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SIMULATIONS OF THE PLATE-TYPE ELECTROSTATIC PRECIPITATORS HIGH FREQUENCY POWER SUPPLIES USING PSCAD/EMTDC 3.0.8 SOFTWARE

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Abstract:

The globalization of the environmental pollution problems caused by the increse of industrial production will lead in the cleaning of the waste gases. The structures and control of power supplies of the plate-type electrostatic precipitators is one of the most important factor to diminish the pollution. The plate-type electrostatic precipitators must operate in its electromagnetic environment without interfering with the operation of other equipments (radios, televisions and mobil communications systems). The power supplies and the electrical model of electrostatic precipitators has non-linear elements that cause distorsions of the power supplies currents.

The paper presents the simulations of the primary and secondary currents and voltages, the total harmonic distorsion and the apparent power depending on frequency (between 4 and 24 kHz) of the plate-type electrostatic precipitators high frequency power supplies using PSCAD/EMTDC 3.0.8 software.

Keywords:
plate-type electrostatic precipitators, power supply, current harmonics

1.INTRODUCTION

In thermal power stations, the gas particles from boilers are passed through a Corona charging field where they receive an electric charge, usually negative for the plate-type electrostatic precipitators, and then as charged particles are deflected by the electric field. Then the charge particles are moved from the negative electrodes (discharge electrodes) to positive electrodes (plate electrodes) where will be deposited. The positive electrode is normally earthed. The particles are remove from the positive electrodes into receiving hoppers by mechanical shock impulse rapping in a dry application (the case of plate-type electrostatic precipitators). The plate-type electrostatic precipitators are made from a number (three or four for thermal power station) of series sections (fields), each section is energized by its own transformer rectifier set and has it own hopper [2,6].

The electric power system is very complex. EMTDC is a simulator of electric networks with the capability of modelling complex power electronics and controls of the non-linear networks. When run under the PSCAD graphical user interface, the PSCAD/EMTDC combination becomes a powerful means of visualizing the enormous complexity of portions of the electric power systems. It is widely used by electrical engineers from industries and academic institutions world wide.

For a maximum collection efficiency is important that the voltages in the sections of plate-type electrostatic precipitator (ESP) to be close by electrical discharges. This condition is carry out if the voltages in the sections of ESP are continuous adjustable in the range of Corona voltages [3]. The change of gas parameters at the entrance of ESP causes more electrical discharges and the collection efficiency slows down. The sections of ESP must have a power supply, that assure a continuous voltage, and an automat voltage regulator, with proper tuning [5].

2. HIGH FREQUENCY POWER SUPPLIES FOR PLATE-TYPE ELECTROSTATIC PRECIPITATOR

In the last two decades, the development of fast electronic switching devices (fast-thyristors, IGBT and so on) have cause the development of power supplies of ESP [1].

The main circuit of a.c.-c.c. convertor for a section of ESP is presented in fig.1.

