NEW CONCENTRATOR OF 5 MA ON "ANGARA-5-1" FOR LINER IMPLOSION.

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Abstract

The new current concentrator on multimodule "Angara-5-1" was designed for low impedance loads (imploding liners). The optimization of concentrator scheme was based on the optimum between effects of inductance and electron losses in vacuum magnetically insulated transmission lines (MITL). The scheme with a small diameter magnetic separatrix was chosen for eight unit current addition in vacuum.

Introduction.

The methods of power addition for multimodule generators is important for the projects of large facility creation. Especially it is important for installations with MITL that use parallel power addition on low impedance loads like liners.

On installation "ANGARA-5-1" [1] two types of concentrators - disc and conic with compact separatrix was investigated. The results of these measurements permits us to evaluate reliability of numerical simulation and to make some qualitative conclusions.

The main goals of a concentrator upgrade were:

1. To reduce total inductance of a concentrator by decreasing of a parts of magnetic field in the area outside of separatrix and increasing a parts of magnetic field inside separatrix. It permits us to reduce complete inductance without reduction the gap between MITL electrodes.

2. To reduce inductance inside separatrix for increase of stability of a concentrator to jitter of separate modules.

Angara-5 disc concentrator design

"Angara-5-1" generator consist of eight separate modules. The output voltage of every module is equal to 1.1MV, module current - 0.6-0.8 MA, pulse duration ~90 ns. The disk concentrator design is shown at Fig 1. It was used for our investigation up to summer 1995. It consists of eight cylindrical vacuum MITLs with diameter 30 cm and gap 10 mm connected to two flat discs with diameter 60 cm.

The gap between anode (top) and cathode (bottom) disks decreases from 3 cm at 30 cm radius to 0.7 cm in central part of concentrator. The total inductance of disc concentrator is equal 10 nH for liner length 1 cm and liner diameter 30 mm. The total inductance of all vacuum arrangement between water-vacuum interface is equal 16.5 nH for the same load sizes. The total current through the load was measured by magnetic probe, consisted of 8 magnetic loops, placed uniformly on radius 14 cm and connected in parallel. The signal from probe was registered by oscilloscopes (1.5 GHz, 1 GHz including cable line).

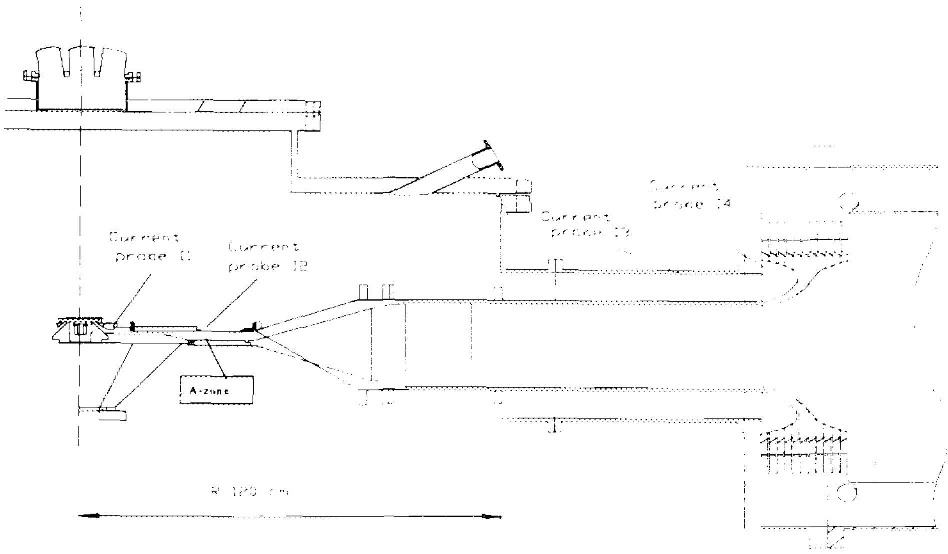

Fig 1. Disc concentrator design

Angara-5 conic concentrator design

The layout of conic concentrator is presented on Fig. 2. In comparison of disc concentrator the MITL length is increased. The radius of all MITL connection is decreased from 30 cm to 13 cm. The current probe for conic concentrator consists of eight magnetic loops. This probe is like to the current probe of disk concentrator but the every loops are measured separately.

