Fermi National Accelerator Laboratory

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Mechanical Construction of the 805 MHz Side-Coupled Cavities for the Fermilab Linac Upgrade *

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MECHANICAL CONSTRUCTION OF THE 805 MHz SIDE COUPLED CAVITIES FOR THE FERMILAB LINAC UPGRADE

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Abstract

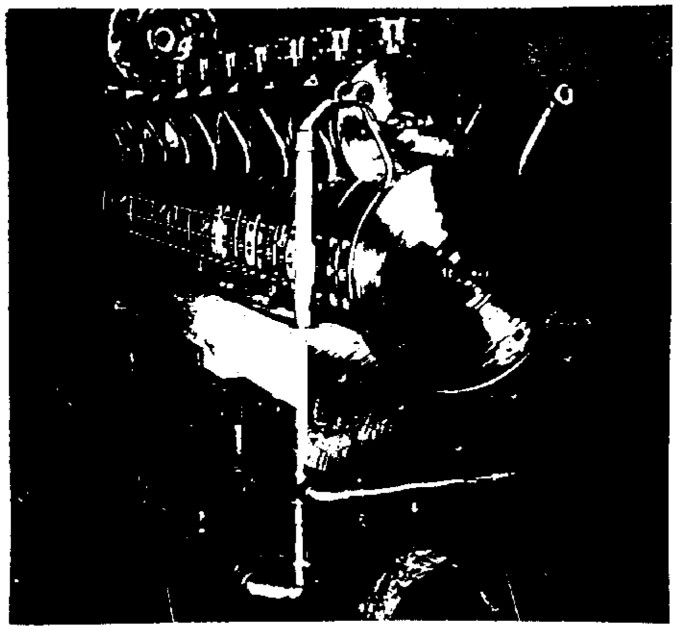
The manufacturing processes for the Side Coupled Structures (SCS) are intimately connected with their tuning requirements. Present Computer Numerical Controlled machining allows very repeatable accuracies of dimensions. This has led to a manufacturing sequence which reduces the need for repeated machining steps. Surface tolerances in the high field region of the accelerating cells were assured. Tuning steps were reduced at all stages of construction. This paper will describe the mechanical steps used to fabricate the SCS structure at Fermilab.

Introduction

The construction of the Fermilab Side Coupled Structure has evolved through years of experience from people who have worked on linac structures. The SCS was pioneered at Los Alamos in the 1960's for the construction of LAMPF. Based on beam dynamics and power considerations, the Fermilab SCS was segmented into 28 sixteen cell sections. In 1988 Fermilab began a research and development program which would lead to the design and construction of a side-coupled linac for the 400 Mev Linac Upgrade. Information about design, tuning, and construction techniques used for side-coupled cavity linacs was gathered from Los Alamos, SLAC, and other sources. After sifting through all the information, and digging into our own bag of tricks, we came up with the Fermilab version of the SCS.

Side Coupled Cavity Construction

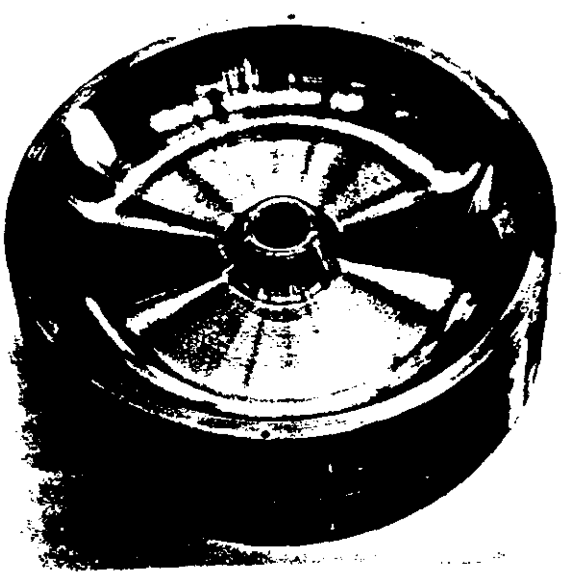
The Fermilab SCS is similar in appearance to the LAMPF SCS, but that is about as far as the similarities go. The construction of the Fermilab SCS is significantly different.



The biggest factor which dictated the design of the SCS was the availability of repeatable CNC machining. Superfish was used to calculate the exact shape of the main cavity sections. [1] The cavity shapes were transferred to CAD drawings and CNC programs. Models were machined using aluminum to check the predicted frequency in relation to the actual frequency. Adequate correlation and good repeatability of frequencies were achieved. CNC machining controlled tolerances to within .001" over a set of 17 segments. [2]

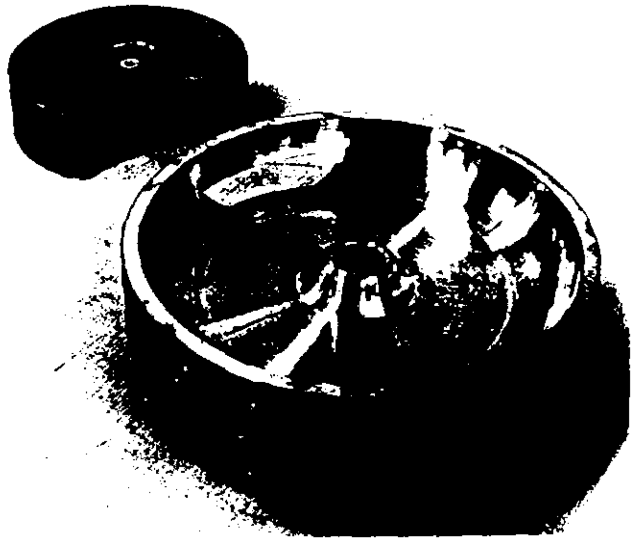
The first major decision which was made was to buy all our copper for the project from Hitachi. (Class 101 OFE) This decision was based on advice and past experiences of SLAC. The copper was purchased in a cross-grain forged condition. Hitachi also agreed to rough machine the copper to within .050" of our final dimensions. The rough machining turned out to be a real bonus in that the parts had one machining operation completed when delivered, and we didn't have to pay to ship the extra weight from Japan to the USA. The copper was delivered from Hitachi to Copper & Brass Sales in Oakland, Cal.. From there, we had the Main Cavity section shipped to Pyromet Industries in San Carlos, Cal. for annealing. The Side Couplers were shipped to Fermilab without being annealed.