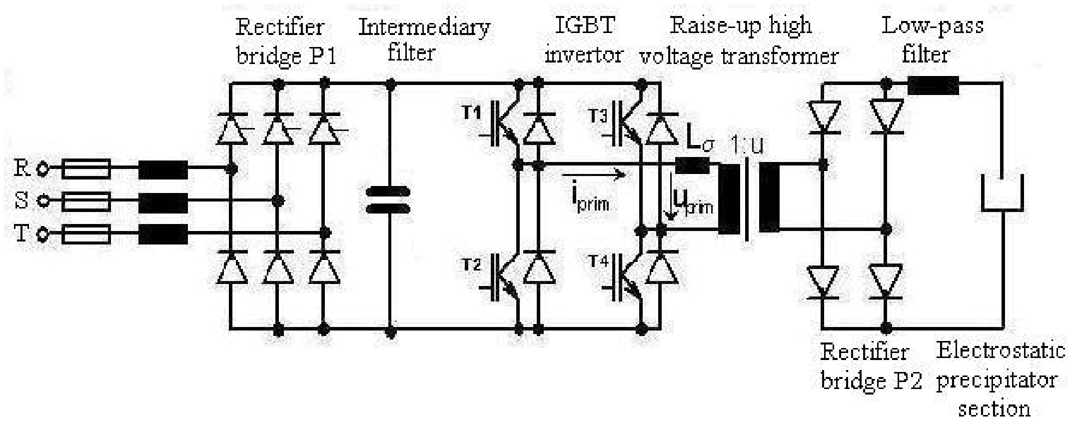

Fig.1. *A.c.-c.c. convertor for a section of ESP*

The circuit from fig.1 has the main components:
- the primary three-phase rectifier bridge P_1 without control;
- the c.c. intermediary filter to slow down the voltage ripples that is an electrolytic capacitor with small disipation;
- the primary invertor, with different configuration and components, with switching frequency in the range from kHz to 50 kHz;
- the raise-up single phase transformer at high voltage and frequency (380V/65kV) for the section of ESP; is made from ferrite toroidal core for minimize disipation;
- the secondary high voltage and frequency rectifier bridge P_2 that is used to obtain the continuous voltage in section of ESP;
- the low-pass filter to reduce the current harmonics that appears from electrical and Corona discharges; is made from R-L components.

3.SIMULATIONS OF THE PLATE-TYPE ELECTROSTATIC PRECIPITATORS HIGH FREQUENCY POWER SUPPLIES

With the PSCAD/EMTDC 3.0.8 software was simulated a high frequency power supply unit of ESP section presented in fig.2. This power supply unit may be energized a section of a large plate-type ESP (the gas flow Q=650000 m^3/h, distance between the same electrodes s=0.350 m) from the Thermal Power Station Mintia-Deva from Romania. The plate-type ESP has four identical sections. In fig.2 is presents the electrical installation of one ESP section using in simulations.

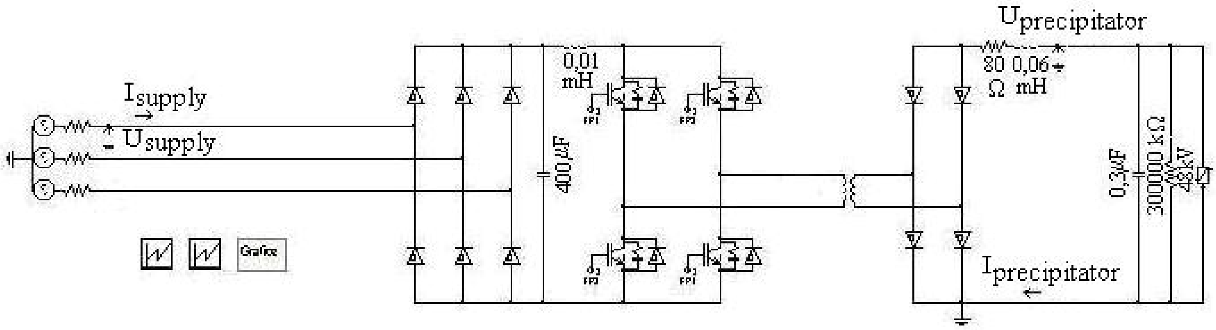

Fig.2. *The electrical installation of the ESP section using in simulations*

The control of firing angle of transistors is presented in fig.3.

