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EP SYSTEM DEVELOPMENT AT IHEP*

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Abstract

Electropolishing (EP) System is a critical facility for SRF cavity treatment, especially for high performance cavities which are necessary for several great projects like LCLS-II, CEPC, Shanghai XFEL, and so on. So, an EP system was under development at IHEP. At this stage, we would like a horizontal EP facility. Main purpose is for elliptical SRF Nb cavities like 500MHz single cell cavities. Besides, it should be compatible for other frequency cavities, such as 650MHz and 1.3GHz cavities. In this paper, we will mainly report the preliminary design for the EP system. Several key points in the design will be also discussed.

INTRODUCTION

EP as a critical technology for SRF cavity surface treatment was widely accepted and developed in the world [1]. In the beginning of EP development, it mainly shows advantages on the improvement of the cavity accelerating gradient. Taking, for example, it is proved that the application of EP could improve the accelerating gradient of ILC cavities from about 25MV/m by BCP treated to around 35MV/m. So, it became a standard procedure of ILC project. 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]. So, we also would like to develop an EP system at IHEP for the R&D and projects on SRF cavities.

CAPABILITY GOAL OF THE EP SYSTEM

At present, there are two types of EP system. One is horizontal EP (HEP) system, and another is vertical EP (VEP) system. For VEP system, it is developed in recent years, and much later than HEP system. In VEP system, the cavity will not rotate along the axial direction. So, no rotation sleeves are needed. It will be more convenient for acid draining and compatible with DI water cleaning. So, it takes smaller space and lower cost comparing with the horizontal EP. However, at present, VEP still belong to state-of-the-art technology. Good results from VEP are still limited especially for project used cavities. So, as first step at IHEP, we will begin with HEP at this stage.

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Taking account of possible projects in the future, such as HEPS, CEPC, Shanghai XFEL, and so on. We would like that the system can be compatibility for following cavities as shown in Fig. 1:

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

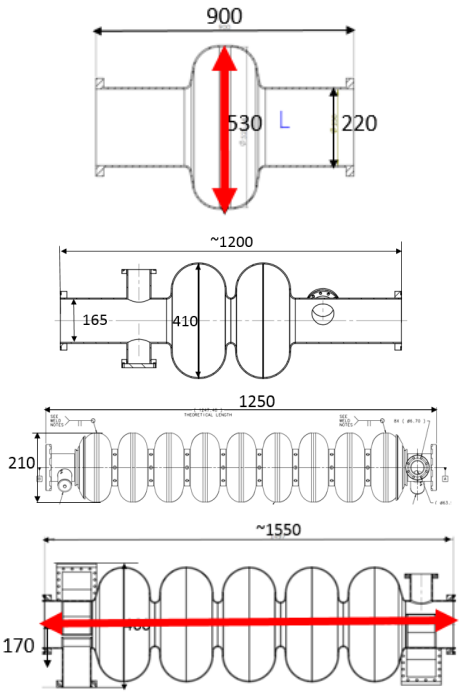

Figure 1: Sketches of four types of cavity prototypes which may need EP at IHEP. The frequencies of cavities from upper to lower are 500MHz, 650MHz, 1.3GHz, and 650MHz, respectively.

As we see in Fig. 1, although there are four types of the cavities, actually for EP system we only need to choose two types as consideration. One is 500MHz single cell cavity since it has a largest radial size. The other is 650MHz 5-cell cavity since it has a largest axial size and inside cavity volume.

SYSTEM DESIGN

Main Components of the System

Figure 2 shows main components for the whole system. It can be roughly divide into four parts:

1) Plumbing and Instruments;
2) Mechanical Structure;
3) Control and Data Logging;
4) Infrastructure;

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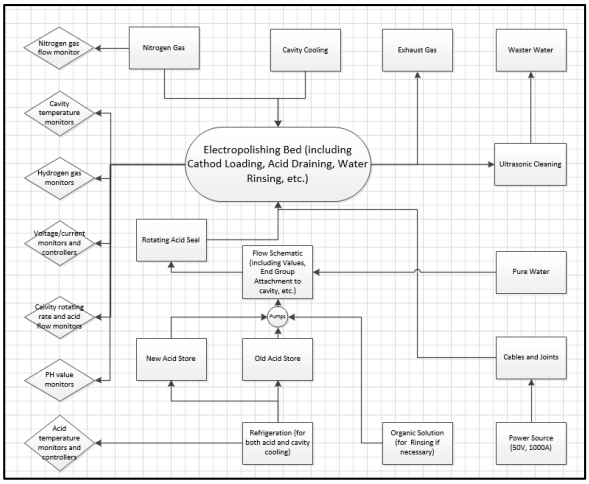

Figure 2: Main components for EP system.

Plumbing and Instruments

Plumbing and instruments part is mainly for the control of solution circulation in EP process. Several units of the system are belonging to this part. Following are the main units we listed:

1) Solution mixing unit
2) Storage unit
3) Circulation unit
4) Cooling unit
5) Hydrogen gas dilution.