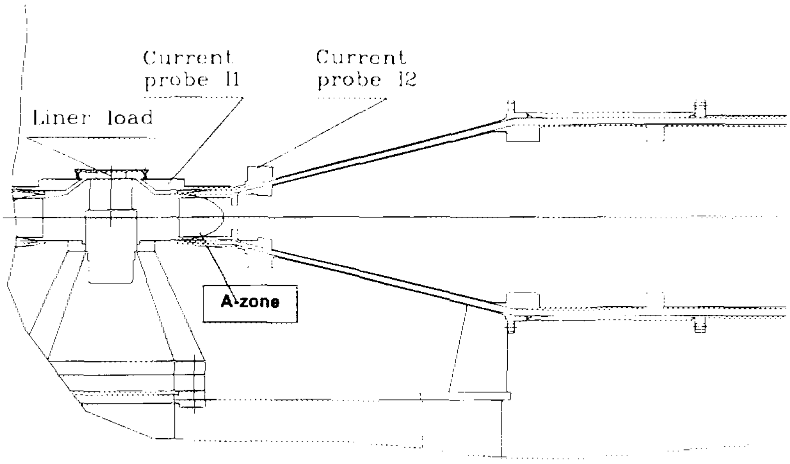

Fig 2. Conic concentrator design.

The total current is measured by numerical addition of all loops signals. This method allow us checking the uniformity of current distribution near the liner. The anode-cathode gap for cylindrical MITL is equal to 10 mm. The minimal gap between anode ad cathode take place in conic part near the liner and is equal to 6 mm.

Experimental results

Two types measurements have made on both concentrators. We have measured the dependence of total current on load inductance for different foil cylinders. For such type load the signals of separate loops of a current probe I1 coincides one to another under the form and amplitude. For shots using loads containing gas flows the these signals can be different. We connect this fact with penetration of a small amount of gas density in a MITL gap near the probe I1.

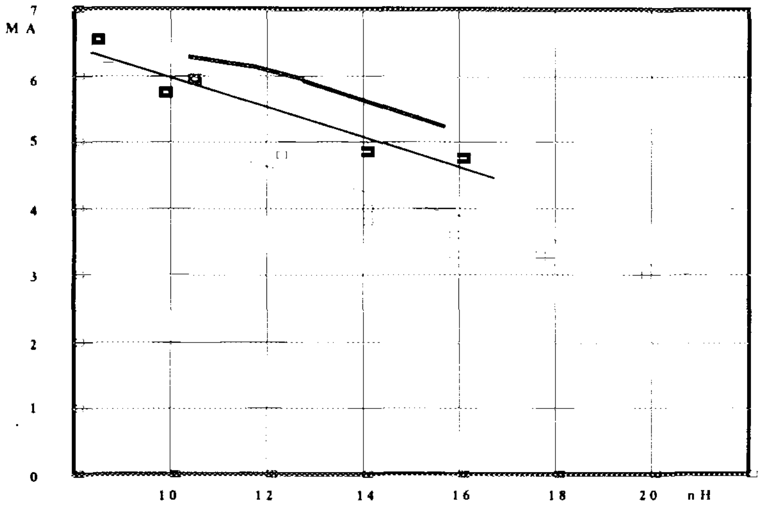

Fig.3. Dependence load current from concentrator inductance. Line - calculation for conic concentrator. Points-experiment for disk concentrator. Bold points-experiment for conic concentrator.

