A FLEXIBLE SYSTEM FOR THE HIGH PRESSURE RINSING OF SRF CAVITIES*

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Abstract

The Physics Division SRF group at Argonne National Laboratory has built a new, high pressure rinse system for the joint ANL/FNAL Superconducting Cavity Surface Processing Facility (SCSPF). The rinsing tool can be easily reconfigured vertically or horizontally to process a variety of SRF cavity shapes and sizes including elliptical, spoke, quarter- and half-wave cavities. The system has been commissioned with a new 72 MHz β=0.077 quarter-wave cavity as part of the ATLAS Intensity Upgrade at ANL. The tool is also designed to rinse 1.3 GHz elliptical single-cell and 9-cell cavities, as well as the new 650 MHz elliptical cavities under development for Project-X and Fermilab.

INTRODUCTION

A high pressure rinsing system was needed for post electropolishing (EP) processing of the new quarter-wave resonators (QWR) for the ATLAS Intensity Upgrade at Argonne National Laboratory (ANL). Post EP high pressure rinsing (HPR) of niobium can result in a >99% reduction in surface particulates [1], reducing the chance of field emission. The locations of the four cavity ports and two beam ports make it necessary for an HPR tool with the flexibility to accommodate those locations. Therefore the HPR tool was designed with both a rotating cavity mount and a spray wand which was attached to a variable positioning arm. These two features enable the tool to accommodate virtually any type of cavity, including QWR, half-wave resonators, elliptical cell, and spoke cavities.

TOOL DESIGN

2-Hinged Arm

In order to accommodate the various locations of ports on different cavity types, the HPR wand was mounted on a 2-hinged arm (see Figure 1). The two pivot points allow the wand to be positioned anywhere within the 26" radius of the arm base. Once the wand has been located properly, two wing nuts are tightened down, locking the wand in a fixed position for cavity rinsing. All moving parts are located below the cavity, minimizing particulate contamination.

The arm was made out of aluminium because of its strength and light weight. These qualities minimize the deflection of the wand due to the weight of the tool. After machining, the aluminium was clear anodized to make it resistant to the de-ionized (DI) water used to rinse the cavities.

The hinge pins located in the two pivot points of the arm are made of 316 stainless steel. PEEK bushings are inserted between the pins and the aluminium arms, providing high strength and low friction.

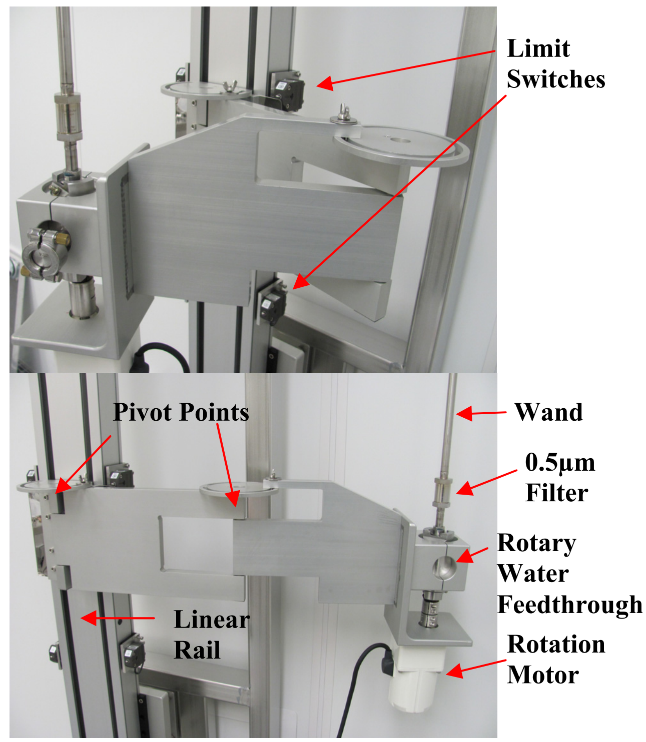

Figure 1: Mounting the HPR rinse wand on a 2-hinged arm allows for the rinsing of any port within the 26" radius.

Wand

Different cavity geometries require different spray patterns in order to adequately rinse the cavity rf surface. Spray patterns can be changed by simply changing the wand on the HPR tool. Currently, the bottom of the wand is welded to one half of a filter. This filter half can be unscrewed from the other half, and the wand can be switched with another wand with a different spray pattern (see Figure 1). Fabrication is already underway on a new, cleaner, method of attachment which uses sanitary fittings instead of threaded fittings. The filter halves will no longer need to be unscrewed in order to switch the wand out; rather just a single sanitary fitting will need to be undone. All welds are full penetration welds in order to eliminate even small dead zones which may promote the growth of bacteria.

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A nozzle is welded onto the top of each wand. The flow pattern of each nozzle is tailored to individual cavity geometries. One requirement is that the vector forces of the water jets exiting the nozzle sum to zero. This ensures that the wand will not deflect when the high pressure pump is turned on.

