A NEW RFQ LINAC FABRICATION TECHNIQUE *

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Abstract

The use of hydrogen furnace brazing has been applied as a joining technology to the fabrication of a Radio-Frequency-Quadrupole (RFQ) linac for the Los Alamos Accelerator Performance Demonstration Facility (APDF).. The design concept provides a monolithic cavity with no longitudinal rf, vacuum, or mechanical joints. A 530 MHz, 0.46 meter long engineering model RFQ has been fabricated and tested at the Los Alamos National Laboratory as a technical demonstration of this concept. It is planned that two funneled RFQ's for the APDF (7 MeV, 350 MHz, 100 mAmp CW, each eight meters in length) will be manufactured by this method.

Introduction

There are a number of currently planned applications which will require one or more high energy (> 7 MeV), high duty factor (15% to CW) four-vane RFQ linacs in the frequency range of 350 to 450 MHz. These include the following:

Accelerator Production of Tritium , APT, [1]
Next Generation Spallation Neutron Source, NGSNS, [2]
Accelerator Transmutation of Waste, ATW, [3]
Accelerator Performance Demonstration Facility, APDF, [4]

Some of these projects will require a pair of RFQ linacs which are funneled in order to provide the required beam current. For the APT, ATW, and APDF projects, each RFQ linac is eight meters in length. The proposed 7 MeV 350 MHz CW RFQ linac for the APDF project is shown on Figure 1. This is described in detail in reference 5. The long structure necessitates that the RFQ be designed as four resonantly coupled cavities [6]. With the large number of possible applications, it was deemed prudent to carryout a modest program to develop an RFQ structure which would have minimal cost and production time.

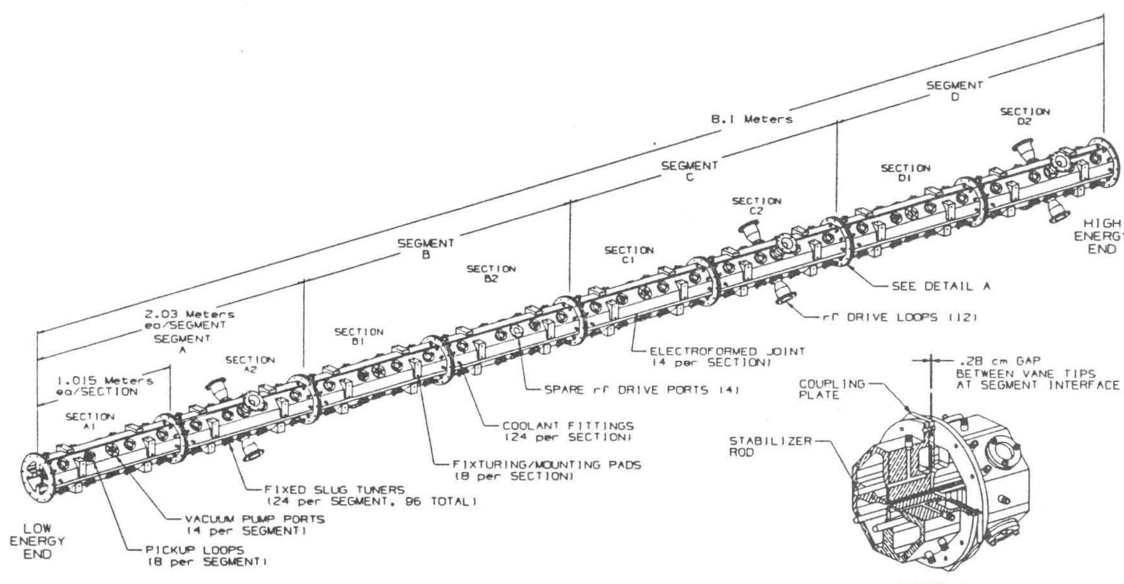

Figure 1: APDF 7 MeV 350 MHz RFQ

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RFQ linacs produced by LANL/AOT-1 during the past few years have been fabricated using electroforming as a joining process. This technique was developed by LANL, Grumman Aerospace Systems, and GAR Electroformers for the RFQ linac for the Beam Experiment Aboard a Rocket (BEAR) Project [7]. The objective was to produce a flight-qualified low duty factor 1 MeV H^- RFQ. The difficulties of producing a flight-qualified structure were mitigated by the low duty factor (0.025%) which permitted the use of an aluminum structure with copper-plated rf surfaces. The cross-section of a 350 MHz electroformed joint RFQ is shown on Figure 2.

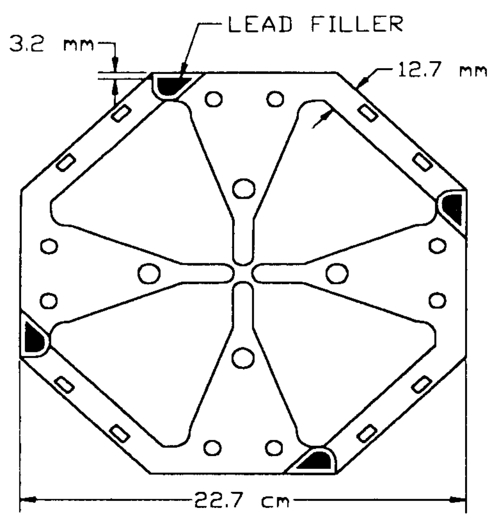

Figure 2: Electroformed 350 MHz RFQ Linac

The major advantages of the electroformed joint concept are the following:

Integral Vacuum Vessel: The cavity walls form the vacuum vessel, thus allowing easy access to tuners, rf probes, drive loops, and coolant fittings.

