THE HIGH QUALITY WATER COOLING SYSTEM FOR A 100 MeV CYCLOTRON*

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Abstract

A high quality water cooling system with total heat power dissipation of 500 kW has been built and successfully used for a 100 MeV high intensity Cyclotron. The main features of this system are high water quality with specific conductivity bellow 0.5 μS/cm, high cooling water temperature stability better than ±0.1 ℃ for long time operation，and much electric power-saving in comparing with classical design. For some special usages, such as high beam power target and vacuum helium compressor, they all are well treated and reasonably separated from the main cooling system. There are totally 108 distributed water branches corresponding to different sub-equipments of the cyclotron. The water cooling system is under automatic control with PLC, the operation status and all parameters can be remotely monitored from the control room. All of the involved equipments can be switched on/off by one key, no on-duty staff is needed at normal conditions. This system has been put into commissioning for two years and proved successful and reliable.

INTRODUCTION

Beijing Radioactive Ion-beam Facility (BRIF) has been built at China Institute of Atomic Energy (CIAE). As a key component of BRIF project, CYCIAE-100 provides a 75 MeV – 100 MeV, 200 μA– 500 μA proton beam [1,2]. The main part of heat power dissipation coming from different equipments of the cyclotron should be taken away by water cooling system, which is totalling about 500 kW. There are some special requirements, such as high beam power target with strong radioactivity and vacuum helium compressor requiring ultra-low temperature cooling water. Besides, the main magnet power supply and RF system require cooling water have higher temperature stability to maintain their high specifications, external ion source locating at 40 kV high level require the cooling water of low conductivity. All of the special requirements should be considered in the general design of the water cooling system.

Unique climate of Beijing is another factor of considerations for the water cooling system design. The four-seasons are clear and there is a much difference in temperature between summer and winter, usually above 50 . Fully take the advantage of the natural environments of Beijing could save much electric power and decrease the operation cost during the continuous run terms.

GENERAL DESIGN

Based on the requirements of the 100 MeV cyclotron, the cooling water system was generally designed with one main system and two sub-systems. The main system is used for the most part of equipments of the cyclotron, and the two sub-systems are used for hot targets and vacuum helium compressor respectively.

The key parts of the main system are located in the recycling water supply room and the cooling devices including a large scale of heat dissipation tower and 10 cryo-generators are located outside nearby. A specially designed water storage tank with a separator inside is used for internal and external recycling water simultaneously. The de-ionized water production and water quality improving devices are built online to keep the cooling water always in good conditions. The cooling water delivered to the RF power generators, RF cavities, main magnet coils, ion-source, beam lines and so on through different water tubes and distributed branches.

There are totally 108 distributed water branches corresponding to different sub-equipments of the cyclotron. At each branch, there are one water flow switch for safe inter-lock, one flow meter for monitoring, one temperature sensor for remote diagnostics.

The cooling water used for the high power targets is supplied by a dependant water loop located in the radioactive-protective room, which has heat exchange with the main cooling system but physically separated from it to avoid any pollute of the main cooling water.

The cooling water of 15 ℃ required by vacuum helium compressor is provided with another separated water cooling system, because it is much different in temperature from the main cooling water of about 25 ℃.

The general diagram of water cooling system is shown in Fig. 1.

