STATUS OF 178.5 MHZ RF SYSTEM FOR THE DUKE FELL STORAGE RING

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Abstract

A new RF system for the DFELL (Duke Free Electron Laser Laboratory) storage ring is presented. High power RF generator with a GU-101A tetrode and bimetal cavity with a higher order modes ceramic load are described. Results of the RF system tests are discussed.

INTRODUCTION

About 10 years ago, Institute of Nuclear Physics produced an accelerating cavity and control system for the DFELL storage ring, USA.

The RF system has been successfully operated during almost 10 years. However, the RF system did not allow storing high beam currents because of synchrotron oscillations arising from interaction of the cavity HOMs with the electron beam. Although the cavity was equipped with two HOM tuners, it was practically impossible to set the cavity HOM frequencies so that they did not affect the beam dynamics at high currents and in multibunch mode.

In 2001, DFELL started a machine upgrade project aiming at the FEL experiments in VUV spectrum range [1]. After the upgrade the machine should operate at energy up to 1.2 GeV with average current up to 300 mA and number of bunches from 1 to 64. The storage ring upgrade calls for a new 178.5 MHz RF system with a cavity with HOM-damping. The accelerating voltage across the cavity should be up to 730 kV.

HIGH POWER GENERATOR

A vacuum tube generator for the new RF system was produced on the basis of high power tetrode GU-101A (Fig. 1). BINP has developed and operate generators with output power up to 600 kW [2, 3], containing modules (up to 4) based on GU-101A tetrode. The DFELL RF generator provides up to 140 kW output power in the frequency range

Fig. 1: New DFELL generator

of 178…179 MHz. The generator is a 3 stage power amplifier with an external drive. In two first generator stages, GU-92A tetrodes are used. A high power GU-101A tetrode is used in the output stage. The amplifier is driven by a 100 W solid-state pre-amplifier. The output power is delivered to the cavity via a 75 Ohm rigid coaxial feeder.

In order to increase the reliability of the generator and to extend the lifetime of the tubes, the tubes operate in somewhat relaxed regimes. The voltages of power supplies and dissipated powers are slightly reduced in comparison to values recommended by the manufacturer.

Table 1: Parameters of bimetal cavities for the fundamental (accelerating) mode

	BINP FEL	DFELL Duke-1	DFELL Duke-2
Operation frequency f, MHz	180.4	178.5	178.5
Characteristic impedance R_{acc}/Q, Ohm	110	114	88.6
Transit time factor T	0.903	0.919	0.764
Quality factor Q	41000	42000	39000
Shunt impedance R_{acc}, MOhm *	4.50	4.77	3.46
Accelerating voltage V_{acc}, kV	850	640	730

* Shunt impedance is defined as $R_{acc} = V_{acc} / 2P$, where V_{acc} is the accelerating voltage.

BIMETAL CAVITY WITH HOM DAMPING

BINP has gained a wide experience in production of bimetal RF accelerating cavities [4]. Over 25 bimetal cavities have been produced, tested and now operate in various facilities (BINP, Korean Atomic Energy Research Institute, DFELL).

The RF cavity for the new RF system DFELL, "Duke-2", was developed on the basis of a "standard" bimetal (copper clad stainless steel) RF cavity. Parameters for the fundamental mode of the cavity are listed in Table 1. For comparison, parameters of the "standard" cavity of the BINP microtron FEL and the old DFELL cavity are also presented. Old DFELL cavity had only slight modifications from "standard" one in the geometry to fit the operation frequency of the Duke storage ring.

The appearance of new RF cavity for DFELL is shown on Fig. 2. The cavity is equipped with RF power absorbing load for HOM damping. HOMs are coupled to the RF absorbing load via a large (700 mm) diameter beam pipe. The cutoff frequency of the pipe for the accelerating TM_{01} mode is substantially higher than the fundamental mode frequency, so the fundamental mode is trapped in the cavity, while the HOMs propagate out of the cavity to the absorbing load. The load is within 1200 mm distance away from RF cavity, so it does not cause any considerable influence on the Q-factor of the fundamental mode. Power loss in the load at accelerating frequency is 100 W. The large opening in the cavity wall causes a fundamental mode resonant frequency shift up. A nose cone at the opposite cavity face wall is needed to bring the frequency down to the design value. Also, the transit time factor decreases due to the field pattern distortion. This leads to higher fields in the cavity at the same accelerating voltage.

Cylindrical shell of the cavity has some ports for connection of various units. Coaxial input coupler with a cylindrical ceramic window is installed on top of the cavity. Two ports are used for fundamental mode tuners, noncontact plungers.

The cavity is pumped out by two combined vacuum pumps (each pump includes ion and getter pumps) of PVIG-250/630 type with total pumping speed of 630 *l*/s each. Pumps are attached at the bottom of the tube connecting the cavity to the HOM load. According to the experience with bimetallic cavities, after manufacturing and assembly the Duke-2 cavity was baked at 300 °C. After an RF processing vacuum in the cavity of $1 \cdot 10^{-10}$ torr was achieved.