Upon arrival at Fermilab, the copper parts were inspected and then shipped to the CNC machine shops for the next phase of machining. The accelerating and coupling cavity components were machined to pre-calculated dimensions determined by experimental models and Superfish calculations.

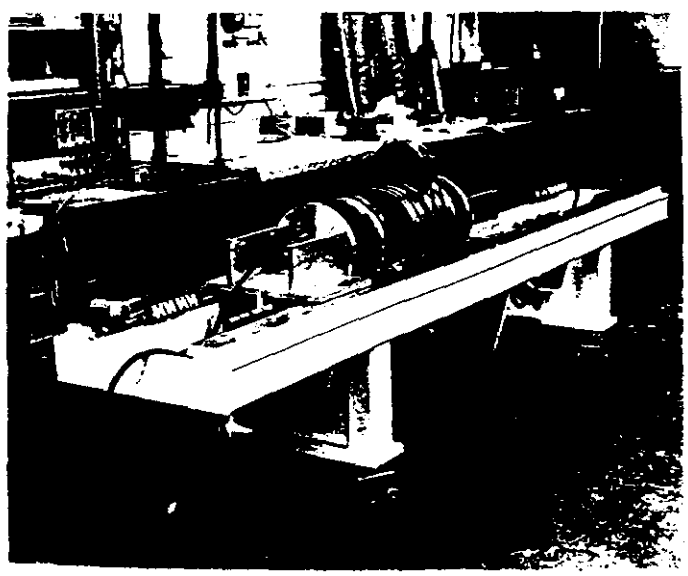


The Main Cavity sections were brought to the tuning lab at Fermilab after machining and each half cell was inspected, labeled, and the frequency measured. From there the Main Cavities went to our machine shop for an initial coupling slot cut.

While the Main Cavities were going through these steps, the Side Couplers were being inspected after their first machining. They were then packaged in specially made foam shipping containers and shipped to Pyromet for the brazing of the two halves. This braze was accomplished using 35-65 braze alloy. A .002" foil was placed between the halves, and a .030" diameter wire was placed in the groove on the outside. The Side Couplers were then returned to Fermilab where they were leak checked and sent to an outside machine shop to have the vacuum port hole machined in the top of the Side Coupler and the scallop machined by EDM in the bottom. The tolerance on the arc was held to +/- .001".



Five Main Cavities and Side Couplers were staked on a special fixture and the Pi/2 frequency was measured. One to two additional cuts were needed to achieve the final slot depth. All the remaining cavity sections and bridge ends were machined to this depth.



The Bridge Ends, Terminating Ends, and Bridge Side Couplers needed special attention. Because of their non-repeating geometry, they require a different frequency than an interior cell. The frequency change was accomplished by removing material from the side wall. The exact frequency was determined when the stack of five is checked for slot depth.

The Bridge Side Coupler is unique to Fermilab in its design. The flange which joins the Bridge Coupler to the Bridge Side Coupler is placed just above the tuning stub in the Bridge Side Coupler. This was done for several reasons. It allowed the flange which couples the two parts to become very simple in geometry, thus, permitting us to use a rather standard type of copper gasket which acts as a vacuum seal and as a current carrying device. Another reason why the flange was located in this position, was to allow the tuning stubs to have a similar shape as those in the Side Couplers. Thus, the Bridge Side Couplers can be finely tuned after the Cavities are assembled to the Bridge Couplers by simply pushing or pulling on the stubs.

After all the tuning steps are completed in the specially designed stacking fixture, the parts are packed into an air ride cushioned box and shipped by an air ride van to Pyromet Industries in San Carlos, California where they are hydrogen furnace brazed.

The Bridge Side Couplers, and the Side Couplers have previously been brazed with 35-65 braze alloy at this time. The first brazing step was to braze the Side Couplers to the Main Cavities at the saddle joint, and to braze the stainless steel vacuum port to the Side Coupler. This was accomplished using 50-50 braze foil, .002" thick and a 50-50 powder mixture fillet. After brazing, the joints were visually check for vacuum integrity. If there were any questionable areas, the joints were filled with 72-28 CuSil powder mixture. The Main Cavity joints were lapped to make sure that they were absolutely flat for the next brazing step. After lapping, the joints were brush silver plated. The cavity was now stacked to a specific stacking order which was determined by matching the frequencies of the half cells. Having stacked the entire cavity, a .030" dia. braze wire of 72-28 CuSil wire was wrapped around each joint between cavity sections. The cavity was placed in the hydrogen retort and brazed. After the brazing operation, the entire structure was vacuum leak checked, packed into the same shipping crate that it came to Pyromet, and returned to Fermilab.

References

1 The Determination of the 805 MHz Side Coupled Structure Dimensions for the Fermilab Linac Upgrade. T. G. Jurgens. 1990 Linac Conf.. These proceedings.