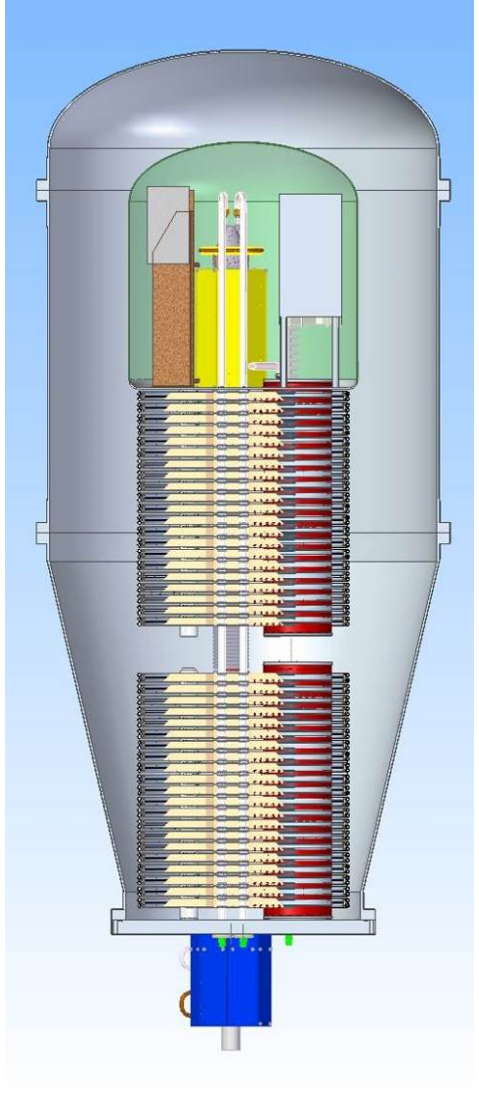
Cascade transformer for high voltage cooler

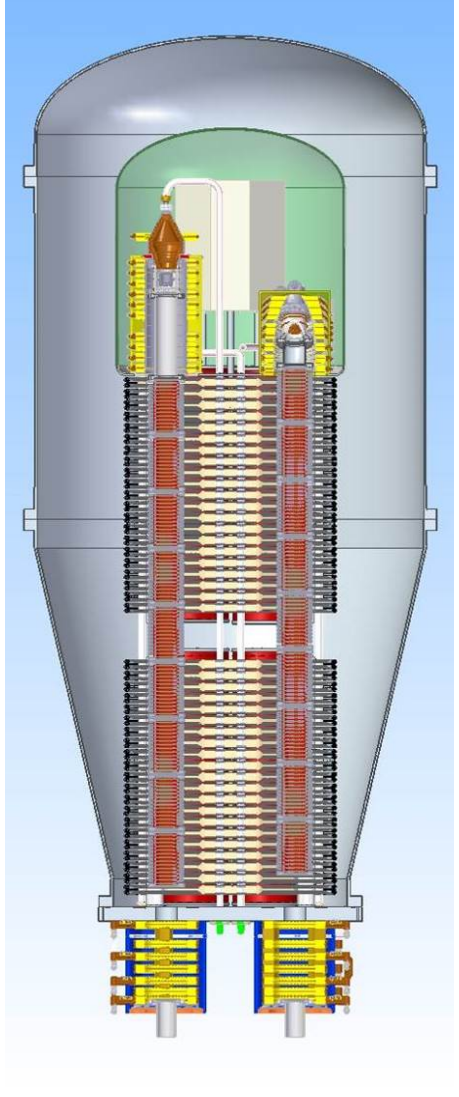
Parkhomchuk V.V., Bryzgunov M.I., Goncharov A.D., Denisov A.A., Poluhin V.A., Putmakov A.A., Reva V.B., Skorobogatov D.N.