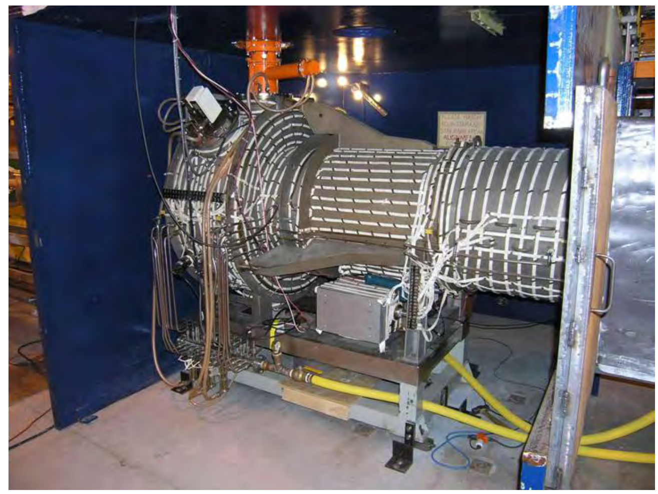

Fig. 2: Duke-2 cavity

A conducting ceramics KT-30 produced by "Start" company, Russia, Fryasino was chosen as an absorbing material for the HOM load. The composition of the ceramics is: TiO_2 – 30 %, A-995 – 70 % (Al_2O_3 – 99.8 %, MgO – 0.2 %). The RF absorber elements are ceramic cylindrical cups with diameter 32 mm and height 45mm. Every absorber is fixed on an internal wall of the load tube with a bolt. The material used and the design of the loads sustain baking of the cavity with the loads at the required temperature.

SUMMARY

Cold measurements of the cavity have shown that the HOMs are indeed well suppressed (Fig. 3 and 4). According to calculations, this should allow storing currents over 300 mA. During hot tests of the cavity, the accelerating voltage of 890 kV was achieved. At present time, the new RF system is tested and installed in the storage ring. Commissioning of the DFELL storage ring with the new RF system is in progress now.

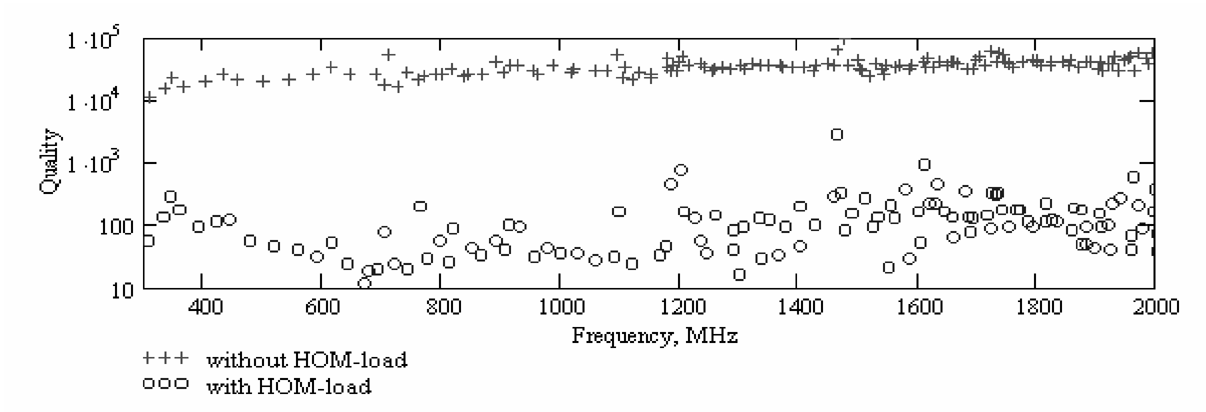

Fig. 3: Calculated Q values for the HOMs (TE_{0mn}, TH_{0mn})

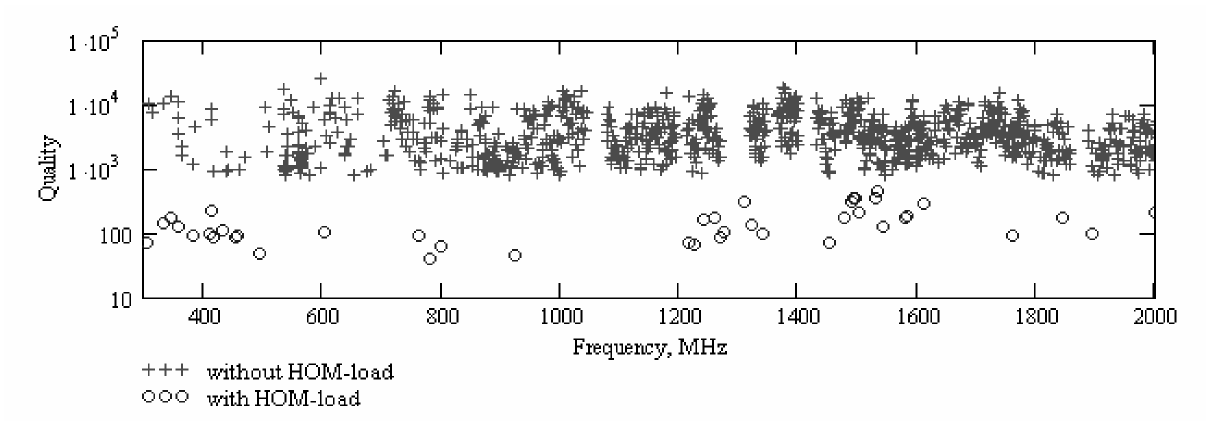

Fig. 4: The measured Q of the HOMs

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