TEST RFQ FOR THE MAX-PROJECT

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Abstract

A 17 MeV MHz proton linac is being developed as a front end of the driver accelerator for the MYRRHA facility in Mol. As a part of the MAX (MYRRHA Accelerator Experiment and Development) project a 4-rod Test-RFQ with a resonance frequency of 176 MHz has been designed and built for the MAX-Project. But the RFQ had to be modified to solve the cooling problem at cw-operation, the geometrical precision had to be improved as well as the rf-contacts. The developments led to a new layout and a sophisticated production procedure of the stems and the electrodes. Calculations show an improved Rp-value leading to power losses of <30 kW/m only, which is about 60 % of the power losses which could be achieved safely at cw-operation of the similar Saraf-RFQ. Thermal measurements and simulations with the single components are in progress. The temperature distribution in cw-operation will be measured and the rf-performance checked.

INTRODUCTION

The development of MYRRHA (Multi-purpose hybrid research reactor for high-tech applications) is important to investigate advanced technologies for future power generations. With this test reactor the transmutation of long-lived radioactive waste of nuclear power plants will be studied. Also the reactor will contribute to the present material research and replace the expiring molybdenum reactors, which are essential for the nuclear medicine. An absolutely reliable proton accelerator is required for the operation of the reactor. Breakdowns of the cw proton beam will cause thermal stress in the reactor core and it will also decrease the lifetime of the reactor. This is the reason why the design of the LINAC and the proton injector part has to be very safe [1]. Figure 1 shows an overview of the MYRRHA linac. A short and effective injector section is recommended by a KONUS (combined zero degree structure) beam dynamics design [2].

MYRRHA INJECTOR

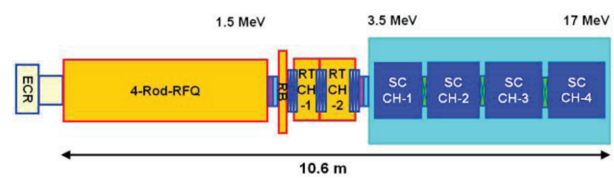

Figure 2: General layout of the MYRRHA injector.

The planned injector (fig. 2) consists of an ECR source, a Radio Frequency Quadrupole (RFQ), two room-temperature CH-cavities and four superconducting CH-cavities. During the EUROTRANS project the RF frequency of the 17 MeV injector part has been set to 352 MHz. The new layout is changed to 176 MHz. The main reason is the possibility to use a flexible and cheap 4-rod-RFQ instead of the 4-vane-RFQ. This 176 MHz RFQ accelerates the particles to 1.5 MeV.

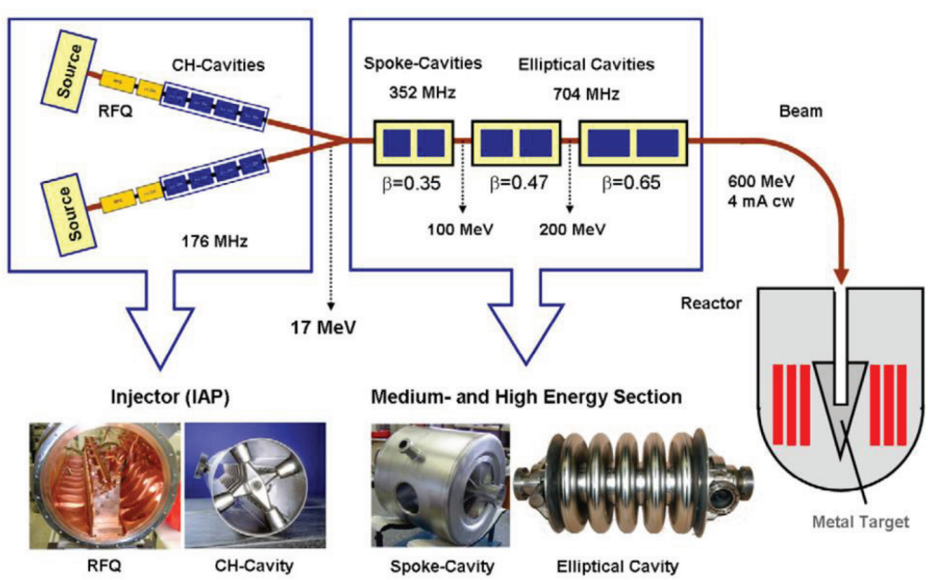

Figure 1: An overview of the MYRRHA driver linac.