Abstract

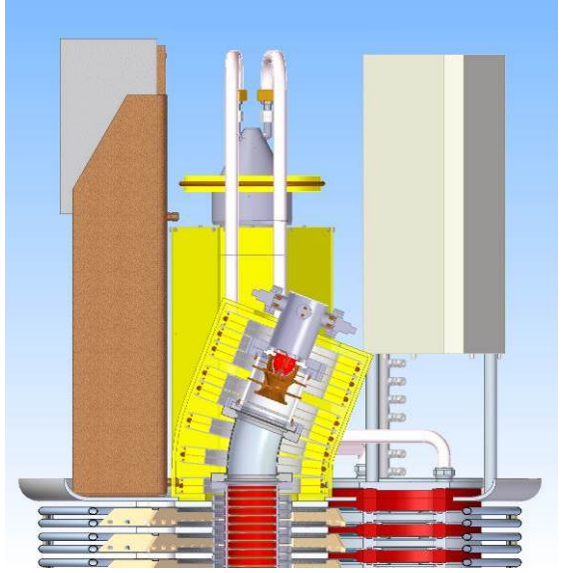
Expearance of using the different systems for powering the high voltage coolers are discussed. The acceleration and deaccelerate the electron beam tube need the rlectric power for solenoids and the control electronic. At BINP was used diferent systems: many cascades transformed, pressed gas turbins generating.



High voltage vessel NICA cooler. For powering magnet coils along acceleration tube used 2 cascade transformer

