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DEVELOPMENT OF EP SYSTEM AT IHEP*

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Abstract

Electropolishing (EP) is a necessary technology for high quality cavities including both high accelerating gradient and high quality factor cavities, which will be used for several future large projects such as CEPC, Shanghai hard X-ray FEL, ILC, and so on. An EP system was development at IHEP, CAS. In last years, we finished all the engineering design and fabrication including functional circulation loops design, system parameters choices, key equipment choice or design, components test and fabrication. According to the functions of various components, the whole system were divided into three main units: electrolyte mixing, acid solution and mechanical platform, and several key components such as rotation sleeves, DC power supply and so on. Since the system is designed for both R&D and mass production, several characteristics comparing with those in other labs in the world can be realized, including dozens of solution circulations, electrolyte mixing, new and old acid separation, cavity outside water cooling, cathode vertical assembly, and compatible for several types of cavities. We will report them in this paper.

INTRODUCTION

After SRF cavity was fabricated, usually a so-called 150 μm damage layer need to remove. Normally, there are two methods. One is BCP, and another is EP. For BCP, the operation is simple, and polishing rate is faster comparing with EP. However, the performance of BCP treated cavity will have a lower threshold. Taking 1.3 GHz cavities for example, usually the gradient of BCP treated cavities will be 25 MV/m while it can be 35 MV/m if EP used. So, EP as a critical surface treatment was widely developed in the world [1]. And became a standard procedure of ILC project.

What is more, in recent years, EP also shows the importance in N-doping technology for High Q_0 studies, which was adopted by LCLS-II [2] and is also an important candidate for future projects like CEPC, Shanghai XFEL. Besides, for Future Circular Collider (FCC) project, a new EP facility is also under fabrication for copper surface treatment which will be used as substrate for Cu/Nb cavities [3].

However, although SRF was developed several decades in China, especially resent study on N-doping, we do need an EP system working for those researches. So, we would like to develop an EP system at IHEP. It will has two purposes, R&D and mass production.

As we know, there are two kinds of EP in the world. One is horizontal EP (HEP), and the other is vertical EP (VEP). For VEP, it is developed in recent years, and has many advantages HEP system, like the system cheap, efficient, easy operation, less space occupation, compatible with HPR, and so on. However, VEP still belongs to state-of-the-art technology. Since one of our purposes for build the system is for mass production like Shanghai Hard XFEL, at last we choose the horizontal EP.

In the other hand, since we still have some R&D program like CEPC, besides 1.3 GHz cavity, we also need to study lower frequency cavities, like 650 MHz, we need the system can be compatible for those different cavities. The following are the types the system can work for:

1) 500 MHz single cell cavities;
2) 650 MHz 1-cell to 5-cell cavities;
3) 1.3 GHz 1-cell to 9-cell cavities.

MAIN COMPONENTS OF SYSTEM

When we investigated the companies to build the system, we found since there is large difference between mechanical part and solution part, the system has to be divided for related supplier. At last, following units are separated from the system to look for suppliers.

1) Mechanical rotation and turning platform;
2) Electrolyte preparation and equipment cleaning unit;
3) Solution circulation and temperature control unit;
4) Other critical components, including rotation sleeves, power supply, automatic control system, pure water system, nitrogen gas unit, and so on.

Mechanical Rotation and Turning Platform

Figure 1 shows a 3D model of mechanical rotation and turning platform. It provides a support for cavities in EP process. The mainly function are as following:

- Rotation when cavity at horizontal;
- Switchable between horizontal and vertical;
- Cathode assembly in vertical direction;
- Power connections;
- Automatic Control;

When a cavity is in polishing process, they will rotate at horizontal direction for a uniform polishing and gas out. The rotation speed can be well controlled.

Before a cavity start polishing, it need in a vertical direction for cathode assembly. It is because that it is very easy to damage the surface of the cavity if a thin and long bar is assembled in horizontal direction.

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When the polishing process finished, the cavity should also be in vertical direction. One purpose is to drain acid since the cavity structure will always leave acid in it if it is horizontal. Another purpose is to rinse the cavity clear with DI water for the same reason.

The turning of the platform is achieved by a customized gear reducer and a motor. We choose this structure since two considerations. One is that it need to have enough power due to big cavities. Another is that it will cleaner than hydraulic unit.

At Last, materials of the platform is SUS304 to avoid the etching and rusting.

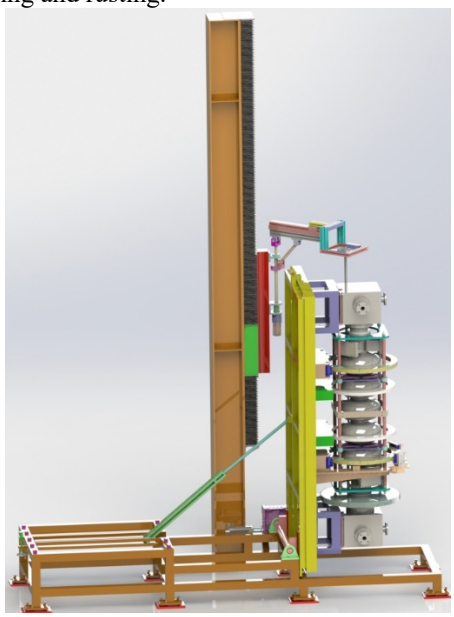

Figure 1: Mechanical rotation and turning platform.

