TEST RESULTS FOR A COLD MODEL OF A CCDTL TWO GAP TO THREE GAP TRANSITION REGION[*]

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Abstract

As part of the APT [1] project we have tested several cold models of a Coupled Cavity Drift-Tube LINAC (CCDTL) [2,3] 2 to 3 gap transition region. This is the region where cavities change from having 2 gaps and 1 drift tube per cavity to having 3 gaps and 2 drift tubes per cavity. We have established that frequency effects of coupling slots can be accurately predicted allowing calculation of the cavity frequencies within the allowed tuning range. The base cavity frequency is very accurately predicted by SUPERFISH and correction for stems and tuners is well established, the major uncertainty prior to these tests was predicting the frequency effect of the coupling slots. These tests have also shown that the cell-to-cell coupling for a given slot geometry can be predicted accurately enough to allow a minimum of slot tuning range to be left in the structure. A large desired field tilt between the two coupled accelerating cavities can be set up by varying the cell-to-cell couplings between the accelerating cells and the coupling cells. Further, the tilt can be predicted accurately enough to allow a minimum of slot tuning range to be left in the structure.

1 INTRODUCTION

We have tested and tuned 3 cold models (CMs) of a CCDTL 2-to-3 gap transition region. These three cold models differed only in detail dimensions, the first cold model was not extensively tested. The transition is the region in a CCDTL where the CCDTL cavities change from having 2 gaps and 1 drift tube (DT) per cavity to having 3 gaps and 2 DTs per cavity. The CMs are of structures from an early version of the APT LEDA [4], designed for a transition 8.09 MeV. A drawing of one of the CMs is shown in figure 1. In this design the transition occurred between Acc24 (accelerating cavity 24) and Acc25 (accelerating cavity 25). The CMs include ½ of a 2-gap cavity (Acc24), a complete coupling cavity (CC24-25), and ½ of a 3-gap cavity (Acc25). The current version of LEDA has the transition at 10.16 MeV between Acc49 and 50.

There were three principle issues to be addressed by these tests.

1) Could the required E_0 field tilt between the 2-gap and 3-gap cavities be established. Nominally the E_0TL for the two cavities should be equal, ignoring any additional field ramp? Since the 3-gap cavity is approximately 3/2 longer than the 2-gap cavity, the E_0 for the 3-gap cavity needs to be approximately 2/3 that of the 2-gap cavity. We needed to know if the tilt could be predicted accurately enough to minimize the required slot tuning range. The tilt is set by the difference in coupling between the respective cells and the common coupling cell.

2) Could the coupling produced by a given slot size be calculated accurately enough to allow a minimum of extra material to be left in the slot region, allowing the maximum use of available space in cramped areas? We are calculating the coupling produced by a given slot along the line described by J. Gao [1]. In addition if the coupling can be predicted accurately then the slots can be cut close to (or right on) the final dimension,

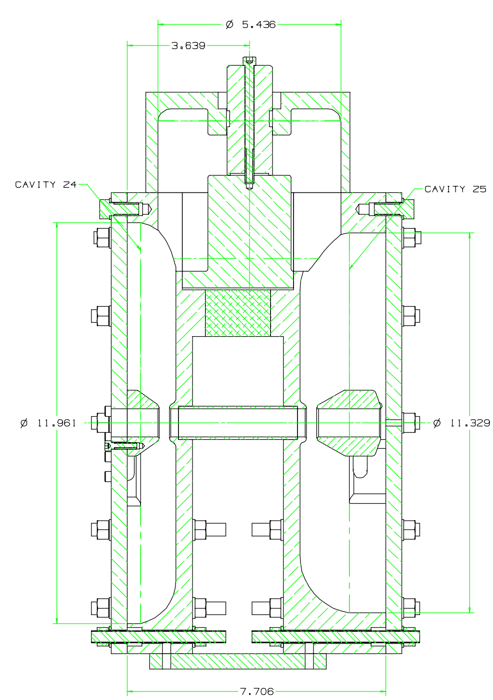

Figure 1: Drawing of transition region cold model.

