Statistical Analysis of the 120°C Bake Procedure of SRF Cavities.

TUP020

L. Steder*, D. Reschke, DESY Hamburg, Germany



120°C bake procedure

The bake procedure is applied as last step of a cavity surface preparation to cure the high field Q-slope. At DESY a simple setup with heating coils is used with systematic uncertainties of $\Delta T \approx 0.5^{\circ}C$ (5°C) over a single (nine) cell cavity height.



data sample and selection

Almost 400 bake procedures at different temperatures are recorded in the DESY cavity database[†] for non-XFEL-series cavities. Parameters like number of cells, manufacturer, surface treatment and test locations at DESY are different.

results deduced from

- best test (in terms of Q₀ @ 7 MV/m) after bake, in case multiple tests existing
- last power rise of vertical test @ 2K

statistics not sufficient to answer all questions

With the help of the data sample a search for an optimal working point for future heat treatments is performed. Main parameters are duration and temperature of the bake procedure:



 no exotic cavities/treatments, no unclear histories, only bake procedures applied at DESY

data sample

- 158 vertical test of 111 individual cavities
- 26 single-cell, 2 three-cell & 83 nine-cell cavities of different manufacturers

data presentation

- maximal accelerating gradient, Q₀ @ 7 MV/m and residual resistance distributions versus baking temperatures
- mean value including σ/\sqrt{N}
- complete sample, different baking durations and XFELseries cavities results
- bin width 5°C: optimisation of statistics versus non-existent bin center correction
- linear fits for complete data sample over whole temperature range and for central bins with most entries









Statistics not sufficient for further distinction concerning:

- test limit (break down, field emission, power limit)
- material (large/fine grain, Niobium vendor)
- surface treatment (EP, BCP, bake with Argon)
- cavity performance at temperatures below 2K

observations

For all three parameters (maximal accelerating field, $Q_0 @ 7 MV/m$ and residual resistance) a slight rise towards larger temperatures are visible, at least for the three central bins, even though the error bars are partially very large. In case of the residual resistance, larger values correspond to worse performance, but at 130°C the resistance drops again. The differentiation according to bake durations does not allow entries in all bins and only an uncertain interpretation of better results towards shorter heat treatment periods.

modified low T bake procedure

- FNAL suggests: 4 hrs @ 75°C + 48 hrs @ 120°C
 [arXiv:1806.09824]
 - ⇒ outstanding results for accelerating gradients and quality factors



temperature and duration optimisation for future bake procedure

In order to judge the above shown results one combined overview is available on the right, containing:

- Q₀ @ 7 MV/m and 23.6 MV/m, maximal accelerating gradient, residual resistance
- individually normalized to 120°C value (standard working point)

Optimization for smallest possible residual resistance and simultaneously large quality factors as well as accelerating gradients

- clearly points to 130°C
- a slight tendency towards procedures shorter than 48 hours (compare plots above) existing



summary

- DESY: 3 cavities treated
 - ⇒ early Q-slope vanishes, absolute Q₀-values slightly better,
 - expected effect for standard procedure
- comparison sister cavities of CAV00351 & CAV00354 standard 48 hrs @ 120°C, (XFEL-series)
 - \Rightarrow similar results for both treatments

Although much data about cavity heat treatments exist at DESY, it is hard to draw strong conclusions. The baking temperature will be **optimised to 130°C**. In terms of cost saving and time consumption it makes sense to reduce the duration of the bake procedure to **24 hours** and **re-evaluate the results** after the collection of some more statistics.

Since the **modified low temperature bake** was up to now **not as successful as reported** by FNAL it will be tested further. Hence, for the next cavity bake procedures a mixture of both procedures will be performed at DESY. At the moment eight cavities are either waiting or are already treated with **4 hours at 75°C followed by 24 hours at 130°C**.

Test results will be reported soon.

* lea.steder@desy.de

+ http://tesla.desy.de/oracle/docs/StartPage/