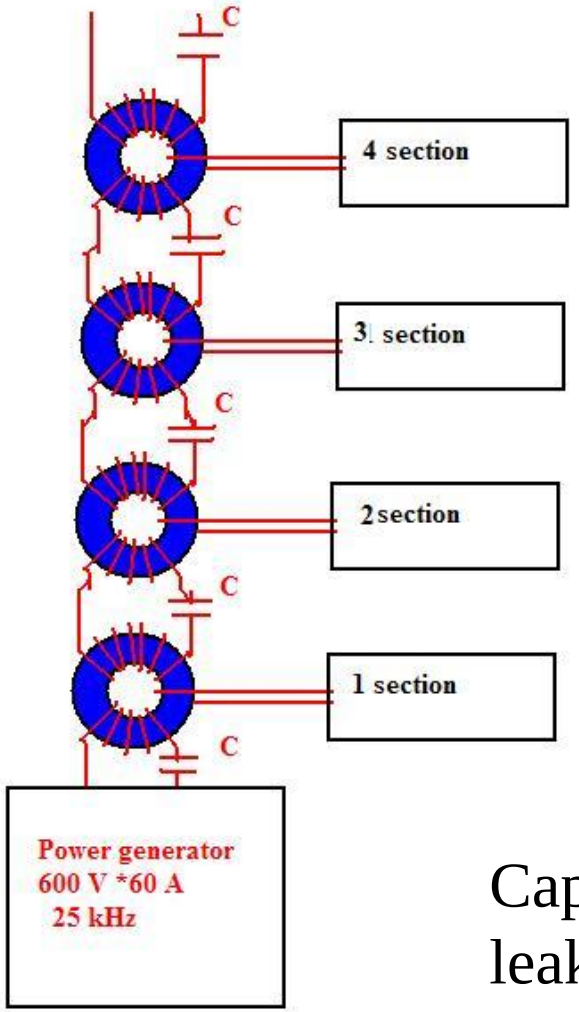


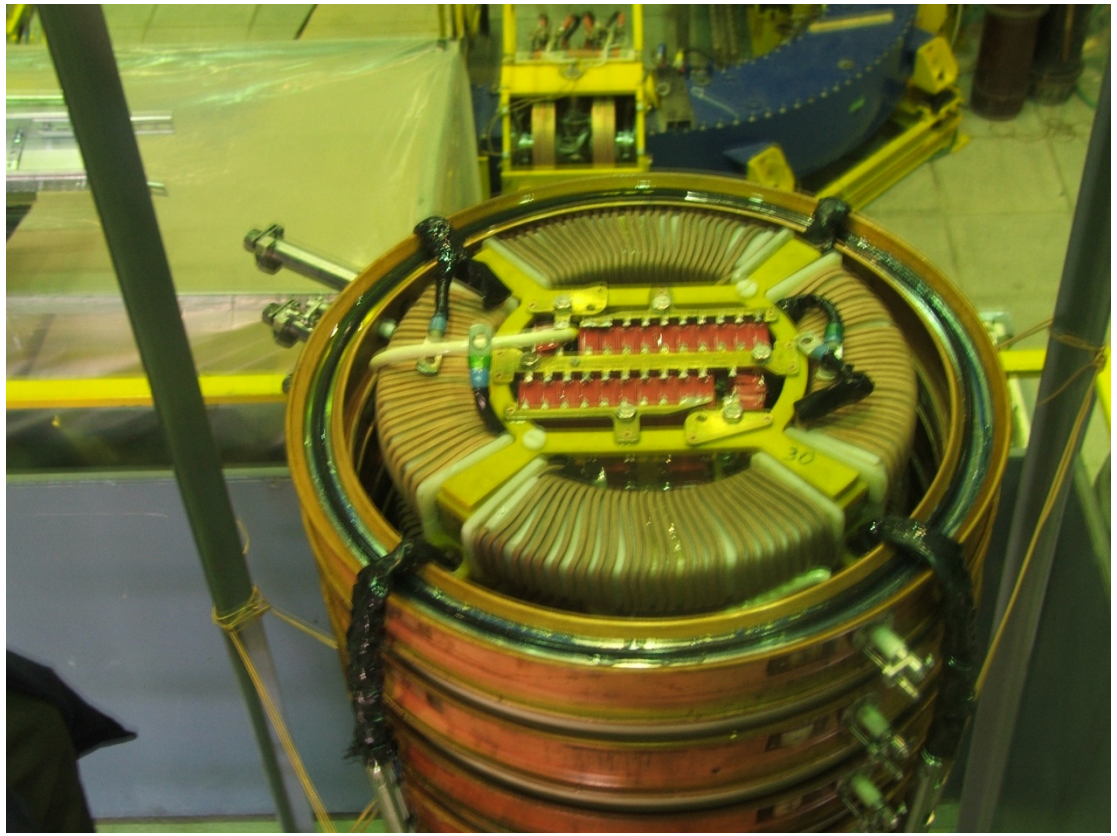
High voltage equipment”s inside vessel with pressed SF6 up to 10 bars



Electron gun shifted from axis for protection cathode from bombarding secondary rest gases ions accelerated at acceleration tube up to 2.5 MV

