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[1.] Gabriel Nicolae POPA, [2.] Sorin Ioan DEACONU, [3.] Iosif POPA, [4.] Corina Maria DINIŞ

NEW TRENDS IN DETECTION OF BACK-CORONA DISCHARGES IN PLATE-TYPE ELECTROSTATIC PRECIPITATORTS

[1-4.] DEPARTMENT OF ELECTROTECHNICAL ENGINEERING AND INDUSTRIAL INFORMATICS, FACULTY OF ENGINEERING HUNEDOARA, POLITECHNICA UNIVERSITY TIMIŞOARA, ROMANIA

ABSTRACT: *Current voltage characteristics are the main tool to control the operation of the ESP fields and to detect the back Corona. The collecting efficiency of an ESP depends on the large number of parameters. An important parameter is the current emitted from the discharge electrodes and collecting plates. Generally, the higher secondary current the better are collecting performances. Some parameters, like back Corona discharges, high resistivity fly ash reduce the collecting performances of the ESP. The paper presents some new methods detection of back-Corona discharges in plate-type electrostatic precipitators.*
KEYWORDS: *electrostatic precipitators, negative Corona, back Corona discharge*

INTRODUCTION

An important un-dust device is plate-type electrostatic precipitator (ESP). It is used in power plant, cement, steel and glass industries. In classical design, a d.c. high voltage (up to 100 kV) is used to generate the Corona effect through discharge wires. The electrons bombard the dust particles from the gas, and after a period of time the particles have negative charges, that are moved toward collecting plates, where the particles are collected [1].

In an ESP a negative applied voltage between a discharge wires (connected at negative polarity) and a collecting plates (connected at positive polarity) produce a negative Corona at discharge wires (Figure 1).

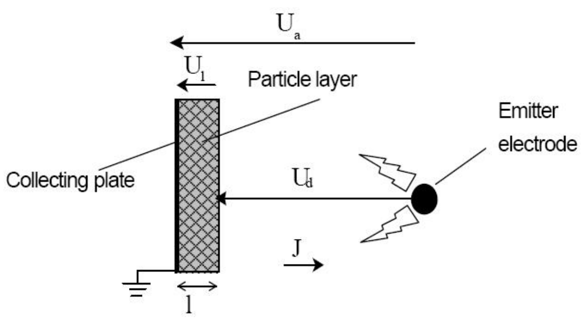

Figure 1. Principle of negative Corona discharge

The collecting high resistance dusts with ESP it is a not well resolved problem. The back-Corona phenomenon is specific for high resistance dust and consists in a series of micro-discharges between the particles from dust layer on the collecting plates. The current-voltage characteristics changes and decrease the efficiency of the ESP.

The back-corona is a non-linear phenomenon [2,3].

A method to determine the occurrence of back-Corona, in a section of ESP, is the measured the current-voltage (i-u) curve. It is important the slope of i-u curve: if the slope is infinite or negative, a back-Corona occurs in a section. The practical experience shows that the mean current depending on minimum value of the precipitator voltage is the better indication of back-Corona [4].

The new voltage control unit include back-Corona detector device. The old back-Corona detector device has the principle of slope of i-u curve. The main disadvantage of this method is that the power must be reduced to detect the back-Corona.

Another method is based on the minimum value of the precipitator voltage, before and after a spark. If the minimum voltage after spark has higher value than the value before the spark, the back-Corona is detected. It is a better method than the first one. If it is not a spark, a blocking period is induced, when the thyristors are not fired. The current is measured before and after this blocking period of time.

METHODOLOGY

The back Corona effect occur when the particle of the dust has a very high resistivity, especially when is burning low quality coal in power plants, sinter plants, and cement plants. When the particulates have high resistivity, a voltage drop can develop on the layer on the collecting plates. If this voltage drop is high can occurs breakdown between discharge wires and the surface of the layer. A hole of dust results in the layer, on the collecting plates. The electric field increased near this hole (Figure 2).

A strong positive field (instead negative field) occurs in the hole, which generates positive ions which neutralize the charged of the particles in the gas. The dust particles may have positive charged and they migrate towards discharge wires. The operation of the electrodes is upside down. This phenomenon (back Corona) is self perpetuating. Many holes occur on the dust layer on the collecting plates, dust particles will *be attaching on the discharge wires. A voltage drop will be on the dust layer. Electrically, a high current occurs on the low voltage operation, and specify to back Corona, the rise current-voltage characteristic is different then fall current-voltage characteristic (Figure 3) [5,6].*

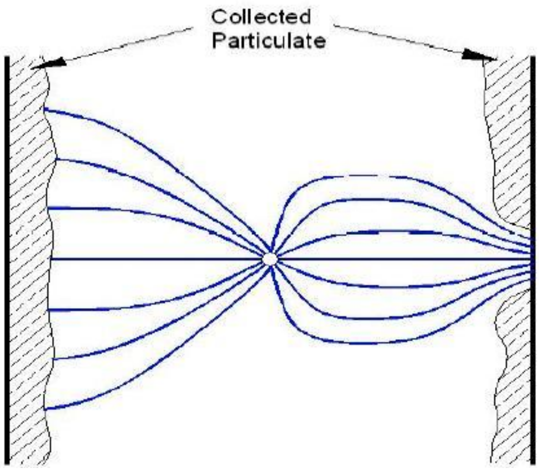

Figure 2. The back Corona between the electrodes

A positive back-Corona discharge occurs when the Corona discharge and layer resistivity are high (10^{10}-10^{11} Ω·cm). The positive ions from the dust layer drift towards the discharge wires and charged the dust particles with positive charges. The discharge wires become the collecting wires, but the total surface it is not large enough and the particles remain un-collected. The collecting efficiency of ESP drastically decreases.

