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THE DESIGN OF AN AUTOMATED HIGH-PRESSURE RINSING SYSTEM FOR SRF CAVITY AND THE OUTLOOK FOR FUTURE AUTOMATED CLEANROOM ON STRINGS ASSEMBLY

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Abstract

High-pressure rinsing (HPR) and cavity assembly are two critical steps in cavity post-processing. Traditionally, high-pressure rinsing processing is based on ultra pure water system, pump, rinsing wand and simple-functional control system; cavity assembly processing is based on simple fixtures, wrenches, bolts and nuts. Beside the equipments, at least two operators are required in either of these two processing. Operators and their actions could bring mistakes and cause extra airborne particle contamination in cleanroom. To avoid the risk from labors, a robot has been introduced in IMP cleanroom for HPR assisting and assembly assisting. Labor cost and cavity RF test results are compared between the circumstances with and without robot assisting. In this work, an automated HPR system that has been designed and will be installed in IMP cleanroom will be presented. In addition, a future automated cleanroom on strings assembly will be discussed as well.

INTRODUCTION

Automation has been already applied in cleanroom on photovoltaic industry, semiconductor industry and pharmaceutical industry. The application aims to increase the production yield. For SRF cavities, cleanroom process is also used to increase the production yield, but there are less devices applied in cleanroom to finish these process automatically. Several years ago, the FRIB project introduced the robot in SRF cleanroom first time [1], which gave us a new orientation for cleanroom automation. Recently, a new robot has been applied in IMP cleanroom, which is assisting operators for HPR process and assembly. In this paper, the difference before and after robot application would be shown. According to our robot assisting experience, a new automated HPR system has been designed, which would be shown in this paper also.

Demands for Robot

There are five types cavities to be used on CiADS project, which are showed in Table 1. At 1967, the '*International Labor Conference*' gave a suggestion of maximum permissible weight to be carried by one worker. It was 50kg. On CiADS project, there are four types cavities over 100kg and the heaviest cavity is about 180kg. So if we think about handling these cavities manually, there are at least 5 technicians required for each cavity, which is impractical for clean room processing. So we need to find a new method to solve this problem.

Table 1: Cavity Types Used on CiADS Project

Cavity type	Quantity of cavities	Weight of cavities
HWR010	9	~50kg
HWR019	24	~180kg
DSR042	40	~180kg
Ellip062	40	~140kg
Ellip082	24	~140kg

AUTOMATION EXPERIENCE AT IMP

Robot Application in IMP Cleanroom

A robot had been installed in cleanroom at 2017 (Fig. 1). The primary goal for this robot is to assisting the processing and cleanroom assembly of HWR015 cavities which are about 120kg. The main parameters of the robot shown below:

- Cleanliness: ISO class 4 & ISO class 5
- Rated payload: 210 kg
- Pose repeatability: ±0.06mm
- Number of axes: 6

Figure 1: Robot installing and adjusting in cleanroom.

In 2018, the first HWR015 string with robot assisting during post-processing and assembly has been delivered. This string replaced an old string with same kind of cavity which is manually assembled in 2017. The cavities in these two strings came from the same vendor and showed similar FE onset fields in vertical tests.

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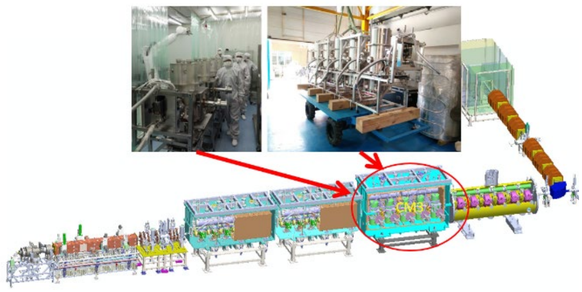

Figure 2: A new robot assisting strings had been assembled in cleanroom.