Drive System

The movement of the wand is controlled with two motors. The first is a water tight motor responsible for rotating the wand (see Figure 1). It has a set speed of 15 RPM and is turned on and off by the operator via a toggle switch. The second motor moves the wand vertically along the linear rail it is attached to. The operator sets the speed and direction of the motor and it stops moving when a limit switch is reached. Several limit switches are placed on the linear rail, allowing the operator to select a range of distances for the wand to travel, accommodating various geometries.

Plans have been made to replace the motor responsible for the vertical motion of the wand with a PLC driven motor. In doing so, programs can be made for different cavity types. Also, it will eliminate the need for the operator to watch the tool and switch the direction of travel when the limit switch is reached.

Rotating Cavity Mount

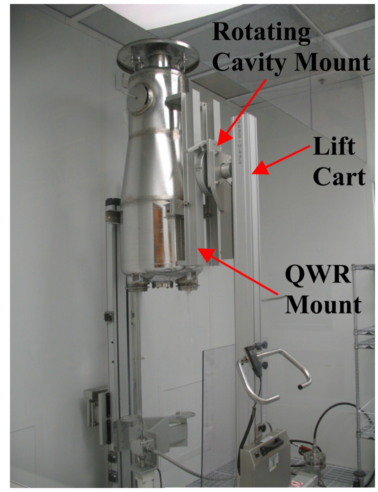
In order to rinse through ports on opposite ends of the cavity, the cavity must be able to rotate. This is accomplished with a rotating cavity mount attached to the lift cart (see Figure 2). The mount permits 360° rotation in 90° increments. In addition to rinsing through ports located on various sides of the cavity, this feature also allows for clean assembly of the cavity. The hardware can be attached with the ports facing down and the operator underneath the cavity.

In order to switch between cavity types, a cavity holder specific to that cavity type is attached to the rotating cavity mount. Four bolts hold the specified cavity holder firmly in place. By attaching the cavity holder directly to the cavity rotation mount the ability to rotate the cavity is retained for all cavity types.

ROOM FEATURES

Cart

The HPR tool consists of two main pieces: the linear rail which the wand travels vertically on, and the cart to which the cavity is attached. Two cones are attached to the base of the cart. One slips into a slot on the HPR tool and the other stops against a flat plate. The cart is then locked in place using two clamps. This allows for repeatable placement of the cavities. Furthermore, this feature allows the cavity to be attached to the cart when it first enters the clean room. It can then be rinsed, assembled, and moved about the room without removing it from the cart. Figure 3 shows how the cart is locked in place.



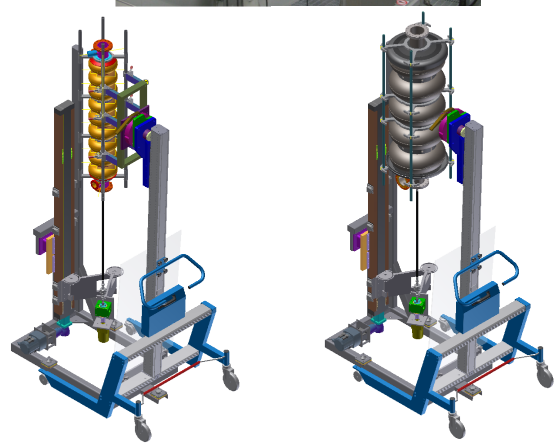


Figure 2: The tool can accommodate virtually any type of cavity. Shown are a 650MHz 5-cell elliptical cavity (bottom right), a 1.3 GHz 9cell elliptical cavity (bottom left), and a 72MHz quarter wave resonator cavity (top).

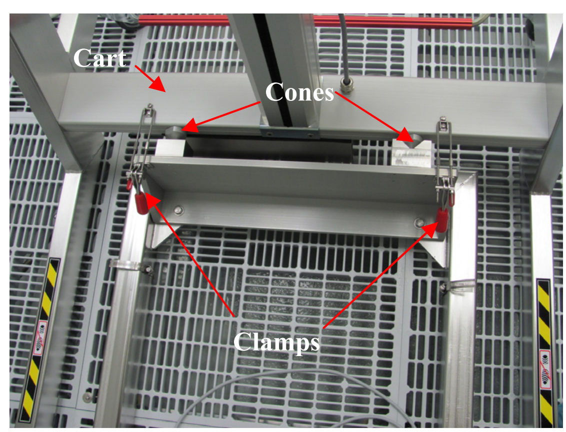


Figure 3: A mounting block and tie down clamps for the cart ensures repeatable positioning of the cavity. This also provides the ability to move the cavity about the room, rinse it, and assemble it without removing it from the cart.

Hand HPR

A hand held HPR wand has been installed in the clean room as well. It is used to HPR the hardware in the room, saving time when compared to blowing the hardware off with pressurized N_2. This HPR is also used in the weld preparation of cavity parts. All cavity parts at ANL receive a short (5 µm) buffered chemical polish, followed by HPR before they are welded together. A stainless steel trigger gun (see Figure 4) enables the operator to turn on and off the water stream as desired. The hose is long enough to reach every corner of the room.