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 of our 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 design, it will have a capability with a mixing rate of 50L/hour.

In the storage unit, several containers are prepared for various solutions including mixed fresh acid, bulk EP electrolyte, DI water, and waste solutions. Since we considered that the generation rate of DI water for rinsing after EP may not be overabundant by the existing DI water machine. So we prepared for a large tank for the storage DI water in advance.

The circulation unit is mainly for the electrolyte movement in the EP process. In this unit, the electrolyte lever in the cavity will be controlled at about 60% of cavity inside volume. The flow rate will be controlled by both pump and valves. There is also a heat exchange designed for the acid temperature control. In the unit, rotating sleeves will be also needed.

Cooling unit is mainly for providing cold water for three locations. Two locations are the heat exchanges for electrolyte mixing and electrolyte temperature control. The other one is for cavity outer surface cooling. There are two methods for cavity outside cooling. One is by wind which is used by KEK. Another is by cold water, which is used by JLab, ANL, etc. Here, we prefer to choose the second cooling method, by cold water cooling maybe flowing at upper of the cavities as ANL.

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. However, for this method we need to think about air filler to ensure cleanness of air which will be pumped into cavities.

Mechanical Structure

Mechanical structure mainly provides a support for cavities in EP process. There are two basic functions of this part for horizontal EP. One is to make cavities have a rotation along the axial direction. The other is that this structure can make cavities switchable from horizontal to vertical. When cavities are in polishing process, they will be at a horizontal direction. While, cavities will be at vertical direction in several cases, such as cathode assembly, electrolyte draining, water rinsing and so on. Actually, in the real fabrication, the accuracy of horizontal and vertical level also should be considered since we need control the electrolyte surface and cathode assembly.

Besides basic functions, several other structures we also need to consider in this part. One is cathode assembly structure. Cathodes used in EP usually a thin hollow bar. To avoid cathode to crashing the inner surface of cavity, it is better for cathode assembly at a vertical direction. In our design, an automatic structure is considered. Another is the compatibility for different types of cavities. So, the structure will be able to adjust at horizontal direction and have enough space at vertical direction. Besides, the joint between cavity jig and EP structure need to be considered by two aspects: mechanical and electric connections. Last, materials for the whole structure should avoid to etching and rusting.

Control and Data Logging

In the system, most controls and data logging will be automatically finished. The main controls and data logging are shown as following.

Controls:

- Leaking check;
- Air Pumping for H2 or nitrogen purge;
- Filter/mix acid;
- Rotate cavity;
- Fill/overflow cavity;
- Sweep voltage;
- Start polishing;
- Stop polishing;
- Tilt to vertical and drain;
- Rinse to Resistivity and drain;
- Tilt to horizontal;

Data logging:

- Current with voltage;
- Voltage and current with time;
- Rotation speed;

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- Flow rate;
- Temperatures：
  - Inlet and outlet of the cavity；
  - Three points on cathode surface
  - Outer Surface of the cavity;
  - All the containers;
- Level of solution at various container；
- Resistivity:
  - Rinsing;
  - cavity outside cooling;
- Hydrogen concentration ；

Infrastructure

Beside mentioned above, there will also be several other instruments in the system, such as power supply, chillers, gas monitors and so on. Power supply we choose is a direct current power supply which can be variable to 1000A and 50V. Two chillers with refrigerating capacity of 10kW and 20kW will be used for the cooling unit. The gas monitors is mainly for safety consideration, including HF hydrogen gas, and oxygen gas monitor. We also planned to fabricate a special cabinet outside the main part of EP mechanical system as a safety guard. Environment of EP system also needs to consider from temperature control and cleanness. Shower device and first-aid medicine will also be included.

For the DI water, ultrasonic clean, HPR, and waste disposal, they will be shared with existing infrastructures.

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. The electrolyte for bulk EP we designed can be used for several times for save cost. For fresh EP, the electrolyte will be only used for this process. In fresh EP, the temperature of electrolyte will be better controlled.

Besides, a pre-EP is also 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.

For the automatic control, we will use PLC and touch screen installed in the system. Furthermore, most operation can also be finish by an Industrial Personal Computer which can make some of operation status shown on line.

SCHEDULE

The whole system will be divide into several separated parts to fabrication or purchase. Then there will be an integration and commissioning process when the separated parts are finished. At present, we have finished the concept design. Several administrative processes also have been finished. The supplier survey is now underway. The process design will be finished by the cooperation between IHEP and the company we choose. We hope that all the separated parts can be finished in the end of this year. And the integration and commissioning can be finished in early of next year.

SUMMARY

A horizontal EP system will be developed at IHEP. The system is mainly for ellipsoid cavities like 500MHz single cell cavities, and will be compatible for1.3GHz 9-cell cavities and 650MHz 2 and 5-cell cavities. Concept design and administrative processes have finished. The supplier survey is underway. It is planned that all the assembly and commissioning can be finished in the early of next year, 2018.

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