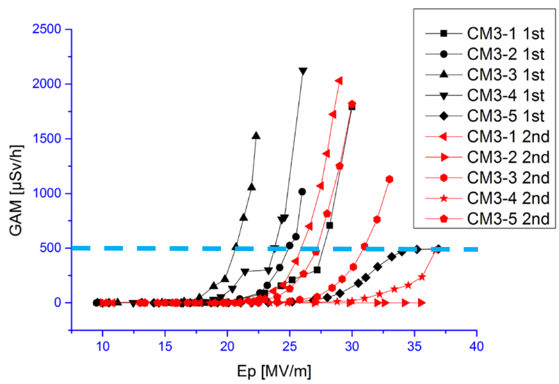

Figure 3: The gamma dose comparison between CM3 1st and CM3 2nd.

The online performance of these two strings are compared. For the manually assembled strings (CM3 1st), the alignment between flanges is very difficult even with the help of support frames. Because of that, it was pumped and vented five times due to vacuum leak. In addition, there were three operators needed in cleanroom for HPR process which naturally brought about more contamination. After the robot had been installed in our cleanroom (Fig. 2), because of the flexibility and maneuverability of the robot arm, the alignment between flanges was much easier than before. And with only one operator required for HPR process, the cleanliness in HPR region can maintain at a higher level. These phenomena all indicate robot assisted string should have a better cleanliness than the manually assembled one. The operational experience of our linac showed on Fig. 3 that the robot assisted string showed much better FE onset field and allowable working gradient, which is gamma dose less than 500 uSv/h.

Labor Saving

The summarized man-hour cost for the two situation is listed in Table 2. There are 18 man-hours saved with the help of a robot arm. Meanwhile, less operators in cleanroom means less contamination from human motion, and the maintaining of cleanliness will be easier.

Table 2: Labor Saving before and after Robot Applicaiton

Items	HPR	Cavity moving
Operators (before)	3	3
Hours (before)	8 hours	1 hours
Operators (after)	1	1
Hours (after)	8 hours	1 hours
Hours saved	16 hours	2 hours
Total hours saved	18 hours	

THE DESIGN OF A FULL AUTOMATED HPR SYSTEM

Mechanical Design

The structure of the automated HPR system is showed in Fig. 4. The cleanroom robot is still the core component in this system. The water shelter frame, linear motion system, spray wand, and rotate water feed through can be the same as used in traditional HPR system. In this system, alignment is the critical issue. The control system should have the ability to detect the cavity status and ensure the cavities aren't collided by the spray wand.

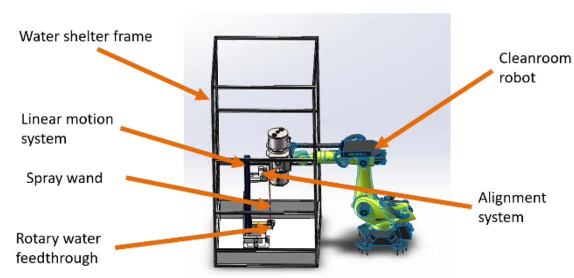

Figure 4: the mechanical design schematic of automated HPR system.

Control System Design

The schematic of the control system is showed in Fig. 5. The PLC will be used to control all the components including motors, pumps, robot and valves. Human-machine interface will be used for program selecting and manual control. This system will be finished in the next a few months and will be used in IMP cleanroom.

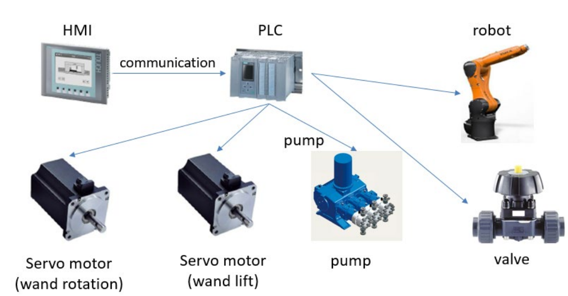

Figure 5: the schematic of the control system.

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CONCLUSION

According to these experience, we can reach the following conclusions. First, robot assisting can better handle the heavy cavities comparing with human hands and support frames. Second, robot assisting could bring maneuverability and flexibility to the assembly process. We believe this will help to increase the RF performance. Third, robot assisting can reduce the manpower needed in cleanroom. More RF and cleanliness result compared between traditional HPR system and automated HPR system will be tested and showed in the future.

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