ADJUSTMENT OF MESON FACTORY LINAC 991-MHZ ACCELERATING SYSTEM

S.K.Esin, T.N.Habibullin, L.V.Kravchuk, V.V.Peplov, V.A.Puntus, G.V.Romanov

Institute for Nuclear Research of the USSR AS, prosp. 60-letya Oktyabrya, 7a, Moscow, 117312, USSR

Abstract

High energy part (main part, 991 MHz, 100-600 MeV) of Moscow mezon factory linac consists of 27 accelerator modules and the matching one. The accelerating module is oscillator system consisting of four DAW structure tanks connected with resonance bridge couplers. Each module is powered by it's klystron amplifier, RW-power is delivered from klystron unit through waveguide system to a central bridge coupler [1]. The main part accelerator structure tuning was began in 1980 and had been completed by the end of 1989. At the moment adjusting of 991-MHz RF-power supply system is finished and high RF-power testing of the system and the modules is produced. This report presents the results of the accelerator tuning, the waveguide system tuning and RF-testing and the results of RF-training of 7 modules.

1. Results of accelerator system tuning.

The method and the results of DAW structure tank tuning are given in detail in [2,3,4,5]. The tuning procedure includes:

1) operating frequency setting to the design value 991 MHz at the temperature 25°C with accuracy ± 0.03 MHz (this tolerance is determined by automatical frequency regulation system); 2) making the tank field averages amplitudes agree to better than ±0.8%;

3) stabilizing the field distribution against the tank frequency perturbations;

4) setting of the standing value wave ratio (VSWR) in the input drive line near the bridge coupler iris less than 1.2.

The module tuning was performed by change of electrical lengths and symmetry of the bridge couplers using special bellows and plungers [6,7,8].

After tuning the mean value of the module frequencies is equal to $\bar{f}$ = 990.788 MHz. The maximal difference between the neighbouring tanks field averages is less than 0.5%. The quality of stabilization S is defined as a change of the rms difference between the tank field averages, arising when the temperature of one of the end tank (first or fourth) differs from the temperature of the others. The tolerable value of S is determined by the beam dinamic requirements and the expecting frequency errors due to nonuniform module heating at a high power operation. It is supposed to be of 0.05 - 0.1%/°C. Before module stabilization the real values of S were equal to 0.4 - - 0.5 %/°C and after stabilization they are equal to 0.013 - 0.05 %/°C.

The volumes of the tanks and bridge couplers increase from the beginning to the end of the accelerator while the sizes of coupling slots between the tanks and the couplers are all the same. So, the coupling decreases, but we had no practical difficulties with the module stabilization connected with this decreasing. Fig.1 shows the main frequency spectra of the modules N°2 and N°27. Fig.2 shows the coupling coefficients value against the module number.

The quality factor of the modules is determined practically only by the tanks at the opretating frequency and is equal to Q = (17-29)·10³. The iris in the driven bridge coupler is used for matching between

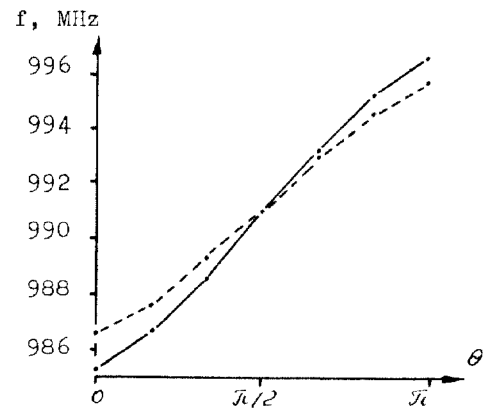

Fig.1. The main spectra of mode frequencies of modules N°2 (———) and N°27 (-------)

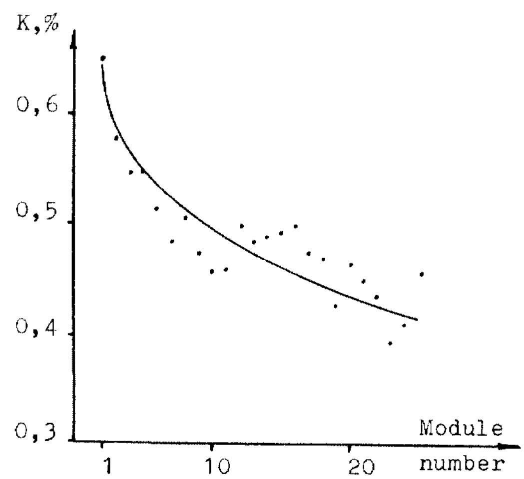

Fig.2. The coupling coefficient between the tanks and the bridges against the module number.

the drive line and the module. The coupling hole should be cut to give a VSWR = 1 with nominal beam loading. The VSWR without beam is varied along the accelerator from 1.25 to 1.52 to match the local shunt impedance. The VSWR setted during tuning procedure differ from the calculated ones less than 8%. Such value of VSWR permits to produce the high power training and to operate with negligible beam loading without replacement of the iris.

Sometimes during high power training of the modules the bad vacuum joints and electircal contacts cause the RF breakdowns and force to reinstall bridge coupler assemblies to repair these defects. After such repairement all module tuning procedures must be repeated with the exception of the matching.