No RF Joints: There are no longitudinal rf joints. This minimizes concerns regarding cavity Q degradation due to corrosion. For CW applications, the electroform provides a thick rf joint which is thermally continuous and has high electrical and thermal conductivities.

RF Tuning Stability: The vanes are integral parts of a monolithic structure. There is no stored mechanical energy to be released due to thermal cycling.

High Structural Efficiency: The completed monolithic structure is entirely load-bearing.

The above features made the electroformed joint concept sufficiently attractive that it was later used by Grumman for the Continuous Wave Deuterium Demonstrator (CWDD) [8] and by LANL for the Superconducting Super Collider (SSC) [9]. The CWDD RFQ was a 350 MHz, four meter long structure while the SSC RFQ was a 428 MHz two meter long unit. An additional feature of the electroformed joint concept is that the cost and schedule may be predicted with a high degree of reliability: both the CWDD and SSC RFQ projects were completed within budget and on schedule.

Two major disadvantages of the electroformed joint concept are high cost and extended schedule. In an effort to mitigate cost and schedule LANL has investigated a number of other joining techniques including welding, dip-brazing, plasma-spray, and hydrogen furnace brazing. LANL has extensive experience in the fabrication of hydrogen furnace brazed linac structures, mostly cavity coupled linacs. For this reason the brazed structure was the first choice for further efforts. A cross-section of a 350 MHz brazed RFQ is shown on Figure 3.

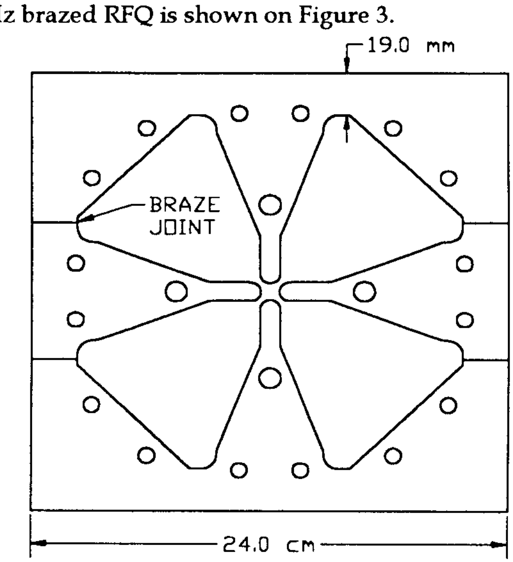

Figure 3: Brazed 350 MHz RFQ Linac

The brazed RFQ linac concept has the advantages of facilitating the attachment of stainless steel flanges for metal vacuum seals. It is compatible with OFE and tellurium (C14500) copper as well as with various methods of forming coolant passages: welding, brazing, and electroforming.

A 530 MHz brazed engineering model RFQ, 46 cm (1.23 λ) long was fabricated, brazed, and tested. The frequency was selected to mitigate cost. This unit is shown on Figure 4..

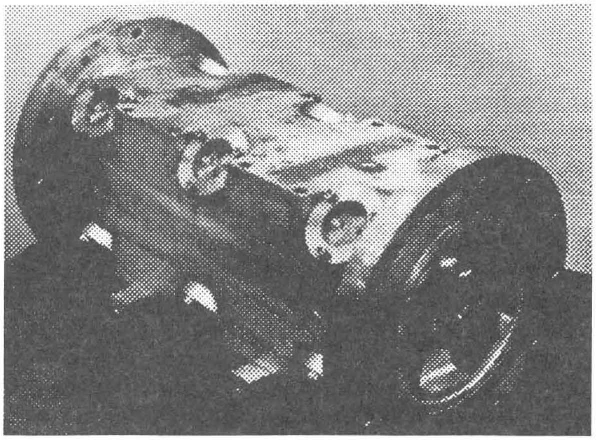

Figure 4: 530 MHz Brazed Engineering Model RFQ

The engineering model was brazed in a vertical orientation with AWS Bag-8, a silver-based eutectic alloy with a liquidus temperature of 780 °C. A major concern was whether or not the structure would maintain its alignment after undergoing the furnace heat. Both mechanical measurements and rf field distribution measurements by the beadpull method were performed before and after the furnace heat. The normalized difference between the pre- and post-braze beadpulls is shown on Figure 5. The differences in the quadrupole and dipole fields are less than one per-cent.

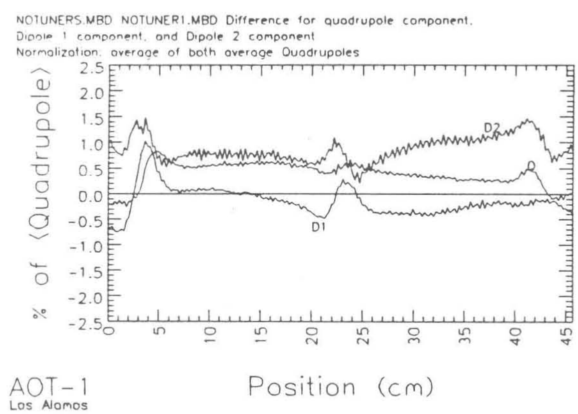

Figure 5: Pre- & Post-Braze Beadpulls

The unit was vacuum tight and successfully passed structural load tests which correspond to five times the loads that it would experience in the APDF configuration shown on Figure 1. A detailed report of the design, fabrication, and testing is give in reference 10.

Conclusions

We have concluded that the brazed RFQ is a robust design. The design and fabrication of the engineering model were completed fully as planned and therefore we are confident that this concept can be extended to long, high duty-factor applications with predictable cost and schedule.

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