FURTHER IMPROVEMENTS WITH DRY-ICE CLEANING ON SRF-CAVITIES

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Abstract

Looking for advanced potentials to clean surfaces of superconducting accelerator cavities, a dry-ice cleaning method promises to be a useful additional final cleaning step to the standard high pressure rinsing with ultra pure water. Dry-ice cleaning using the sublimation-impulse method removes particles and film contaminations, especially carbon-hydrates, without residues. First cleaning tests on single-cell cavities showed Q-values at low fields up to 4x1010 at 1.8 K. Gradients up to 32 MV/m were achieved, but field emission still is the limiting effect. Further tests are planned to optimize the dry-ice cleaning technique.

INTRODUCTION

Although many improvements of Cavity preparation procedures had been done, enhanced field emission still limits the high gradient of superconducting cavities [1].
Advanced final cleaning steps and handling procedures must be applied to avoid surface contaminations like particles and hydrocarbons etc.. High pressure rinsing with ultra pure water is a powerful method to reduce enhanced field emission, but dry-ice cleaning might have additional cleaning potential.Dry-ice cleaning avoids a wet cavity surface,removes carbonhydrates and is applicable to ceramics, so the possibility to clean a cavity with power couplers is given. First tests on flat Nb samples and on single-cell cavities [2] showed promising results, so that additional improvements on the dry-ice cleaning apparatus had been installed.

DRY-ICE CLEANING

A jet of pure carbon dioxide snow is able to remove different types of surface contaminations by a combination of mechanical, thermal and chemical effects. Relaxation of liquid CO_2 in a nozzle (Figs.1,2), results in a snow/gas mixture with app. 45 % snow with a temperature of 194.3 K. In addition a supersonic jet of N_2 surrounds the CO_2-jet so that an acceleration and focussing of the jet is given. Furthermore the N_2 partially prevents condensation of humidity on the cavity surface.The mechanical cleaning effect is based on shock-freezing of the contaminations, strong impact of the snow crystals and a 500 times increasing of volume after sublimation. Contaminations get brittle and start to flake off from the surface. When snow particles hit the surface and melt at the point of impact, the chemical cleaning effect occurs. Liquid CO_2 is a good solvent especially for hydrocarbons and silicons. For an optimal cleaning process, it is necessary to reach a high thermal gradient between jet and surface. Furthermore an exhaust system is needed as safety protection and to carry out contaminations. Basic cleaning parameters are shown in Table 1.

Table 1: Dry ice cleaning parameters

CO_2-pressure	~ 50 bar
N_2-pressure	12 – 18 bar
Particle filtration	< 0.05 µm
Temp. of liquid CO_2	-5° - -40° C
Enviroment of cleaning	Laminar flow class 10

Figure 1: Nozzle inside a cavity

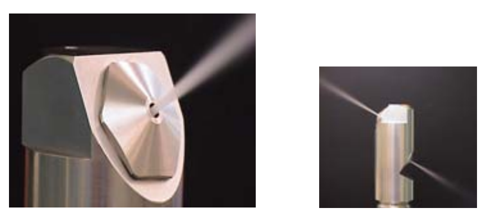

Figure 2: Nozzle system

IMPROVEMENTS

Applying dry ice cleaning as final preparation step, a horizontal orientation of a cavity during cleaning is necessary. High pressure rinsing is only applicable in vertical direction. Also cleaning of multicell cavities in the future will be much easier. In the new apparatus the cavity therefore is installed horizontally.

A new purifier with more capacity is installed. The approved maximum temperature of -5° C can be kept. Cooldown-time is now not longer than 15

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minutes (before > 1h). Compared to the previous tests [2] a permanent operation is possible.

To ensure a high thermal gradient, a heating-system with IR-heaters is installed. Without any heaters water will freeze on the outer cavity-surface in a very short time.

Temperature of cavity, concentration of CO_2 in room-air and exhaust is now monitored and will in future be controlled by software.