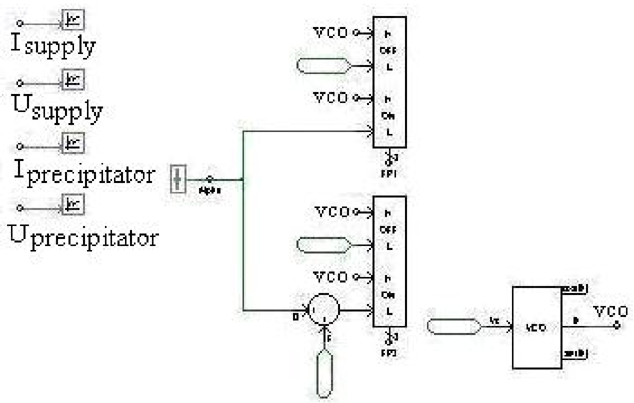

Fig.3. *The control of firing angle of transistors*

The main parameters there are used in simulations are (fig.2): U_{supply}=380V (50Hz, 3~), C_1=400μF, L_1=10 mH (the c.c. intermediary filter); invertor with IGBT bridge; a raise up single-phase transformer 380V/65kV; R_1=80Ω and L_2=60mH (filter to reduce the current harmonics).

The section of electrostatic precipitator was approximate with a capacitor, a resistor and a varistor in parallel connection [1]. The capacitor (C=0,3μF) is the electrical capacitance of the precipitator depends on the geometrical and dimensions of the sections and the dielectric proprieties of the process gaz. The resistance (R=300kΩ) depends on the particle transport in the electrical field. The varistor (U_z=48kV) is given by electrical discharge in the section of electrostatic precipitator.

It were simulated the primary voltage and current, the secondary voltage and current for a firing angle by 30^0, at switching frequency by 16kHz.

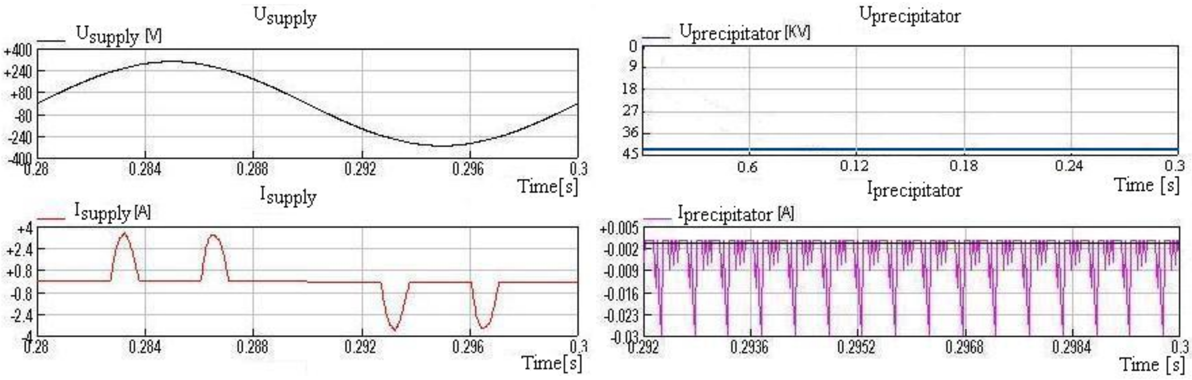

Fig.4. *The primary voltage (U_{supply}) and current (I_{supply}), secondary voltage ($U_{precipitator}$) and current ($I_{precipitator}$) for a firing angle by 30^0, at switching frequency by 16kHz*

In fig.5, 6, 7 are the harmonic analyses of primary (supply) current for the 31st harmonics current, for different firing angle of transistors between 15^0 and 165^0, for different switching frequencies 8, 16 and 24 kHz.