Electrolyte Preparation and Equipment Cleaning Unit

Actually, this unit has two separated function: electrolyte preparation and equipment cleaning unit. Since they both play assistant effects, we separated it from the main part the EP system. Figure 2 shows a schematic diagram for this units. It has following functions:

- Acid mixing
- Acid storage
- DI water cleaning

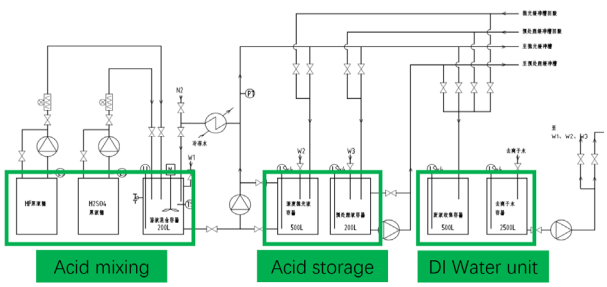

Figure 2: Schematic diagram of electrolyte preparation and equipment cleaning unit.

In the system, a solution mixing unit is designed for preparation for the EP electrolyte which is made up by 98% H_2SO_4 and 49% HF with a volume ratio of 9:1. It will be helpful for us control the quality from the first step of EP electrolyte especially in the initial stage of R&D. Since in the process of acid mixing, an amount of heat will be generated, there will be a heat exchanger.

In the storage unit, containers are prepared for the solution storage, including fresh acid, bulk EP and pre-EP electrolyte. All of them will use in the related process to make sure the quality of EP.

For DI water unit, in the real design, there are two effects. One is to heat the DI water for the cavity rinsing. , Another, it is also a buffer since for 650MHz cavities a large mount water will be used in a short time. At last, waste container is also needed.

Solution Circulation and Temperature Control Unit

The circulation unit is the main unit of the EP system. It is for the electrolyte movement in the EP process, and the main functions are as following:

- Acid circulation
- Acid lever control
- Acid cooling
- Cavity cooling
- Acid draining
- DI Water rinsing
- Hydrogen gas exhaust

The schematic diagram for this unit is as Figure 3.

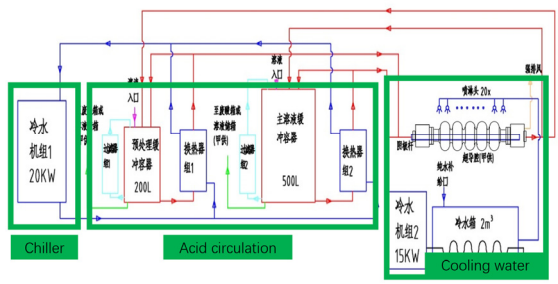

Figure 3: Schematic diagram of solution circulation and temperature control unit.

In this unit, the electrolyte lever in the cavity will be controlled at about 50~60% of cavity inside volume. Two rotation sleeves will be used in both ends. There is cofferdam in each rotation sleeves together with two electric magnetic pumps will control the acid level.

There are also two heat exchanges designed for the acid temperature control. A 20 kW chiller is used for both the two chiller. Cooling unit is mainly for providing cold water for cavity outside to control the temperature.

In the EP process, hydrogen will be generated at cathode surface. So, we need to dilute the H_2 concentration for the safety consideration. There are two ways to dilute it. One is that we can fill nitrogen gas into cavity. However, this method will bring a risk that a positive pressure will maintain inside the cavity. Other is that we can directly pumping the H_2 gas out of the cavity to the air. For this method we need to think about air filler

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to ensure cleanness of air which will be pumped into cavities. In our system, both methods can be used.

Other Critical Component

Beside mentioned above, there are also several other instruments in the system, such as power supply, automatic control system, pure water system, nitrogen gas unit and so on. Power supply we choose is a direct current power supply which can be variable to 1000 A and 50 V. Two chillers with refrigerating capacity of 20 kW is used for temperature control. Nitrogen gas is used for leaking check. A new DI water equipment is being built in the new lab for supporting the needs. At last, an automatic control system will be built to integrated all the PLC control

Besides, we also have prepared several gas monitors, like HF, hydrogen gas, and oxygen gas monitor, and first aid equipment and medicine mainly for safety consideration.

SYSTEM FUNCTIONS AND FEATURES

This system can finish the standard EP process, including bulk EP and fresh EP. The electrolyte for the two procedures will be independent.

Pre-EP is considered in the design similar as that at KEK. In this process, the common part of pipes and instruments shared with those in the other two processes need to be as less as possible.

The leaking check for the whole system will use positive pressure of nitrogen gas. The whole system will be separated into several parts which will be connect to a common nitrogen source. So, we can identify the leaking location more accurately.

STATUS

Up to now, all the components are completed and sent to IHEP from various companies. We have finished integrated and commissioned by using water. The main functional tests and acceptance check are finished at IHEP. Figure 4 is the picture of the EP system integrated at IHEP for the test. At present, we have sent all of components to Ningxia province for commissioning. Figure 5 shows the picture of the EP system commissioning at Ningxia.

SUMMARY

A horizontal EP system has been developed at IHEP. The system can treat several kinds of cavity including 500 MHz single cell cavities, 1.3 GHz 1-cell to 9-cell cavities and 650 MHz 1-cell to 5-cell cavities. Now all the suppliers have finished related contracts and sent the units to IHEP. We have integrated them and made a commission by water. And at present it is under acid commissioning at Ningxia.

Figure 4: The picture of the EP system integrated at IHEP for water test.

Figure 5: The picture of the EP system commissioning at Ningxia.

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