Cascade of serial transformers with amorphous Fe core for powering sections





Capacitors used for compensation leakage inductance

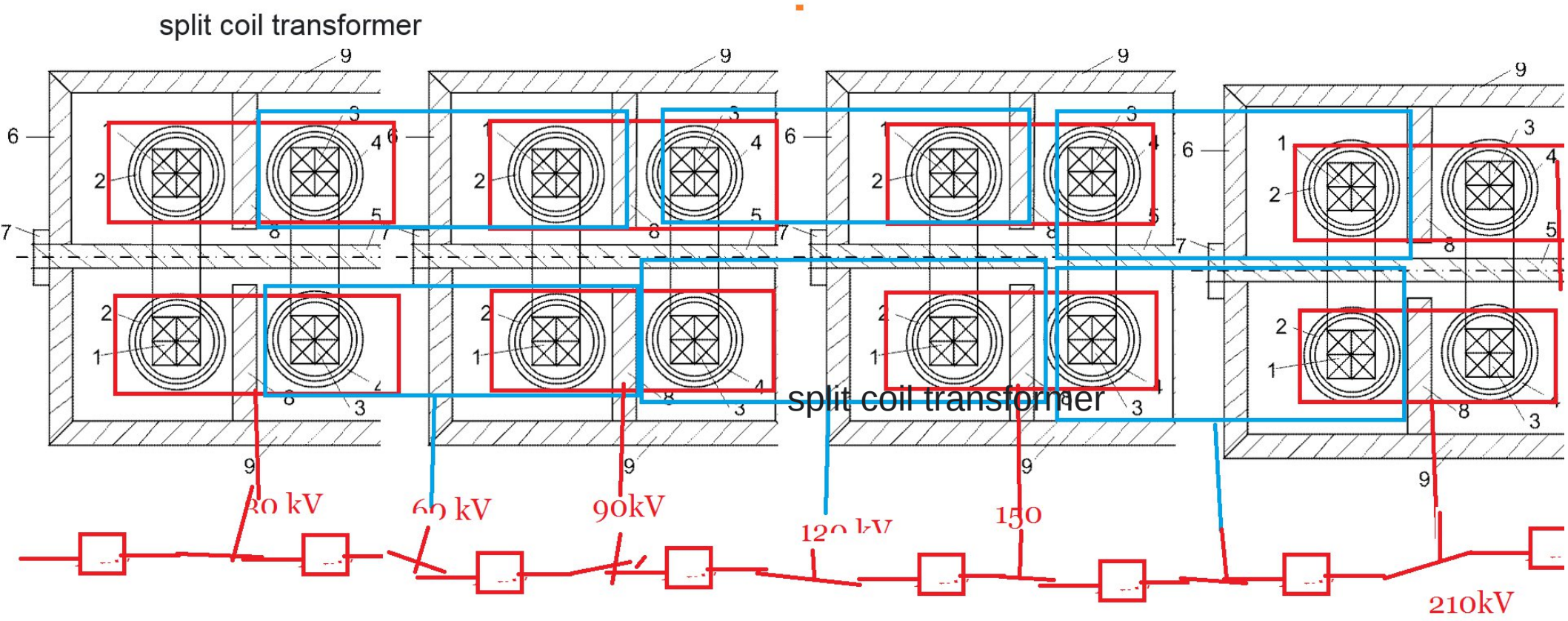
Parameters the section of cascade transformer for NICA project

