Current Status of 120 kW 30 kV SMPS Power Source for e-beam

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Some time ago, within the framework of a low-budget short-term Project, an apparatus was created to supply a high-power electron gun for applications in high-temperature metallurgy. The task of the work was 30 kV and 5 Amperes. The device was created at a level satisfying the Project, but its launch was hindered by the size of the Project deadline and budget, however, recently the interest in completing the Project has noticeably increased, because it seems that a similar device could have a prominent application in medium-power energy, small renewable resources (solar and wind) power plants for direct power injection into High Voltage Networks.

Questions that were successfully completed:

The 120 kW power rectification was based on an innovative thyristor rectifier, which initially charges the capacitor bank with a half-cycle regulator, thus avoiding overloading the fuses, then slowly increases the voltage to a certain level, when the rectifier switches to a full-wave three-phase rectifier mode until it is turned off. This method not only allowed for significant cost savings, but also proved to be gentler on network overloads in operation as an alternative to operating a short-term additional resistance and its short-circuiting magnetic contactor.

The capacitor bank leads were formed with the help of bifilar layers of opposing current located close to each other, which reduced the lead inductance by approximately 95%, and the remaining unwanted inductance was compensated by smaller MKP capacitors directly on the ends of the igbt transistors.

A large-sized transformer was made by gluing together I-shape ferrite rods with very high magnetic quality. This method can be used for fast making ferrite cores of any size. The transformer windings were designed by leading out both ends of each layer so that they could be connected non-consecutively, let the voltage drop between the layers was a single-layer voltage, not a two-layer voltage, as is usually used in transformers. In leakage inductance tests and saturation current tests, the transformer proved to be correctly designed.

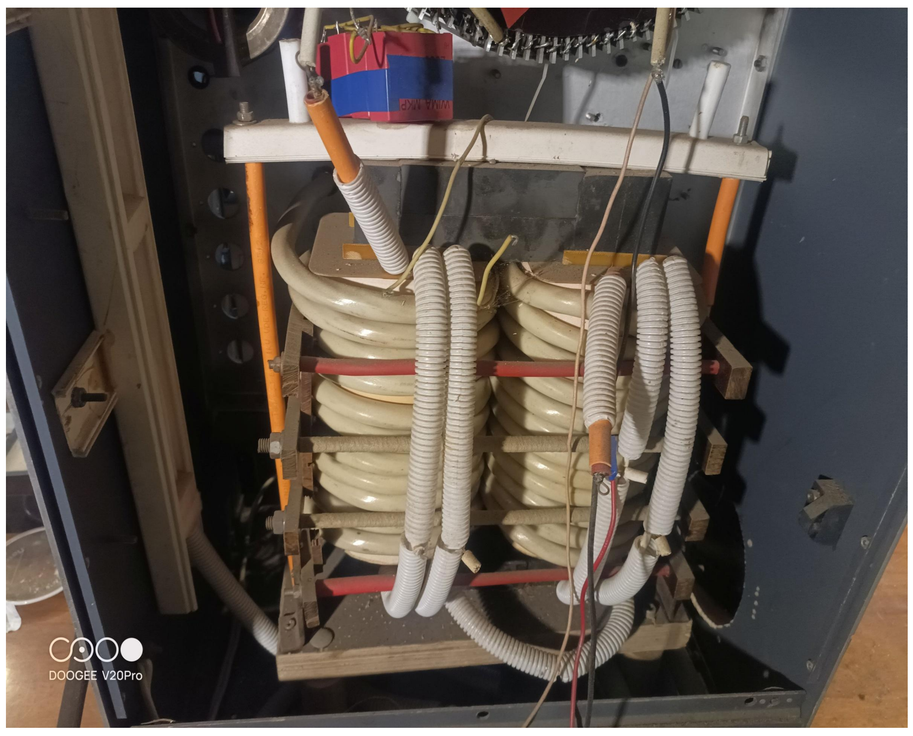
The HV rectifier was made by connecting in series many 1 kV 5 A TO-220 high-speed diodes, mounting them on individual radiators, which are screwed into nests of two pancake-shaped plastic plates, between which a fan blows air from the center to the edges. During testing, a few assembly errors were identified and were promptly corrected, so the infrared Themography control verified that the Graetz rectifier is stable up to a current of 5 A.

Since the e-gun is prone to sporadic short circuits at times, the protection mechanism was built on the basis of a large rod-shaped solenoid, the Q-factor of which was adjusted to an aperiodic mode with the help of massive array of multiple SMD resistors. Such an implementation turned out to be much more miniature and reliable than other possible alternatives. The delay created by the coil was sufficient for the electronic protection circuit trigger during the delay.

Issues that were not solved well enough: The giant transistor gate control chip tended to give unmotivated false opening pulses in some rare modes resulting in throughshoot, which led to the need to replace burned-out 1200 Volt and 700 Ampere transistors several times. The circuit was implemented with increasing complexity and improvements, but today it is clear that the H-bridge specific ZVS control chip must be found other - more resistant to interference.