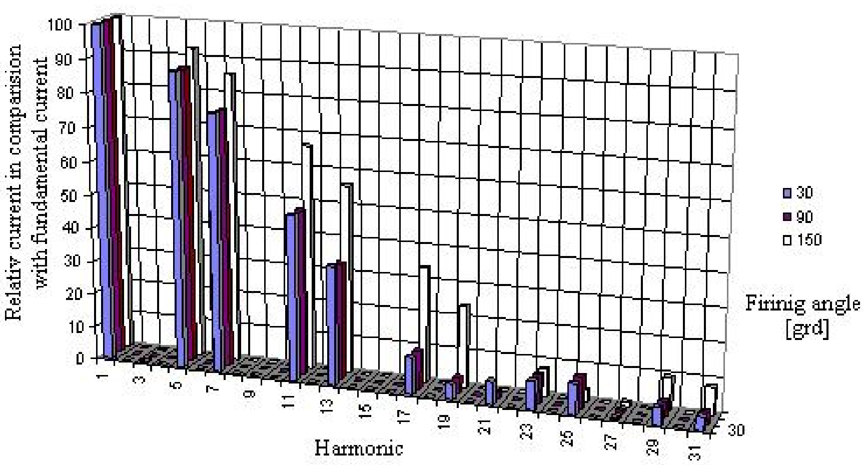

Fig.5. *Harmonic analyses of primary current (I_{supply}) at switching frequency by 8kHz*

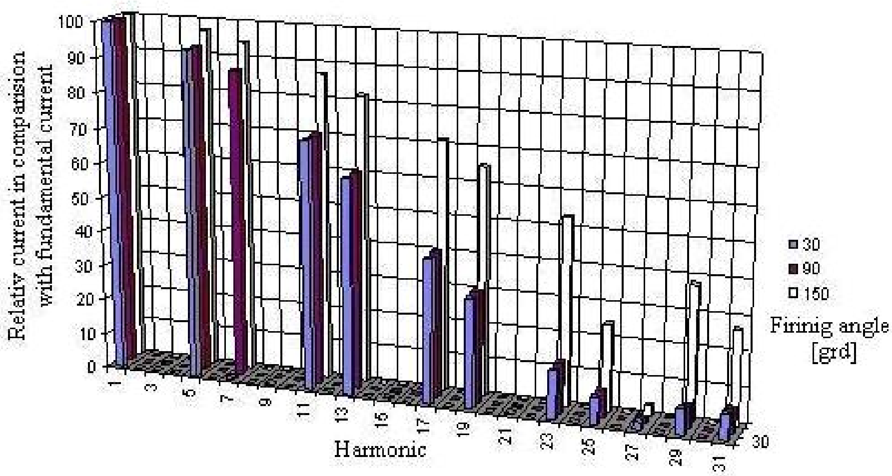

Fig.6. *Harmonic analyses of primary current (I_{supply}) at switching frequency by 16kHz*

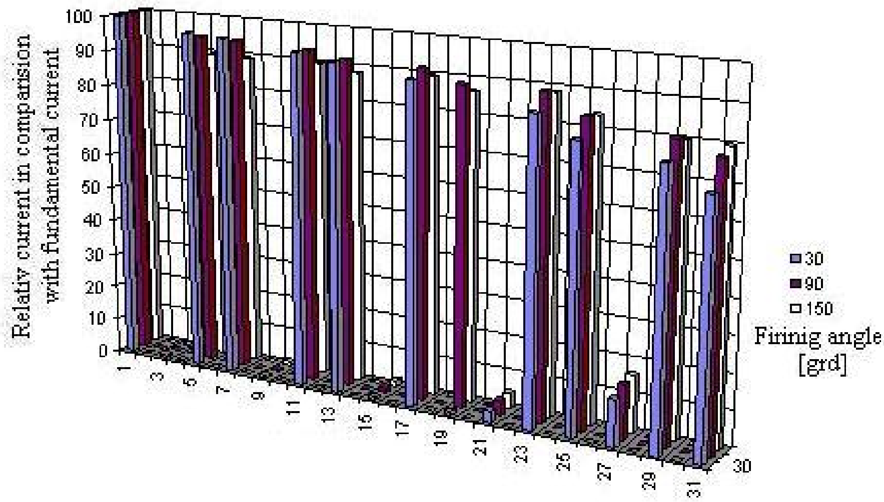

Fig.7. *Harmonic analyses of primary current (I_{supply}) at switching frequency by 24kHz*

In fig.8, 9 and 10 are present the total harmonic distorsions, the r.m.s. primary current, the first harmonic of primary current and the apparent power depending on the switching frequency.