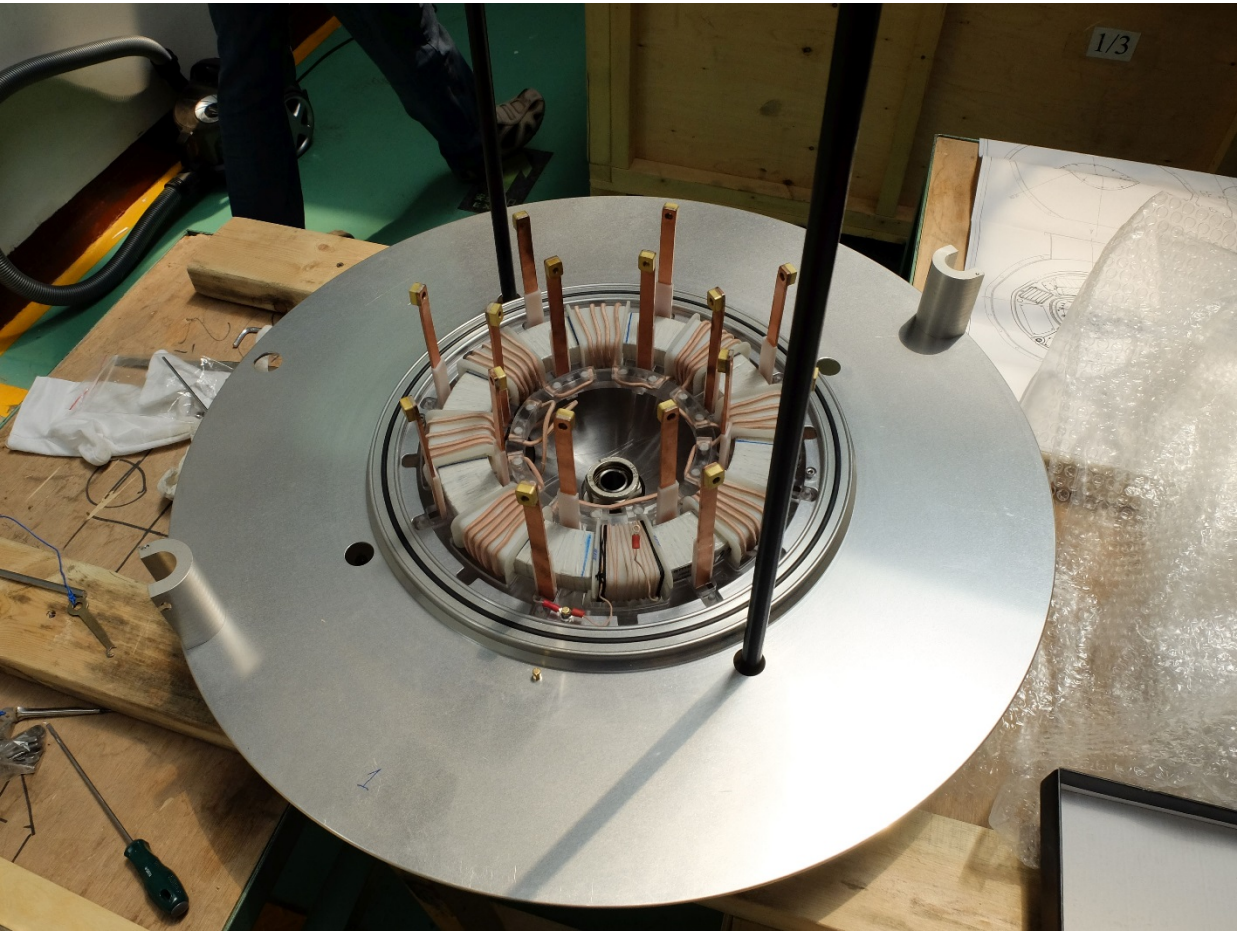
Parameter	Value	Units
Diameter of magnetic core	280-200	mm
Thickness (Two rings 10mm at parallel)	20	mm
Massa of Fe core	4.8	kg
Working Inductions	0.25	T
Specific power losses for induction 0.25T	12	W/kg
Current of coils	up to 50	A r.m.s
Voltage	up to 700	V r.m.s
Transferred power	up to 35	kW
Power Losses at cascade transformer	7	kW
Number of turns at coils	28	turns
Mass of copper at coils (1 section)	230	g
Cross section copper of coils (Litcendrat AWG38)	5.8	mm^2
Winding resistivity at 0 Hz (28 turns)	0.015	Ohm

The design of the transformer is made by analogy with the design of the accelerator tube. The transformer consists of alternating ceramic and metal rings. Inside the metal ring there is a magnetic circuit with two high-voltage sectioned windings and one winding under the potential of the magnetic core to power the section. One high-voltage winding serves to transfer power to the next stage up, the other winding for communication with the lower section of the transformer.

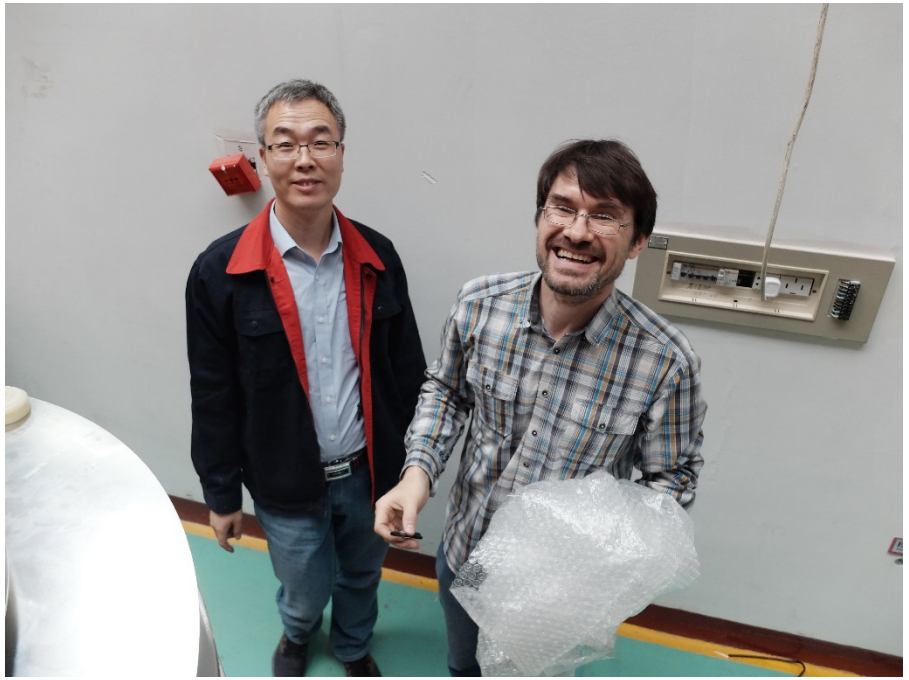
Photo of one stage (21 assembled sections) of a cascade transformer [two stages up to 2.5MV for the NICA project].

