Impact of Medium Temperature Heat Treatments on the Magnetic Flux Expulsion Behavior of SRF Cavities

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Experimental Goal
1. Investigate magnetic flux expulsion behavior as a function of:
   ➢ cool down velocity \( v_c \)
   ➢ spatial temperature gradient \( \nabla T \)
   for the large-grain test cavity 1DE26 before- and after mid-T heat treatment for assumed technical extrema of:
   - 5 K/h and -20 K/h for \( v_c \)
   - 0 \( \Delta T/l \) and 4 \( \Delta T/l \) for \( \nabla T \)
to maximize likelihood of significant measurement results
   (\( \Delta l \) represents the distance between used reference thermocouples located at the upper and lower iris of 225 mm)
2. Study the impact of mid-T heat treatment on sensitivity to trapped magnetic flux

Setup Characteristics
➢ Ensure consistent test conditions
➢ Setup operated in an ambient field of 10 \( \mu T \)
➢ Spatial mapping of magnetic flux density by 621 AMR-sensors
➢ Based on HZB approach [1,2]

Setup Limitations
➢ Inclined \( T \) transition due to an asymmetrical helium flow
➢ Asymmetrical expulsion of magnetic flux

Magnetic Flux Expulsion Behavior (large-grain material)
➢ No impact of cool down velocity & mid-T heat treatment on expulsion behavior
➢ Large impact of spatial temperature gradient:
   - 0 \( \Delta T/l \): 26 % of magnetic flux expelled
   - 4 \( \Delta T/l \): 69 % of magnetic flux expelled

Conclusions
➢ No significant impact of cool down velocity and mid-T heat treatment on flux expulsion behavior of large grain cavity 1DE26 observed
➢ Large impact of spatial temperature gradient on flux expulsion behavior:
   0 \( \Delta T/l \): 26 % of mag. flux expelled; 4 \( \Delta T/l \): 69 % of mag. flux expelled
➢ Only sensitivity to trapped magnetic flux increased by a factor of five due to mid-T heat treatment:
   0 \( \Delta T/l \): 3.5 nΩ/μT(bef. mid-T) to 17.7 nΩ/μT(aft. mid-T); 4 \( \Delta T/l \): 3.1 nΩ/μT(bef. mid-T) to 15.7 nΩ/μT (aft. mid-T)

References

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Experimental Setup

Sensitivity to Trapped Magnetic Flux S
➢ Increase of \( S \) by a factor of five after mid-T heat treatment:
   - 0 \( \Delta T/l \): 3.5 nΩ/μT to 17.7 nΩ/μT; 4 \( \Delta T/l \): 3.1 nΩ/μT to 15.7 nΩ/μT

\[ S = \frac{\Delta P_{\text{trap}}}{P_{\text{trap}}} \]

\( \Delta P_{\text{trap}}, \Delta S : \text{Increase of} R_s \text{ per unit of trapped magnet. flux} \]

The surface resistance \( R_s \) given in the legend was obtained by cubic interpolation for an accelerating gradient of 4 MV/m.

References