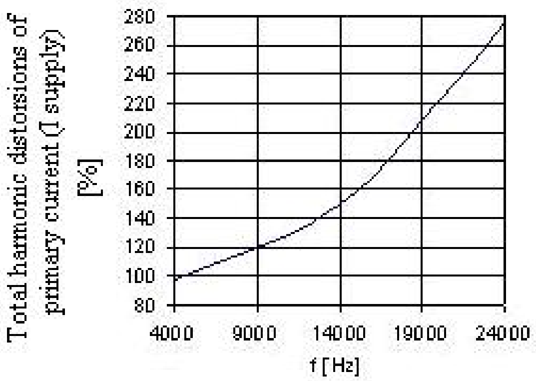

Fig.8. *The total harmonic distorsions the depending on switching frequency*

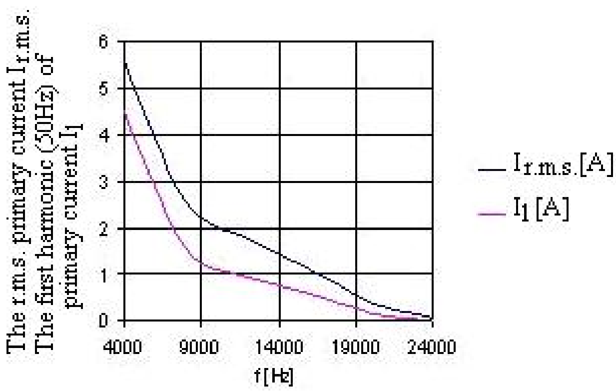

Fig.9. *The r.m.s. primary current and first harmonic of primary current depending on switching frequency*

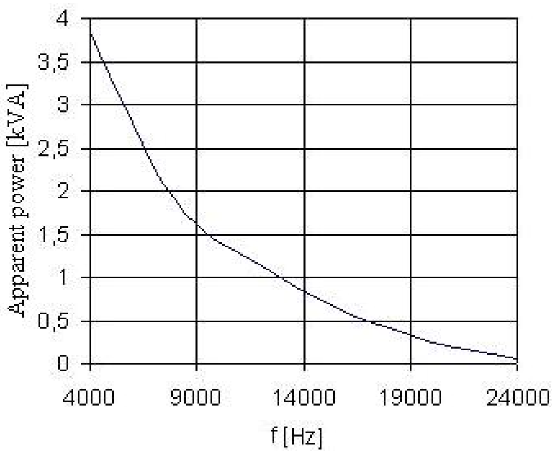

Fig.10. *The apparent power depending on switching frequency*

4.CONCLUSIONS

If its use the high frequency power supplies for plate-type electrostatic precipitator (ESP) sections, the secondary voltage (precipitator voltage) ripples slow down (fig.4) in comparision with traditional electrical power supplies (f=50Hz) [4]. The voltage control in every ESP sections may be done, without any difficult then in the case of traditional energization. From fig.5,6,7 result that the current harmonics grow up in the same time with switching frequency and the firing angle. The primary current has a lot of different harmonics and from this reason has not a sinusoidal form (fig.3). The bigger current harmonics are: 5, 7, 11, 13, 17, 19, 23, 25, 29, 31.

To diminish the harmonics amplitudes must be use passive or acive filter. Passive filter is not expensive, but it has a good function only in stationary conditions, that is not a behaviour of ESP sections. From this reason, a better filtration of primary current can be obtain with active filter, but the electrical installation for one ESP section is more expensive.

The total harmonic distorsions (fig.8) grow up and the r.m.s. primary current (fig.9) slows down in the same time with the rises of switching frequency. The apparent power (fig.10) slows down if the switching frequency rises.

The simulatuions from this paper show the posibility to use of high frequency power supplies for ESP sections, because the specify energy consumption and the gauge decrease, and the efficiency of ESP increase if it uses the performant automat voltage regulators.

5.REFERENCES

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