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CORRECTIONS OF A SUPERCONDUCTING CAVITY SHAPE DUE TO ETCHING, COOLING DOWN AND TUNING

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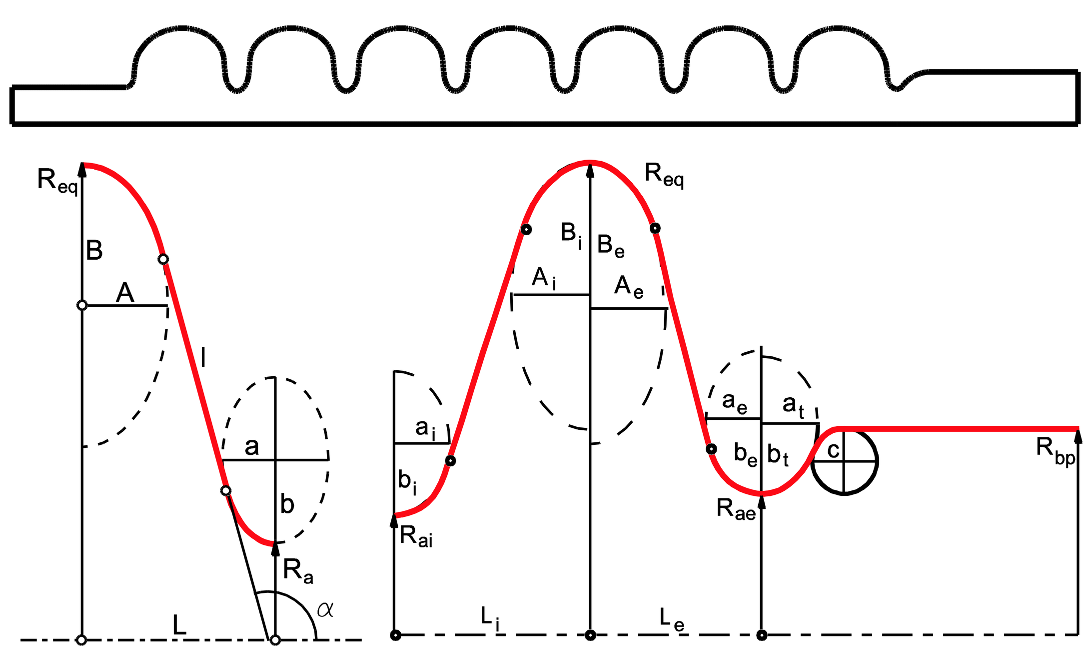
A convenient method to calculate corrections of the cavity shape from theoretical final dimensions to the drawing dimensions for mechanical workshop is presented. This matrix method can take into account changes of the cells shapes due to cooling down to cryogenic temperature, chemical etching, and mechanical tuning.



A multicell cavity (upper picture) and its presentation as a chain of elliptic arcs connected with straight segments: inner half-cell and end cell (lower pictures). End cells can have an additional iris: compare the right and left ends on the upper picture.

A full description of the dimensions of such a cavity excluding the lengths of end pipes can be presented as a matrix:

$$\dim = \begin{pmatrix} x1 & x2 & \dots & xn \\ y1 & y2 & \dots & yn \\ a1 & a2 & \dots & an \\ b1 & b2 & \dots & yn \end{pmatrix}$$

In the first line of the matrix are longitudinal coordinates of the centers of the elliptic arcs, in the second line – the radial coordinates of the centers, in the third and fourth – longitudinal and radial half-axes of the ellipses, respectively.

From final (dim_f) to start (dim_s) dimensions:

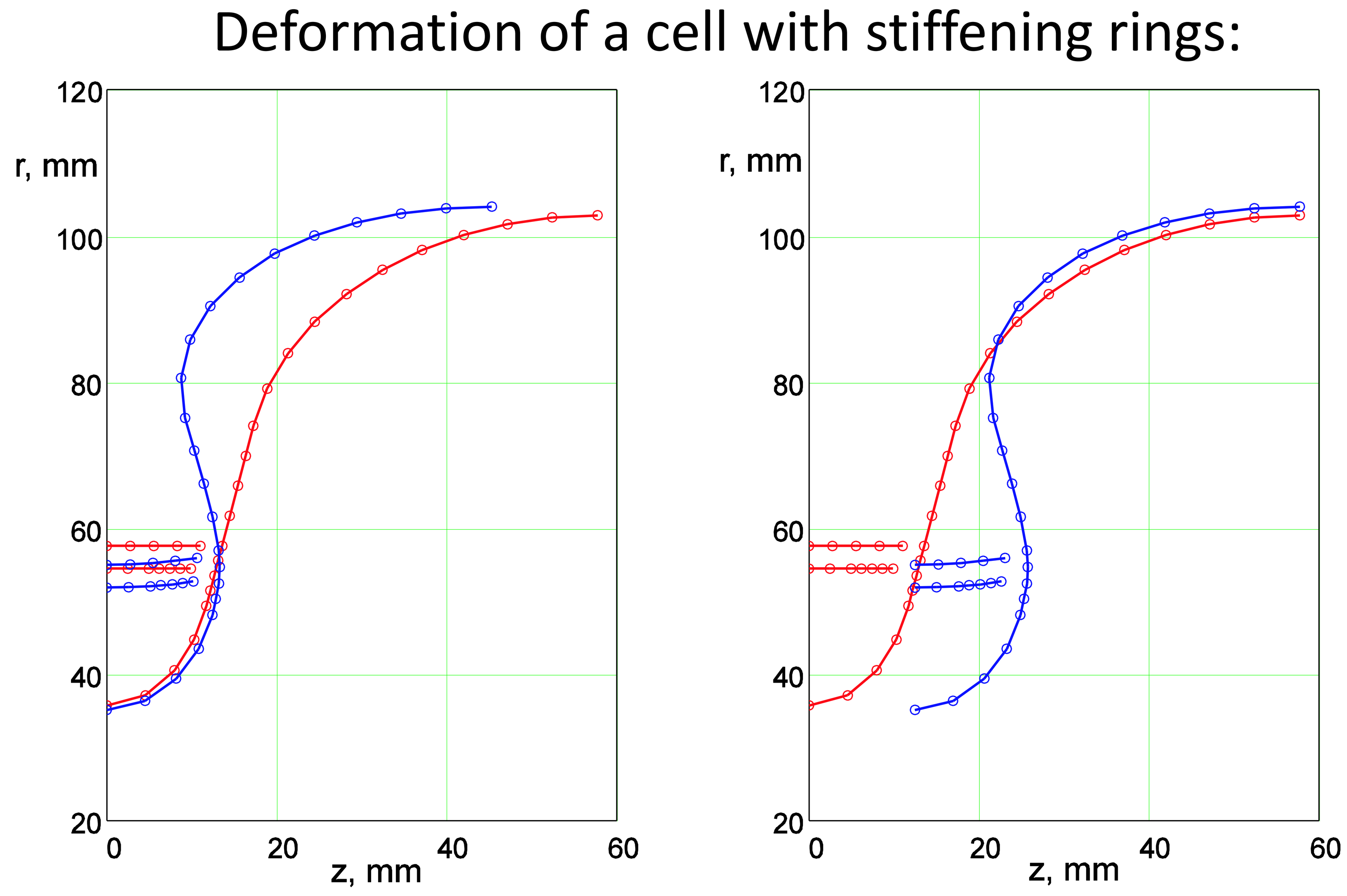
Cooling down: $\dim\_ s = \dim\_ f \cdot (1 + kT).$

Etching:

$$\text{Etch} = \begin{pmatrix} 0 & 0 & \dots & 0 \\ 0 & 0 & \dots & 0 \\ ex1 & ex2 & \dots & exn \\ ey1 & ey2 & \dots & eyn \end{pmatrix}$$

ex1, ey1 and so on are depths of etching (BCP, EP)

Deformation of a cell with stiffening rings:



Iris is fixed

Equator is fixed

Deformation magnified x1000. One can see that deformation is due mainly to the slope of the straight segment.

Deformation of the half-cell with stiffening rings. See picture: Outer surface of the cavity is not shown. After deformation the shape keeps elliptic arcs with a straight segment between them.

P is the matrix of "pliability":

$$\text{P} = \begin{pmatrix} px1 & px2* & \dots & pxn* \\ py1 & py2 & \dots & pyn \\ pa1 & pa2 & \dots & pan \\ pb1 & pb2 & \dots & pbn \end{pmatrix}$$

*px*1, *py*1, … and so on are coefficients in the relations:

$\Delta x1 = px1 \cdot \Delta L, \quad \Delta y1 = py1 \cdot \Delta L,$ and so on.

ΔL is total compression of the cavity. Asterisks designate the cumulative values:

$$px2* = px1 + px2, \quad px3* = px2* + px3, \quad \dots$$

All the corrections are small, so we take into account the first order only and unite them in the final formula:

$$\dim\_ s = \dim\_ f \cdot (1 + kT) - \text{Etch} - \text{P} \cdot \Delta L.$$

Example for the Cornell ERL case:

Final dimensions: etched (150 um), cooled down to 2K, pre-tuned by 300 kHz (stretched to cancel backlash):

$$\dim\_ f = \left(\begin{array}{cccc|cc|cccc} 318.54 & 354.42 & 354.42 & 412.42 & 0 & 57.65 & 1104.25 & 1161.39 & 1161.39 & 1197.26 \\ 19 & 56.95 & 60.30 & 62.35 & 67.31 & 57.12 & 62.35 & 60.03 & 56.96 & 19 \\ 36 & 11.27 & 12.49 & 41.51 & 41.35 & 12.35 & 40.91 & 12.57 & 11.28 & 36 \\ 36 & 20.95 & 24.30 & 40.53 & 35.57 & 21.14 & 40.53 & 24.02 & 20.95 & 36 \end{array}\right).$$

Starting dimensions: for the production drawings:

Left end group inner cells right end group

$$\dim\_ s = \left(\begin{array}{cccc|cc|cccc} 318.91 & 354.93 & 354.93 & 413.01 & 0 & 57.74 & 1105.83 & 1163.05 & 1163.05 & 1199.07 \\ 19 & 57.04 & 60.39 & 62.44 & 67.41 & 57.20 & 62.44 & 60.12 & 57.04 & 19 \\ 36 & 11.44 & 12.66 & 41.42 & 41.26 & 12.52 & 40.82 & 12.74 & 11.44 & 36 \\ 36 & 21.13 & 24.48 & 40.44 & 35.47 & 21.32 & 40.44 & 24.21 & 21.13 & 36 \end{array}\right)$$

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, and CHESS resources have merged and a new lab, (CLASSE), has formed. CLASSE develops and operates facilities and provides infrastructure for the study of beams and accelerators, photon science, particle physics and the early universe, serving students, the public and scientists from Cornell and elsewhere. LEPP's primary source of support is the National Science Foundation.