split coil transformer





First pherit ring with frame for connection cascade pherite rin



Happy Maj and Dima after finish assembling cascade for C

A new cascade transformer with an 8-fold parallel communication loop for a Chinese project

A model of a cascade transformer consisting of three magnetic cores connected by eight parallel turns of communication was obtained from the workshop and tested Fig.1 When making measurements (according to point 2), the input winding W1=32vitka, on the first lower magnetic circuit is powered by a voltage generator (U gen)with a frequency of 25 kHz. The output winding W2=32 turns, a load with a resistance R=62 ohms is connected to the third upper magnetic circuit, and with an overall dissipation power of up to 3000W.

1. To calculate the coupling coefficient of two pairs of connected cascades, the input inductance of the transformer was measured in two modes-with the secondary winding of the transformer open and shorted: Inductance Lxx=15.5 mH Inductance Lkz=56 microns The calculated coupling coefficient for one pair of cascades is equal to: Kc=0.9991

2. Measurement of the voltage transfer coefficient to the load: A measuring current transformer with a current transfer coefficient of 75/1 is included in the loads circuit.

The voltages on the input W1(Ugener)and output W2 (ULoad) windings of the cascade transformer are measured using an oscilloscope in the rms cycle voltage measurement mode for a period.

The measurement results are presented in Table 1.

During the operation (about 40 minutes) of the cascade transformer in the power transfer mode of 2.7 kW to the load, the transformer cores were heated to 30 dg. Celsius. The ambient air temperature was 23 degrees Celsius.

Later, a new transformer was manufactured in a complete set and delivered for the Chinese project.