Significant difficulties were caused by the fact that the laboratory does not have an optocoupled probes that would allow for simultaneous viewing of Vds, Vgs and Id on each of the 4 transistors. Since such probes cost from 30 kEur per piece, and at least 12 pieces are needed, for now We are thinking about producing them on our own, based on the AFBR optotransmitter and optoreceiver. This would allow for a much better understanding of what exactly the bridge control chip is doing wrong.

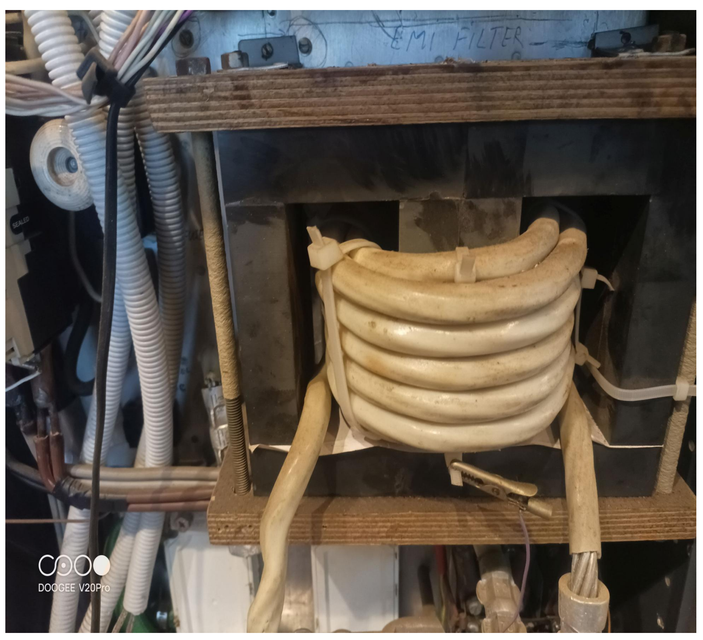
A scientific publication was published about the work done.

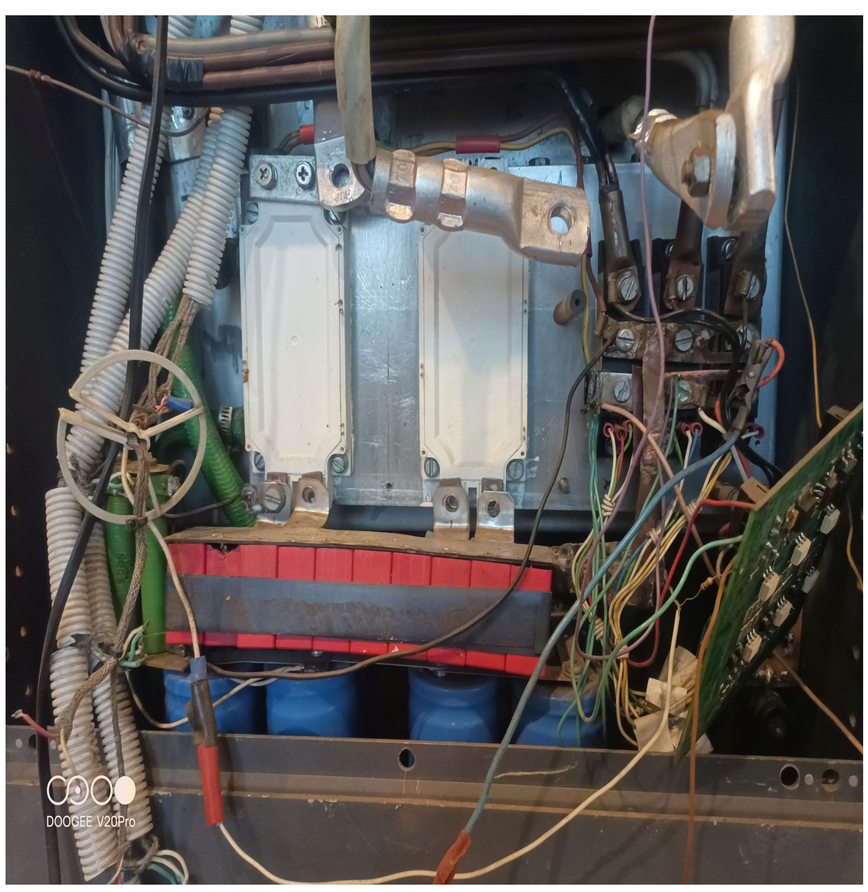


120 kW ferrite transformer

The SMPS case

The H-bridge igbt on the water cooled radiator





Upper part – serial two aperiodic coils
Lower part – 30 kV 5 A Graetz bridge

The ZVS ferrite coil