We have also measured the dependence of total current on a module jitter for Xe jet loads. All these measurements have made for amplitude of pulse formed by generator equal to 1.1 MV. The mass of Xe jet was equal to 180-200mkg/cm and height was equal to 10mm. To analyze current-jitter dependence, we have chosen shots with approximately uniform

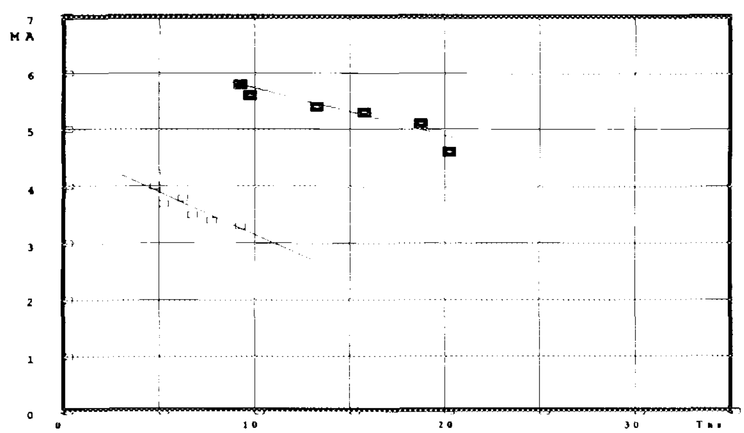

Fig.4. Dependence load current from jitter. points - disc concentrator. Bold points - conic concentrator. Xe jet 180mkg.

distribution of pulse time T1-T8 in a band less than 20 ns. Quantitatively jitter is a square mean of time delay of modules T1-T8, when voltage of every module gets 0.1 of its maximal value. These moments can be defined with +/- 2 ns accuracy. The current-inductance dependence is presented on Fig. 3. The current-jitter dependence is presented on Fig.4. For definition of the generator output parameters the numerical model suggested in [2,3] was used. In this model the main electromagnetic processes presence in MITL : electron leakage current, self-magnetic insulation, wave processes in the line were took into account. There were fulfilled two series of the calculation to simulate jittter of the installation influence . In the first one the ignition time of each modules have been taken from the experiment and in the second value of the current maximum have been obtained by means of averaging over a set of calculations with ignition time distributed in accordance with Gauss distribution.

Discussions

The question on losses in MITL was investigated for axial lines. Connection several parallel lines one to another leads to 3-D problems for E and H fields. From topological reasons it is possible to show, that manifoldity of magnetic surfaces results to existence of points with a zero magnetic field on a surface MITL at any distribution of currents between MITLs. The dimension of these areas depends on the current distribution on MITL surface and can be determined from 3-d calculation. Our calculation according to code [1,2] can be use only for estimation of current losses in this zone. We mark this zone on MITL surface as A-zone in our drawing Fig. 1 and Fig.2.The total current losses we can separate into two parts - the first part is the losses in cylindrical MITL and the second part is the losses in A-zone. The coincidence of measured current and the current calculated by code [1,2] for conic concentrator show us that the current losses in A zone are less than losses in cylindrical MITL. For disc concentrator had the difference between calculated and measured current.[4]

Fig. 3 shows increase of a current through a load for a conic concentrator with comparison on disc one. This increase was predicted by a code [1,2]. The load current for conic concentrator is more than it for disc concentrator for the same value of total inductance. We believe this is because current losses decreasing in A zone. This decreasing is due to two reasons. The first is decreasing of dimension of A zone for conic concentrator in compare to disc one. The second is decreasing of voltage amplitude in A zone due to decreasing of inductance inside separatrix. Fig. 4 show us the decreasing of sensitivity of load current to the module jitter. We also explain it by losses in A area decreasing.

Conclusions

Conic concentrator has the less than disc one inductance in area inside sparatrix and has less current losses. We believe that concentrators with compact separatrix is good as a multimodule current adder for high power installation.

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