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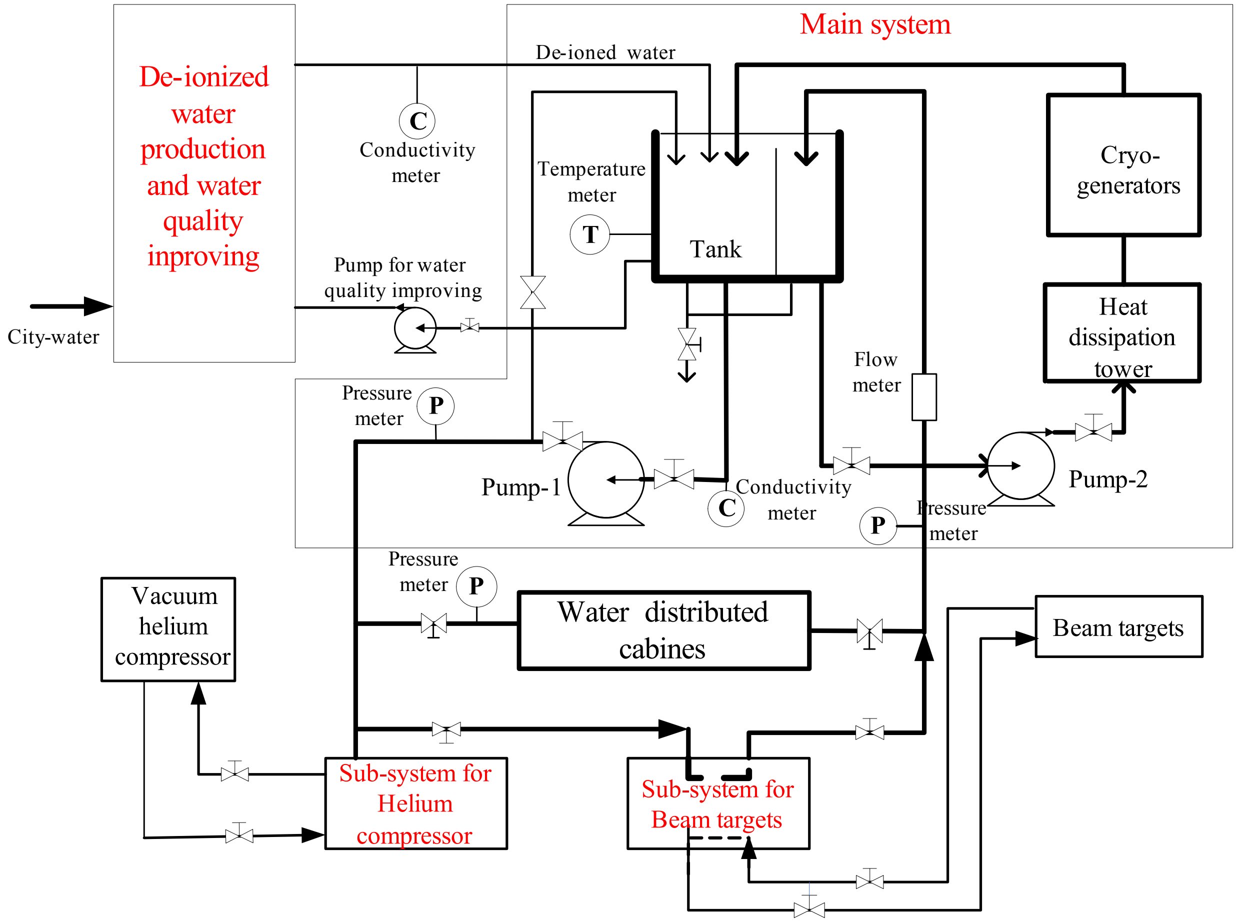

Figure 1: The overall diagram of water cooling system.

MAIN FEATURES OF THE SYSTEM

High stability of water temperature, high water quality, much electricity and water saving, operation reliability are the main features of the system.

Stability of cooling water temperature is better than ± 0.1 ℃ for long time operation, see Fig. 2. Water temperature is controlled through two loops or two steps: firstly, the showering pump with changeable rotation rate is used in the heat dissipation tower and controlled with water temperature at tower exit; secondly, the 10 cryo-generators on/off sequence are well programmed based on water temperature in the tank.

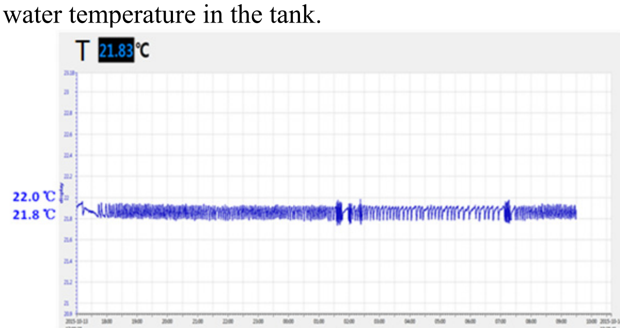

Figure 2: The cooling water temperature display.

The conductivity of cooling water maintains bellow 0.5 µS/cm, see Fig. 3. It is realized with an online water quality improving loop including a conductivity sensor, a recycling water pump and an EDI device, which can automatically put on /off according to cooling water conductivity.

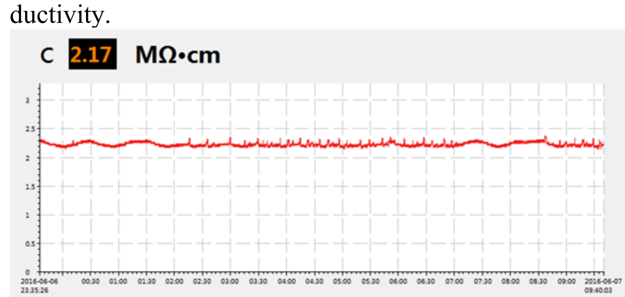

Figure 3: The cooling water quality display.

Water cooling system has adopted a combination of tower and cryo-generators (see Fig. 4), and kept tower dissipation in advance with cryo-generators as a complement. It takes the advantages of the climate in Beijing and fully uses the natural resources. The practice is shown that power consumed by cooling tower is only about one fourth comparing with cryo-generators for same amount of heat dissipation. There is much electricity saved in this

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way for a continuous operation. The online water quality improving loop usually delivers about 10% waste water, but it is much better than the city water in quality. All the waste water produced by EDI is fully reused, only its small part is drain away. The electricity and water saving could cut off much operation cost.