Between 1.5 MeV end-section of the RFQ and the entrance of the first sc CH-cavity the energy gap is covered by two rt CH-cavities. The main acceleration takes place in the four sc CH-cavities. For the MYRRHA project it is planned to build two identical injectors to fulfil the stringent reliability requirements of the whole project. Good performance of the injector was shown by beam dynamic simulations. [3] [4]

RFQ

By changing the resonant frequency from 352 MHz to 176 MHz it is possible to use a 4-rod RFQ instead of a 4-vane RFQ. Compared to the 4-vane RFQ the 4-rod RFQ has excellent tuning and access capabilities with a significant lower technological risk and capital investigation.

Figure 3: Picture of a typical 4-rod RFQ.

To limit the thermal load of the cavity to 25 kW/m the electrode voltage has been fixed to 40 kV. This is only half the value which has been already shown for a safe operation. A short four stem section of the RFQ is under construction for testing the properties and the behaviour under high average power. Figure 3 shows a typical cw 4-rod RFQ and Table 1 shows the main design parameters.

Table 1: RFQ Beam Dynamics Design Parameters

Operation frequency	176 MHz
Injection energy	30 keV
Operation energy	1.5 MeV
Length	400 cm
Electrode voltage	40 kV
Impedance	67 kΩm
RF power	100 kW
Thermal load	25 kW/m

TEST-RFQ

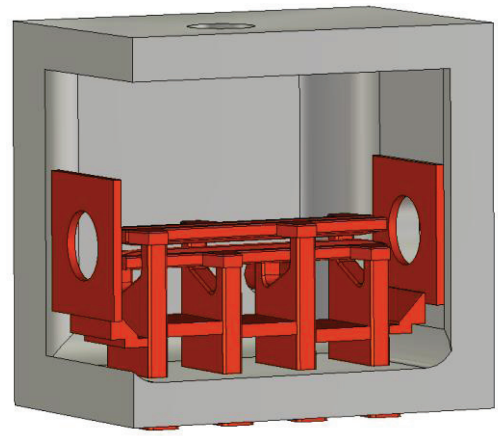

Figure 4: MWS model of the Test-RFQ

The test RFQ-cavity (fig. 4) has of a 5 cm thick tank with a length of about 50 cm and the electrode length is 36.8 cm. Between the stems there are three tuning plates to help the cavity to get the right frequency. By modifying the position of the tuning plates, the frequency can be variabled from 160 MHz to 192 MHz. For a better connection, silver plated tuning plates will be used. During operation a tuner will be used to correct the frequency

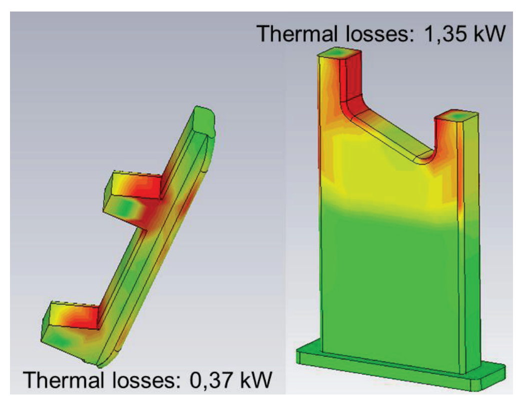

Figure 5: Current distribution and thermal losses.

First simulations with microwave studio shows, that the total thermal losses in this test-RFQ is about 8 kW. In figure 5 the current distribution is shown, the thermal losses are about 1.35 kW for a single stem and 0.4 kW for a single electrode. The highest field is at the connection between the electrodes and the stems [5].