[*] Funding provided by U.S. Department of Energy.

minimizing the coupling slot tuning required.

3) Could the frequency of the accelerating and coupling cavities be predicted accurately enough so that the cavities would be within the allotted tunable range? The base cavity frequency is very accurately predicted by SUPERFISH and corrections for stems and tuners are well established. The major uncertainty was predicting the frequency effect of the coupling slots.

2 FIELD TILT AND COUPLING MEASUREMENTS

The second cold model to be fabricated was slightly off frequency but was tunable and usable for field and coupling measurements. Table 1 shows the frequencies of Acc24, Acc25, and CC24-25 measured with the other cells shorted (with rods shorting the cavity gap along the cavity axis) as the cavities were tuned to 702 MHz with two rounds of tuning cuts.

Table 1: Measured individual cavity frequencies for the second cold model with all other cavities shorted.

Meas	1	2	3
Acc24 Fmeas	702.013	702.040	701.996
Acc25 Fmeas	705.253	702.639	702.589
CC24-25 Fmeas	707.645	702.310	701.982

During each tune step the mode frequencies were measured. These mode frequencies are used in the modal analysis program DISPER [2] to calculate the accelerating cavity frequency, the coupling cavity frequency, and the coupling for an infinite string of coupled cavities assuming that all of the coupling cavities, all of the accelerating cavities, and all of the couplings are the same. The “average” coupling, calculated by DISPER, is the best available for evaluating the cold model and is used throughout these tests. Table 2 shows the measured mode frequencies and the Acc and CC cavity frequencies and coupling calculated by DISPER. The final k_{avg} value calculated by DISPER is 4.63%, 93.72% of the target average coupling of 4.94%.

Table 2: Measured Mode frequencies, and DISPER calculated cavity frequencies and couplings.

Meas	1	2	3
0 Mode	689.900	686.764	686.602
π/2 Mode	703.300	702.369	702.337
π Mode	723.300	719.340	719.150
Disper Acc F_{avg}	703.300	702.369	702.337
Disper CC F_{avg}	708.748	702.603	702.285
Disper K_{avg}	4.66%	4.63%	4.63%

There is no way to measure the individual couplings from the coupling cavity to each of the accelerating cells, however, the field tilt that results from the different coupling values can be measured directly. The

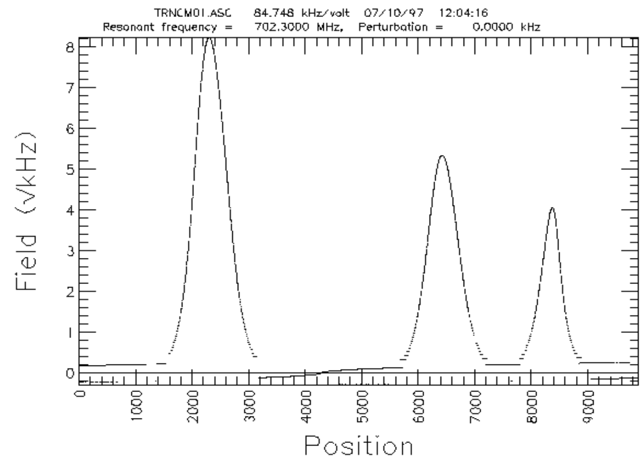

Figure 2: Results of beadpull on the cold model after frequency tuning.

actual couplings need not be measured. The field profile was measured by performing a bead-perturbation measurement after the cavities were tuned. Figure 2 shows the plotted beadpull data. The plot shows (from left to right) the field in the gap in Acc24, the field in the first full gap in Acc25, and the field second (half) gap in Acc25. The measured field in the second (half) gap in Acc25 is not used in the analysis since the terminating wall and bore hole distort the field. A numerical integration of the fields in the Acc24 and Acc25 gaps was performed to generate a value for E_oL for each gap. The E_o value for a full Acc24 and a full Acc25 cavity was then calculated. For Acc24 the measured E_oL was simply doubled then divided by the actual full cavity length. For Acc 25 the cavity field profile from SUPERFISH was used to calculate the E_oL in the middle gap from the measured E_oL in the first gap, the result was added to twice the first gap E_oL and the sum divided by the actual full cavity length. The “measured” values for the single gap E_oL and the cavity E_o along with the SUPERFISH values are shown below for Acc24 and Acc25 in Table 3. Table 4 shows the “measured” field ratios, the target values, and the ratio of the measured to target values.