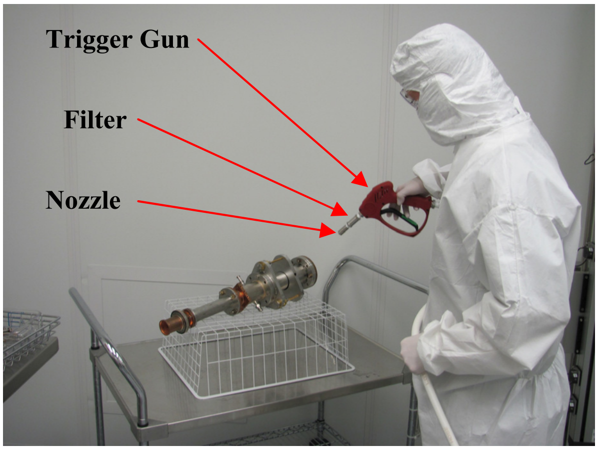


Figure 4: A hand HPR wand allows the operator to rinse the hardware, rather than blowing the hardware off with N_2, saving time. A 0.5 µm filter is located just before the nozzle of the tool, and removes possible particulates from the trigger mechanism.

Water Filters

All DI water used for high pressure rinsing is run through filters to eliminate particulates. The DI water for the HPR of cavities is run through two 0.04µm filters and a final 0.5µm filter. This final filter is located after the rotary water feedthrough of the HPR wand (see Figure 1).

The DI water for the hand HPR is run through one 0.04µm filter and then one 0.5µm filter. The 0.5µm filter is located after the trigger gun for the purpose of catching possible particulates from the trigger gun.

Nitrogen Purge

The SCSPF is supplied with N_2 at 80 PSI. When the HPR system is not in use, the N_2 is run through the water lines. This dries the lines and reduces the possibility of bacterial growth in the system.

Table 1: HPR Operating Parameters

Operating Parameter	**Quantity**
Water Flow	3.5 GPM (13 L/min)
Water Filters	3 (Two 0.04 µm and one 0.5 µm)
Water Pressure	1200 PSI (8274 kPa)
Water Quality	17.75 MΩ·cm
Wand Rotation Speed	0-7.36 in/min (0-18.7 cm/min)
Clean Room Rating	Class 100
Cart Capacity	500-600 Lbs (227-272 kg)

Some aspects of the HPR tool are constant between all cavity types. This is due to the hardware used in the room. All these specifications of the HPR tool are summarised in Table 1.

RESULTS

A prototype 72 MHz QWR cavity for the ANL ATLAS Intensity Upgrade was high pressure rinsed using the new HPR tool at ANL. After a complete, jacketed electropolish [2] and an HPR of the cavity, it achieved a world record performance for this class of cavity. Q-curve results can be seen in Figure 5 [3].

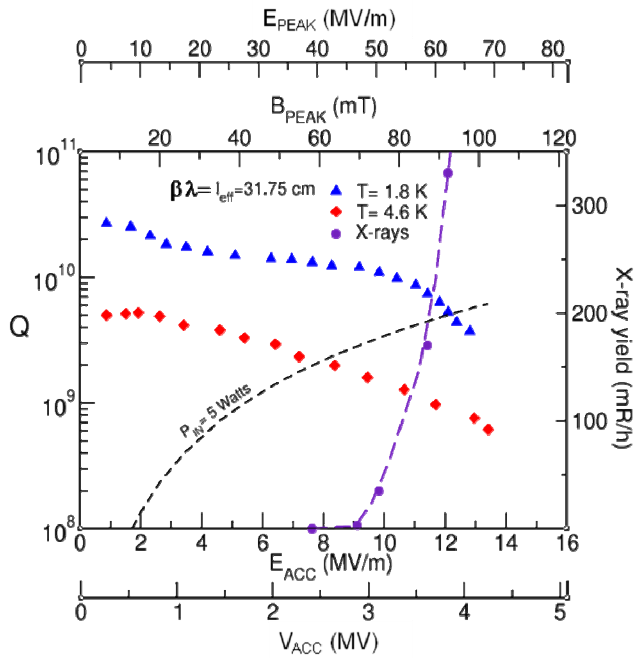


Figure 5: A Q-curve of the new prototype 72 MHz QWR cavity processed at ANL for the ATLAS Intensity Upgrade.

CONCLUSION

A new, flexible, HPR tool has been built at the ANL/FNAL SCSPF. Attaching the wand to a two-hinged arm and the cavity to a rotating cavity mount are the key features behind the tool's ability to accommodate various cavity types.

REFERENCES

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[2] S. M. Gerbick, et al., "A New Electropolishing System For Low-Beta SC Cavities," Proceedings of the 15th International Conference on RF Superconductivity, Chicago, IL, USA (2011).

[3] M. P. Kelly, et al. "SRF Advances for ATLAS and Other β<1 Applications," Proceedings of the 15th International Conference on RF Superconductivity, Chicago, IL, USA (2011).