last year is 21 days. This result affords proof of that our cyclotron technology and operation have much improved. Fig.2 shows the percentage comparison of MC-50 between 2002 and 2003.

## DEVELOPMENT OF MC-50 CYCLOTRON

We have continuously development MC-50 cyclotron. Even though we bought it from Scantronix, Belgium, we have tried to localize many parts of MC-50, such as cooling system, vacuum controller and so on.

Table 1: The Specification of Cooling System for MC-50.[2]

| | |
|---|---|
| System Size | 1600(W) × 1600(L) × 2200(H) |
| Supply Pump Power | 18M3/H ×70M |
| Ion Pump Power | 4M3/H × 30M |
| Power | AC 3P 380V 60Hz |
| Water Tank | 760Φ 950H |
| M.C.C Panel | 500 × 600 × 250 |
| Observation Panel | 247 × 227 |
| Heat Exchanger | M10-BFM |
| Flow Meter | 20A 4-5KG/CM2 |
| Drain | 25A |
| Note | Water Temperature : 10 ~ 12 $^{o}$C<br>Deviation of Temperature : ± 2 $^{o}$C |

### *Vacuum Controller of MC-50*

MC-50 cyclotron consists of vacuum chamber, main switching magnet, beam lines for radiotherapy and production of radioisotopes, and so on. The pressure in the vacuum chamber should be kept under $10^{-6}$ mbar in running period. Two diffusion pumps are working for maintaining required vacuum state. the pumps have water-cooling baffles in order to prevent oil counterflow toward vacuum chamber.[3] As stated above, cyclotron main vacuum chamber's pressure should be below $10^{-6}$mbar, but beam line's vacuum rate is, in general, about $10^{-5}$ mbar. Therefore, beam line's vacuum state may have baleful influence on the vacuum state in the main chamber. We developed new preventive system between main chamber and each beam line. The system have wings inside, and the wings prevent the diffused air molecules from entering into the main chamber. The main chamber's vacuum keeps under $10^{-6}$ mbar by the system.

### *Cooling System of MC-50*

Because cyclotron facility needs high current, high magnetic field, and high radio-frequency for accelerating particle beam, it generates very large heat. Therefore, cooling system is very important for MC-50 cyclotron. If we can not control the heat, then magnetic field would fluctuate and many other part would be damaged by heat. New localized cooling system is installed for nuclear sciences research facility, which is constructed in 2003. Table 1. is the list of specification of new cooling system and diagram is shown in fig3.

In the cooling system, one of the most important part is the heat exchanger. We use the Plate Heat Exchanger (PHE). The plate heat exchanger consists of a number of corrugated metal plates, constituting the heat exchanger surface, that separate the media. These are clamped together in a frame. Alternate plates are inverted, and the gaps between the plates form liquid flow channels. Each liquid flows in alternate channels in opposite directions. The liquid is sealed from the atmosphere by elastomer gaskets. Connections for the two liquids are normally located at the fixed end of the frame. Multi-pass units have connections on both movable and fixed frames. Fluids are at all times separated by two gaskets. The schematic of heat exchanger is shown in fig4.[3]

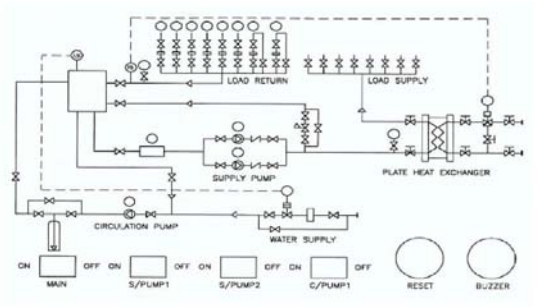


Figure 3: Diagram of Cooling System[2]

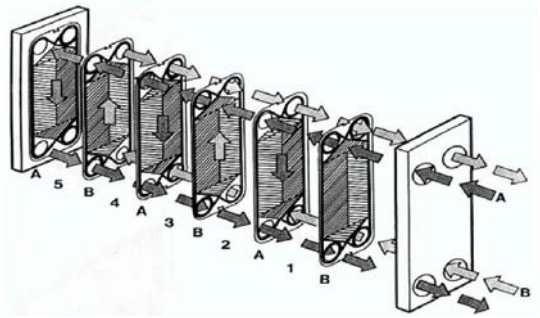


Figure 4: Schematic of Plate Heat Exchanger

## PLAN FOR APPLICATION OFOPERATION RESULTS

The operation results shown in previous section are very beneficial basic data for the operation of advanced cyclotron, reference for preventive maintenance, development of medical and heavy ion cyclotron, establishment of basic science and technology, cyclotron application research, etc.

For increasing use of MC-50 cyclotron, we have opened a laboratory to foreign intercourse from 1999 and cyclotron user committee was established in 2000.[4] We built beam irradiation room for research of nuclear science in 2003, and constructed 30MeV cyclotron named cyclone-30 only for radioisotope production. Before construction of cyclone-30, the beam time for research was not enough for all users desire. However, much more users have opportunity for using MC-50 now. Furthermore, many nuclear reaction experiment can be executed because nuclear science beam irradiation room has been equipped. A researcher can perform the experiment, which is demanded low natural radioactivity as like as nuclear physics experiment. The experiment using neutron is possible to be performed in Gentry room and beam irradiation using high beam current is available in in target room. Consequently, we expect that research projects from various fields will be greatly activated in 2004.

For cyclotron application in various fields, we need several prior conditions. First, cyclotron user committee should be activated and user group should be supported much more than now. The research project using cyclotron should be assigned to the industrial company and research institute. A basic and applied science research should be performed simultaneously by increasing research fund.

In addition, industrial application of cyclotron should be increased. For example, the researches using cyclotron, which are abrasion test of engine, semiconductor application, SER measurement by neutron and neutron radiography are very encouraged in Europe and America. On the contrast, there are few researches on industrial application theme in Korea. Cyclotron application should be expanded not only to medical and biological fields but also academic and industrial field because application on industry is considered as high value-added research. Samsung electronics has started effective measurement of proton and neutron since 1999. Usong and Sunmun university groups join in QC research using cyclotron.[5] These are the leading researche groups for semiconductor business of Korea.

We are expected to make the medical heavy ion cyclotron in the future, which is called dramatic cancer therapy machine showed amazing success rate in clinical experiment.[6] Therefore this facility has become the spearhead cancer therapy machine, which has being spread all over the world rapidly. MC-50 cyclotron of operation, preventive maintenance technology and accumulative data , will be fundamental know-how for research of heavy ion cyclotron. Also, training professional cyclotron operator and developing high technology have the greatest effect on accomplishment of research. In short, MC-50 has continuously contributed to promote national prosperity and elevate social welfare.

## REFERENCES

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