Table 3: Relative single gap EoL and full cavity Eo.

	Acc24	Acc25
Measured single gap EoL	0.716757	0.445895
SUPERFISH single gap EoL	106.297	73.6647
Measured full cavity Eo	0.17124	0.094548
SUPERFISH full cavity Eo	2.5395	1.562

Table 4: Measured field ratios, and target ratios.

	Measured	Target	Meas/Target
EoL Ratio	62.21%	69.30%	89.77%
Eo Ratio	55.21%	61.51%	89.77%

The coupling can be increased by the small amount required during the assembly tuning phase, there is adequate space for the slots to be enlarged by the required amount. The E_o tilt of Acc25/Acc24 was 55.21%, 89.77% of the target 61.51%. Reducing the tilt can be done during the assembly tuning phase while the average coupling is increased.

The results of coupling and field tilt measurements with a third cold model were also quite good. The final k_{avg} value of 4.72% calculated by DISPER is 94.21% of the target average coupling of 5.01%. The E_o tilt of Acc25/Acc24 for this cold model was 58.00%, 94.30% of the target 61.51%.

3 FREQUENCY MEASURMENTS

Since we had good results with coupling and field tilt using the second cold model, the primary goal for the third cold model was to evaluate our frequency predictions.

All of the accelerating cells were designed with the intention having a small tuning range. This would be accomplished by nominally leaving a small amount of a fixed tuning ridge in place after the cell was tuned to 700 MHz. The cells would be fabricated with an additional amount of this ridge in place, hence the nominal fabrication frequency target of greater than 701 MHz. In theory, with all of the ring removed the frequency of the cells should be 699 MHz. For this model, the extra tuning ridge left in place was fixed at about 2.5mm for Acc24 and Acc25. The effect of this step on Acc24 and Acc25 is shown below for both the SUPERFISH predicted tune rate in Table 5 and the measured average tune rate in Table 6 (For these measurements, the cavity frequencies were not corrected for T, relative humidity, barometric pressure, or referred to vacuum).

Table 5: Tuning Step effects for Acc24 and Acc25.

	Acc24	Acc 25
SF Frequency with no step	699	699
Tune Step Height (in)	0.099	0.099
SF Tune Rate (MHz/in)	-22.0499	-36.0754
dF from step	2.18294	3.571464
Expected Fab Freq	701.1829	702.5715
Actual Fab Freq	700.541	702.766
Error	-0.64194	0.194536

Table 6: Tuning Step effects for Acc24 and Acc25.

	Acc24	Acc25
SF Frequency with no step	699	699
Tune Step Height (in)	.099	.099
Meas Tune Rate (MHz/in)	-16.7299	-34.3182
dF from step	1.656259	3.3975
Expected Fab Freq	700.6563	702.3975
Actual Fab Freq	700.541	702.766
Error	-0.11526	0.3685

The agreement between the expected and actual fabrication frequencies is within the tuning range provided by the tuning ridge. For Acc25 the agreement between the SUPERFISH tune rate and the measured tune rate is also good. It is not clear why it is not as good for Acc24.

4 CONCLUSION

We are quite satisfied with the results obtained with the transition region cold models. We have established that frequency effects of the slots in this region can be predicted allowing calculation of the cavity frequencies within the allowed tuning range. We have shown that the coupling can be predicted accurately enough to allow a minimum of slot tuning range to be left in the structure. Finally, we established that the required E_o tilt can be set up and that it can be predicted accurately enough to allow a minimum of slot tuning range to be left in the structure.

5 REFERENCES

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