2. RF testing of the waveguide system.

The waveguide system consists of the reference drive line, 28 waveguide drive lines (33-40 meters long), connecting every module with it's klystron amplifier, and 3 reserve waveguides lines (up to 80 meters) providing connection the reserve klystrons and the modules. Every drive line has two RF windows, separating the pressurized drive lines from the evacuated linac structure and klystron; a directional coupler; an adjustable phase shifter; a waveguide switch; a ferrite isolator; the sections of rectangular waveguides (220x104 mm); the sections of flexible waveguides and the "E"- and "H"-type bends.

After the installation of the waveguides system the tuning of the drive lines and the measurements of their parameters were produced. Before tuning the VSWR in the input of the drive lines in many cases excedeed the required value of 1.5 at the operating frequency. The tuning of the drive lines were produced by pressing the waveguides in the certain points. After this the VSWR in the drive lines is less than 1.5 at any position of the adjustable phase shifter. Setting the VSWR in the lines was produced without isolators. Power dissipation in the drive lines with the ferrite isolators doesn't exceed 1,0 dB.

High power RF testing of the lines were performed using a matched dummy load at pulse power up to 4.5 MW, pulse length of 140-145 mcsec and frequency of pulse repetition 1, 10, 50 and 100 ■Hz.

The electircal discharges in the drive lines occured at the pulse power exceeding 3.5 MW. The typical places of discharges were RF windows, the drossel gaps in the phase shifters. The connections of the flexible waveguide section and "E"- and "H"-type bends also turned out an electrically weak part of the drive lines. The following operations were performed to eliminate the discharges: the waveguide section connections were thoroughly revised and superfluous indium, used for better electrical contact, were removed; the inner surfaces of the flexible sections and the bends were additionally treated; the radiuses of curvature in the bends were made greater; the proper gaps were setted in the drossel connections and in the RF windows.

After tuning and RF-training the drive lines operate without discharges at nominal power. But during RF training of the modules the discharges in the modules cause a power reflection back into the drive lines from the modules. The result is standing wave in the drive lines and the level of discharging in the lines lowers to 2.0-2.5 MW of pulse power. This is taken into account during rf training of the modules.

3. RF training of the modules.

The rf training of the modules starts at the required vacuum conditions 10^{-5} - 10^{-6} Pa. The training is began with a low level of pulse power and a low frequency of pulse repetition. In the begining of the rf training the absorbed gases intensively go out from the inner surfaces of the modules. The typical picture is the worsening of vacuum by approximetely ten times at pulse power 100 KW and frequency of pulse repetition 10 ■Hz. To avoid the damages of inner surface of module by electrical discharges due to bad vacuum the klystron amplifier is switch off at vacuum $2\cdot10^{-4}$ Pa (vacuum blocking). While the gases are pumped out and the vacuum becomes better the pulse power is increased.

In the pulse power interval 200-400 KW the multipactor (as we consider) discharge occures and the vacuum deteriorates. In this case the top of the pulse envelope of the RF field in the module has a zigzag shape as shown in Fig.3a. After some training the intensity of discharge decreases , the vacuum becomes better and the pulse power may be gradualy increased. It is impossible to pass the interval of multipactor discharge by one jump in power because of vacuum blocking.

Beginning with the pulse power of 1 MW the RF breakdown in vacuum occur. In a moment of breakdown the pulses of RF field in module break and become shorter from the front side or the back side (Fig.3b), the reflected power sharply increases, the vacuum is spoiled, the pulse increasing of X-rays is observed, the discharging currents of the magnetic-discharge pumps near the place of RF breakdown increase . If during RF training the number of RF breakdowns in the certain place doesn't decrease, than the module have to be reassembled for eliminating the reasons of discharges.

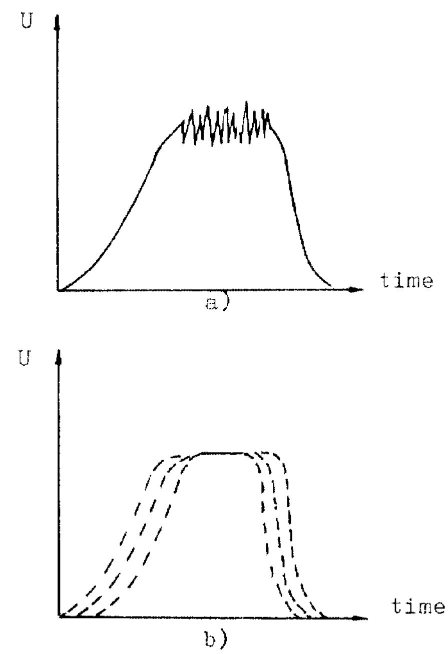

Fig.3. The RF field pulse at the moment
a) multipactor discharge
b) electical breakdown
U - signal from detector in the module

While the operation at nominal pulse power of 2-2.5 MW is achieved the frequency of pulse repeatition is increased up to 50 (100) ■Hz, the pulse power is decreased approximately twise and the procedure of RF training is repeated. We consider the RF training of the module completed when the number of RF breakdowns is less than one breakdown per 15 minutes at the nominal pulse power with pulse repetition equal to 100 ■Hz. The mean time of RF training is 40-50 hours.

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