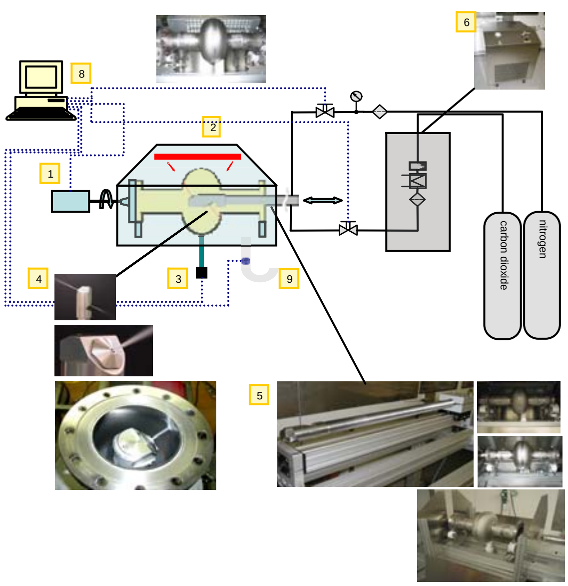

Figure 3: Schematic layout

Figure 3 shows some new objects which have been installed. Infrared-Heater (2), Infrared-Temp.Sensor (3), horizontal nozzle system (4,5), new liquifier (6), motion control and monitoring (8), exhaust of N_2 and CO_2 (9).

CAVITY TEST RESULT

All RF-tests show typical Q-values above 10^{10} at 2 K for superconducting cavities at 1.3 GHz. The highest Q-value of 4 x 10^{10} at 1.8 K indicates that almost no surface contamination is caused by dry-ice cleaning. Gradients up to E_{acc} = 33MV/m are achieved, but still more optimization of cleaning process and handling procedure has to be done to reduce field emission, which still is the limiting effect. Fig. 4 shows RF-test results of a 1-cell Cavity cleaned with old and improved dry-ice cleaning apparatus. Between the tests the cavity was stored under air for several months and no high pressure water rinsing was applied to the cavity.

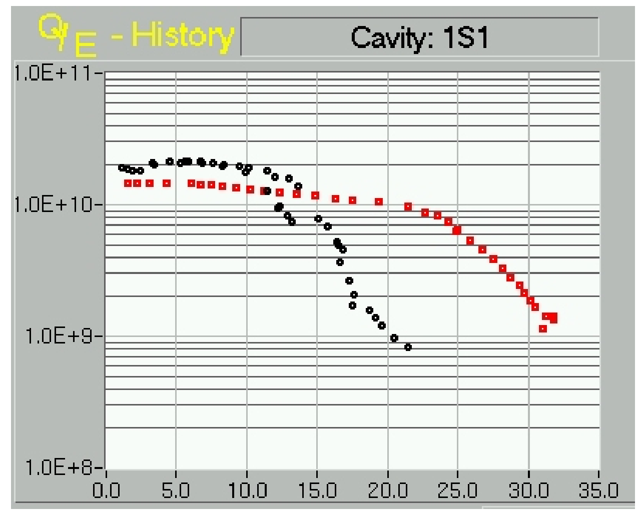

Figure 4: Q/E_{acc}-performance of a 1-cell cavity. Test after dry-ice cleaning with old setup (black). Test after storage under air and dry-ice cleaning with optimized equipment (red).

SUMMARY

Test results show that in principle no previous cleaning steps with high pressure water rinsing are necessary to obtain high Q-values and Gradients. The major problem is still field emission, but there is evidence that handling of the cavity after cleaning is the limiting factor. Heating the cavity, to reach a high thermal gradient, needs further optimization. A countoured Infrared-Heater with an optimal wavelength, adequate to Niobium is ordered and will be installed in near future. Optimization of cleaning parameters like speed of nozzle support, rotation speed of the cavity and pressure of N_2 etc. is in progress.

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