Because of the thermal losses, a very good water cooling system is required to hold the frequency steady during cw operation. A new water cooling system was designed for the stems and the electrodes. Figure 6 shows the cooling channel inside a stem, it is split into two parts so that both sides of the stem are well cooled.

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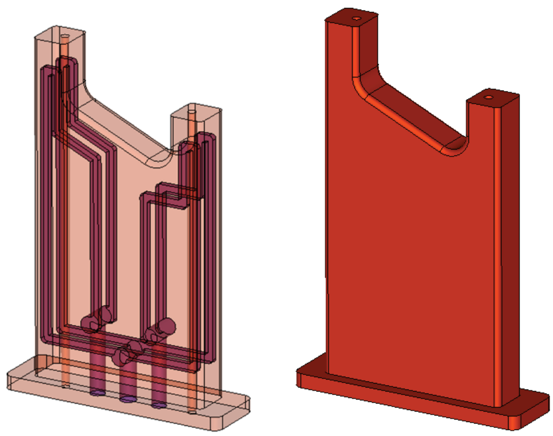

Figure 6: New stem design with the cooling channels.

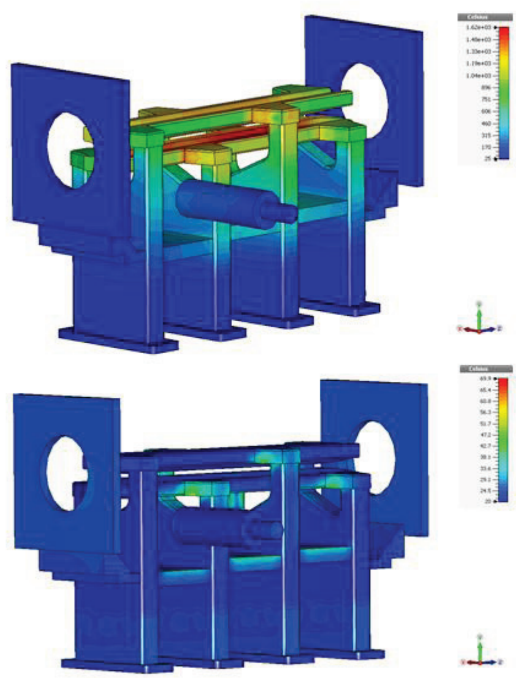

Figure 7: Thermal Microwave Studio simulations with (bottom) and without (top) cooling.

Thermal simulations with this cooling system were done with MWS. Figure 7 shows the difference of the resonant structure without a cooling system and with a water cooled system at 20°C water temperature. In the upper picture there are a very high temperature on the electrodes, with the cooling system there are only a few hotspots with a maximum temperature of about 58 °C. Thermal measurements on a single stem show the temperature distribution on the stem. For this measurement the stem was heated to 90°C, at this temperature the water cooling system was turned on.

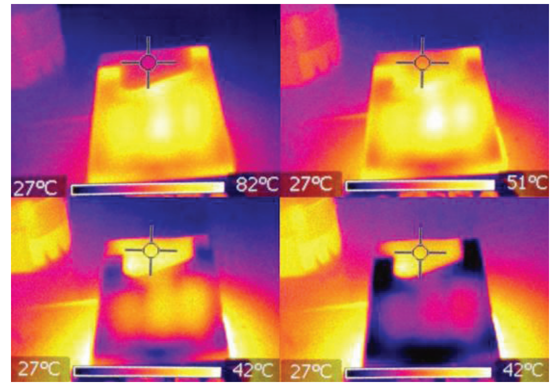

Figure 8: Thermal measurements on a single stem.

Figure 8 shows the different temperatures during the measurement. The stem was cooled down to nearly water temperature after 30 seconds with a water flow rate of only 0.08 l/s at a water pressure of 1 bar.

STATUS

Thermal simulations for the test-RFQ and first thermal measurements on the stems were completed. The stems and the tuning plates were inserted into the cavity. The electrodes will be delivered in September 2012. After the alignment, tuning and vacuum test of the cavity first RF-measurements will be done.

ACKNOWLEDGEMENT

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