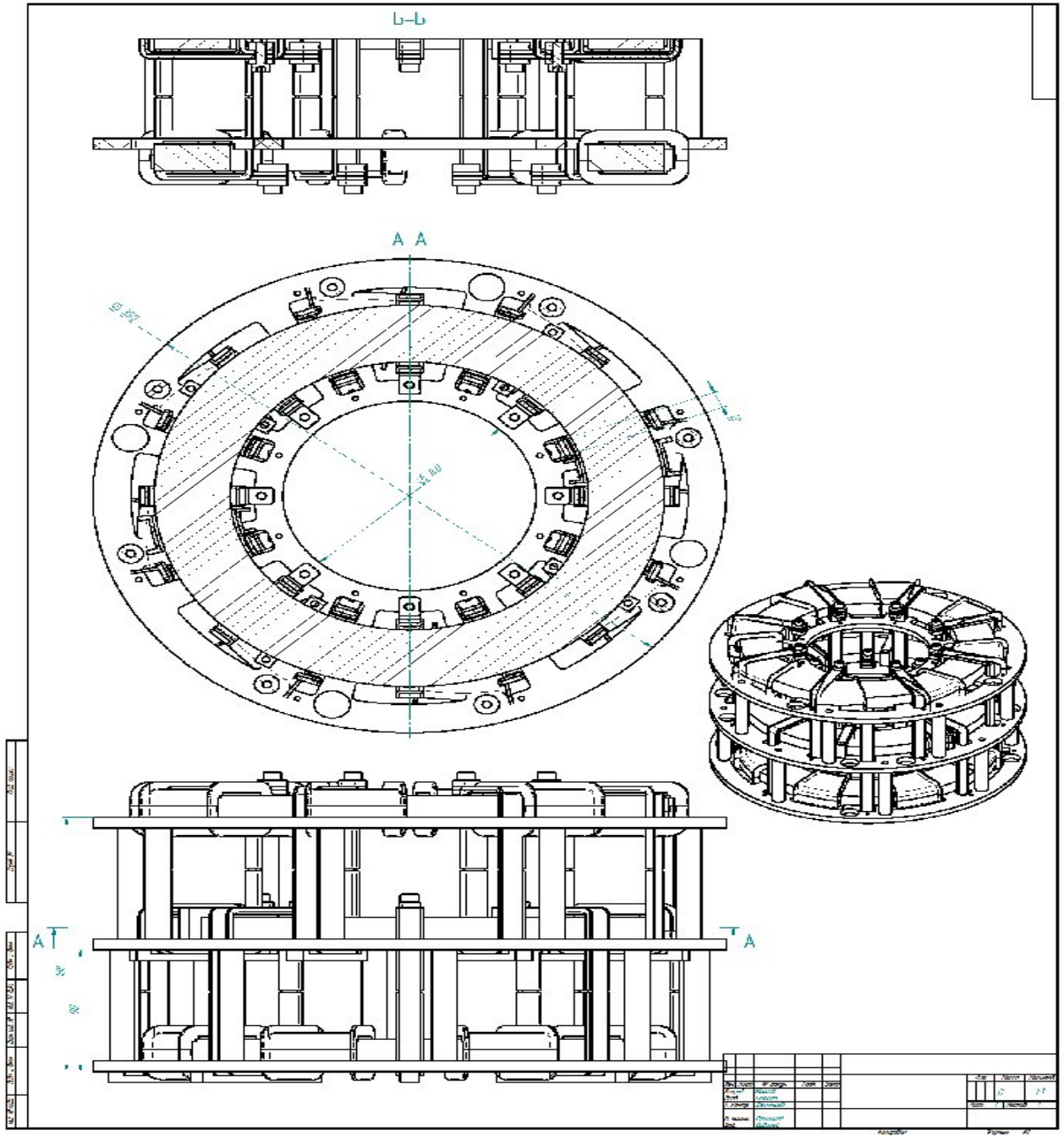
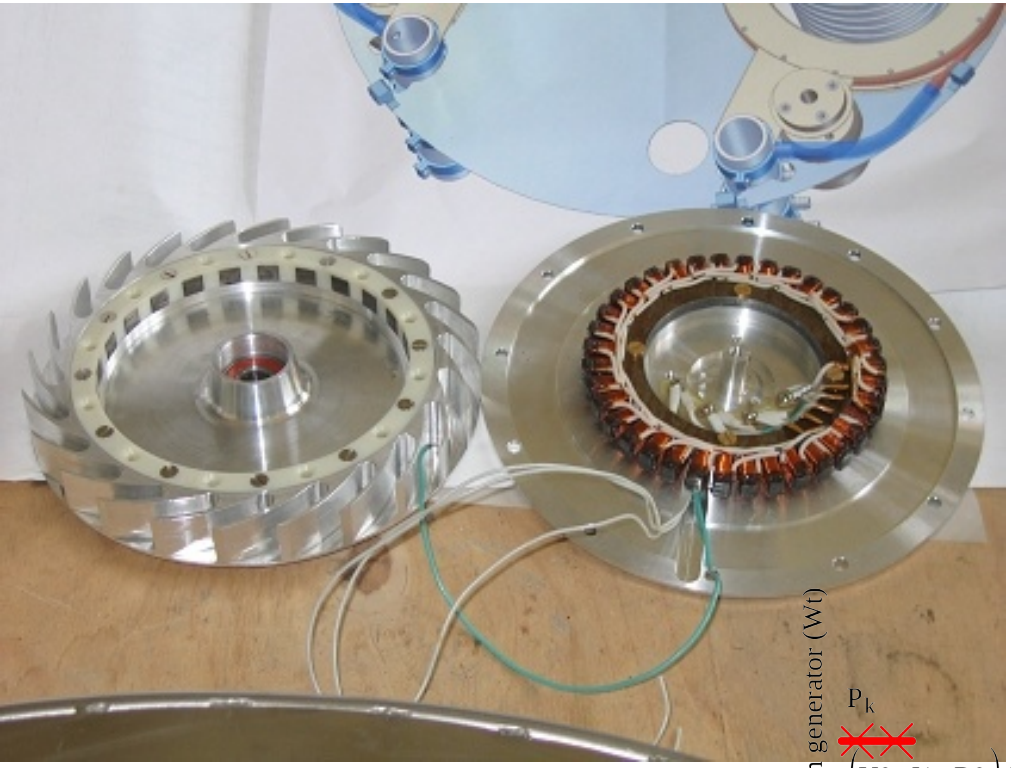


