Transistor technology for induction melting furnaces

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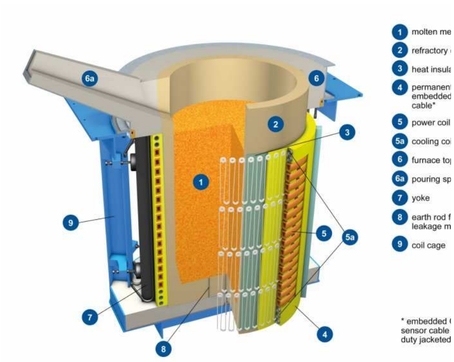
1. Introduction to induction melting furnaces

A modern coreless induction furnace is shown in picture 1. It melts metal ("charge") by the means of electric energy – alternating current. The charge works as the core of the coil (wound copper profile). The energy transfer to the core happens by "iron losses" their main sources being eddy currents and (for ferromagnetic materials) magnetic hysteresis and finally anomalous losses.



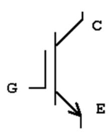
Picture 1

2. The road from the net frequency melting furnace to modern transistor technology

Initially induction melting furnaces where relatively simple devices, as long as they used net frequency (50/60Hz) – while modern furnaces use medium frequency which ranges from 250 Hz to a high kHz range. All that was needed on the supply side where transformers to adjust the voltage.
These net frequency MF had a few disadvantages, mainly the need to maintain a minimum level of molten material through the whole melting process (modern medium frequency furnaces can be emptied completely) and a very intense stirring effect on the molten metal, which is under certain conditions not desirable.
Therefore medium frequency furnaces were introduced. They require additionally a frequency converter that increases the frequency from 50/60 Hz. Such a device consists of a rectifier part and a an inverter. Originally both the rectifier and the inverter where equipped with thyristors. Thyristors, once they are conducting, cannot be switched off actively. This results in an unfavorable behavior in the supply network, the thyristor frequency converter together with an inductive load showing low power factors (ideal pf = 1.0) – utilities typically charge additional costs to commercial customers who have a power factor below some limit, which is typically 0.9 to 0.95. To eliminate this disadvantage transistors were introduced in the inverter part of the frequency converter.

3. IGBT – insulated gate bipolar transistors and their advantages

IGBT (symbol see picture 2) are designed to switch on and off very rapidly, therefore they are very well suited for industrial control systems. That is why they are the prime choice for the application in frequency converters for medium frequency induction melting furnaces, especially in the critical inverter part. Because in the crucial parameters (voltage rating, current rating) they surpass other transistor types (power bipolars and MOSFETS) they are used despite their higher price.



Picture 2

4. Comparison between thyristor and IGBT inverters

IGBT allow to reach constantly a much better power factor (0.99-1.0). They are also more reliable (self-protective) and allow for a simpler cooling setup, because they are suited for indirect cooling.

5. Experience from use, reliability, examples of installations

IGBT are being used in a few hundreds OTTO JUNKER induction furnaces and the results are very satisfactory. The reliability is outstanding and the behavior in the network makes it possible to avoid additional costs charged by the utility company under all circumstances.