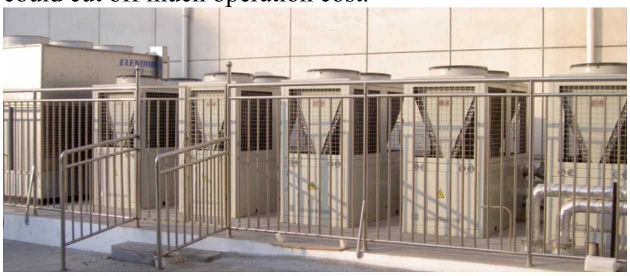

Figure 4: The picture of cooling tower and cryogenerators.

All equipments of this water cooling system have proved reliable since its commissioning. The whole system is under automatic control and can be switched on/off by one key, no on-duty staff needed at normal conditions.

OPERATION STATES

The cooling water system for 100 MeV cyclotron was put into commissioning at end of 2013, supporting the 100 MeV proton beam extracted from the machine in July of 2014. Its main specifications are satisfactory, especially well meet the high stability required by the main magnetic field, RF generators and RF cavities, reducing their temperature drift and providing stable conditions for their long-term operation.

Safety Interlocks with other individual equipments through different branch water flow switches, water temperature monitors and PLC net programming.

System controls, operation status and all parameter monitoring could be done remotely in the control room. Some dynamic displays are given bellow in Fig. 5:

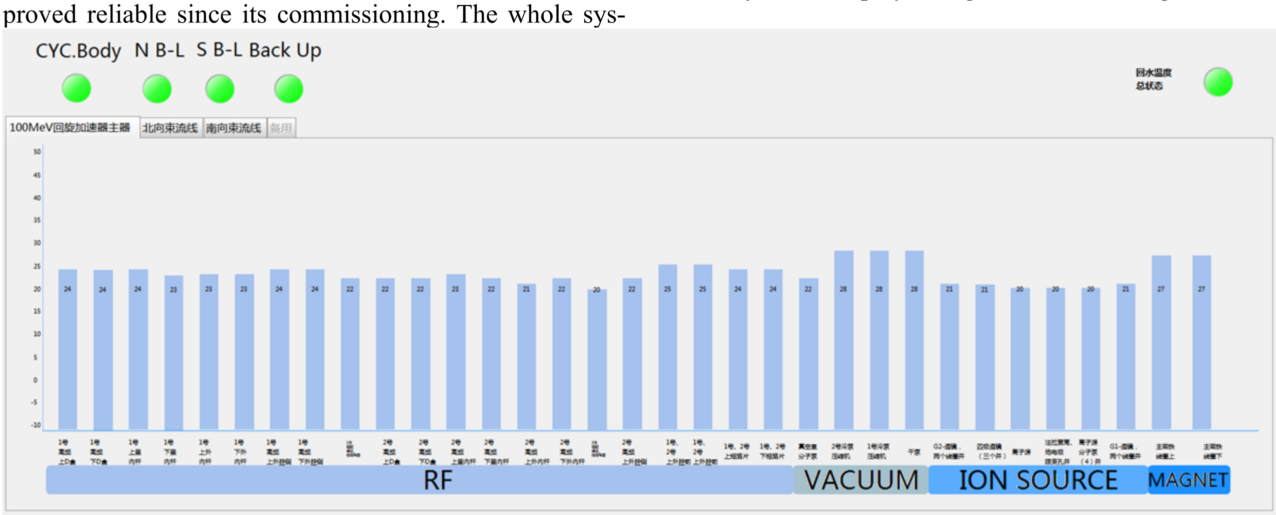

Figure 5: One of the display pages for distributed water branches.

CONCLUSION

This cooling water system is oriented to the 100 MeV cyclotron. It involves a main system and two sub-systems to meet the different needs of the cyclotron. The combination of cooling tower and cryo-generators was adopted from a consideration of Beijing climate and power saving. Two control loop regulations made its high stability possible. Online water quality improving device installed has kept the conductivity of cooling water always at good conditions. More than two years operation has proved its high qualities and reliability.

REFERENCES

[1] Z.G. Li, *et al.*, "General Engineering Considerations for the 100 MeV Cyclotron", in *Proceedings of the 19th International Conference on Cyclotrons and their Applications*, Tokyo, Japan, Oct. 2004.

[2] T.J. Zhang, Z.G. Li, Y.L. Lv, "Progress on Construction of CYCIAE-100", in *Proceedings of the 19th International Conference on Cyclotrons and their Applications*, Lanzhou, China, Sep. 2010, pp. 308-313.

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