Fig.1

Table 1

Ugener. (V)	Ugener.rms (V) the device is an oscilloscope	Igen ImA mA=(mV/0.0933) the device is an oscilloscope	Uload.rms (V) the device is an oscilloscope	Iload.rms Tr-f(mA.rms) mA=(mV/0.0933) the device is an oscilloscope
50	67	-	65.5	1093mA/102 mV
100	134	-	131	2197mA/205 mV
200 load	265	4876mA/455mV	257	4448mA/415 mV
200unload	272	171mA/16mV	-	-
300	396	-	-	6795mA/634 mV

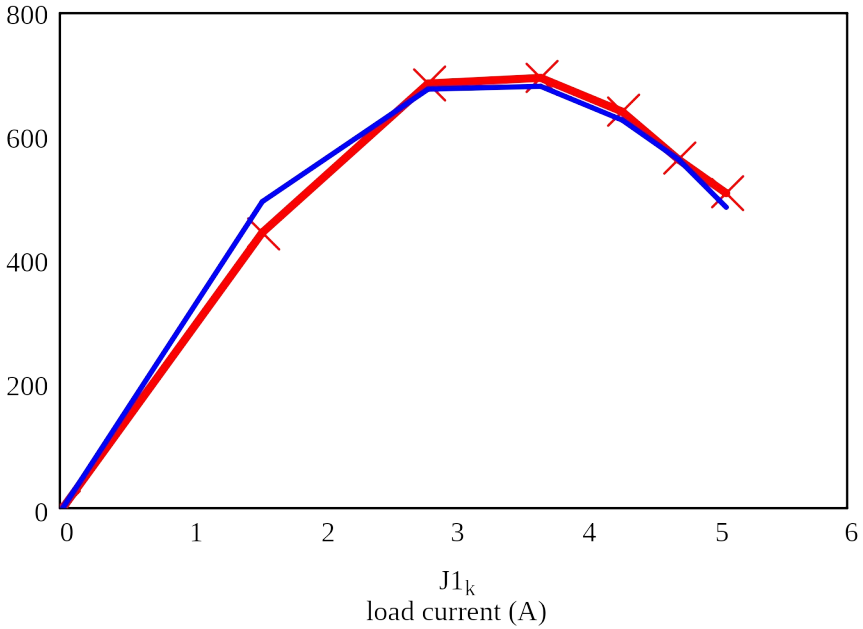
Turbine parameters



4 MeV/60 keV=66 sections
66 turbines looks to many

But it is possible to used industrial turbines with power near 5 kWt
and local cascade transformer
That power 10 sections (on 0.6 MeV)
At this case we need about 7 turbines

$$P_k = \left(U0 - J1_k \cdot R0\right) \cdot J1_k$$



Thank you for attention