Usually, the value of electric field in a dust layer is 10-20 kV/cm, and the value of electric field of air is 26 kV/cm.

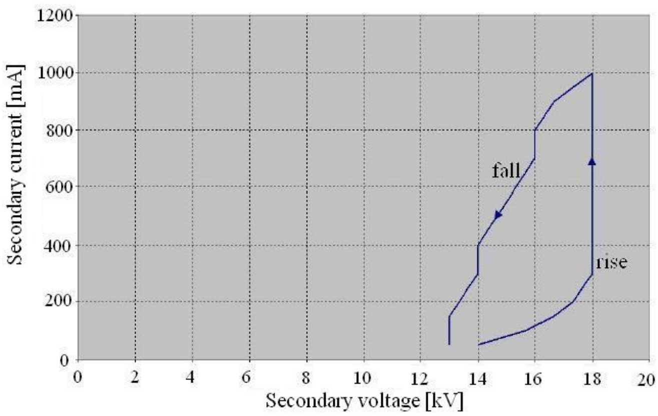

Figure 3. Secondary current as function of secondary voltage in case of back Corona discharges

The back Corona density J_b may be computed with:

$$J_b = k_b \cdot I^{0.4} \cdot (E_l - E_t)^2 \qquad (1)$$

where k_b is the power of the particle layer thickness, E_l is the average electric field in the layer, and E_t is the average electric threshold.

The average electric field in the layer depends on resistivity of the dust ρ, and current density J:

$$E_l = \rho \cdot J \qquad (2)$$

In time, various methods have been proposed to detect the back Corona. The ratio between the peak and the mean value of the secondary voltage depends on the back Corona. Other electrical parameters that depend on back Corona are: power supply impedance, supply frequency, precipitator load characteristics.

A method is to inhibit the thyristors pulses for a period of time, and than applied pulses for a period of time t_1. The controller monitors the effect of the decay voltage. In this period of time is analyzing the decay characteristics of the voltage. Back Corona is detected when is available the equation:

$$U_{ref} - U_{offset} > U_{decay} \qquad (3)$$

where U_{ref} is a reference voltage in the non back Corona condition, U_{offset} is the offset voltage to determine the sensitivity of the detection and it is a controller parameter, and U_{decay} is a decay voltage that is measure Corona onset voltage. The secondary voltage is recorded after the time t_1.

DISCUSSION

At operation of the ESP it is necessary to avoid the negative effects of the back Corona discharges.

In Figure 4 are present the computed current-voltage characteristics for different dust resistivities. The dust thickness is 0.1 cm. The characteristics were made in a model ESP into laboratory [3].

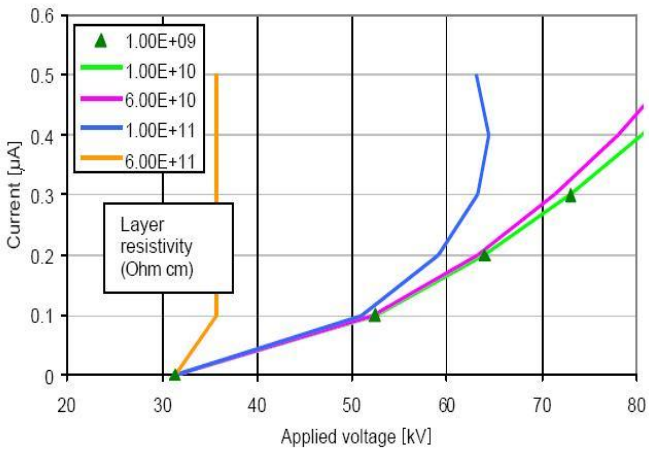

Figure 4. The current-voltage characteristics as function of dust resistivity

For high resistance dust (over $1 \cdot 10^{11}$ Ω·cm) the slope of i-u curve is infinite that indicates the back Corona discharges.

The dust resistivity strongly influences the current-voltage characteristics. The thicknesses of the dust modify the current-voltage characteristics. In Figure 5 the dust resistivity is $6 \cdot 10^{10}$ Ω·cm.

The thicknesses of dust layer increase the current from source. For high value of the voltage, the i-u curve is spreads. The computed and experimental characteristics are likewise.

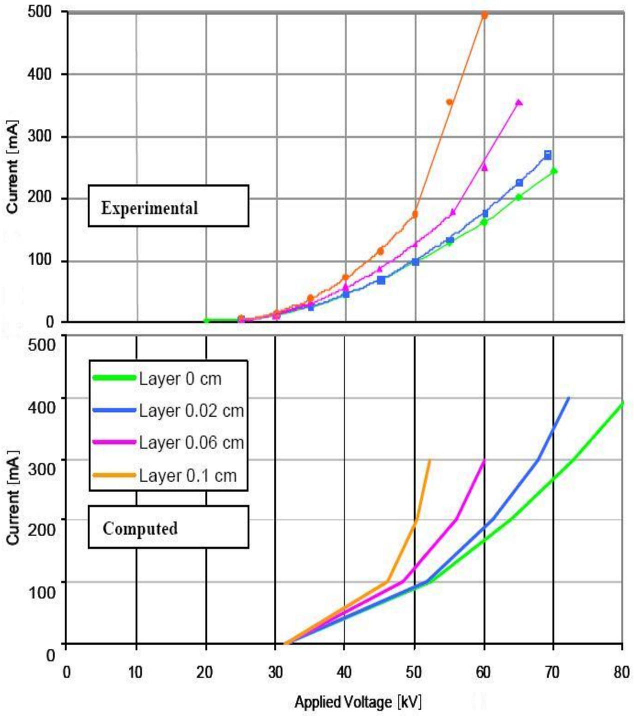

Figure 5. Computed and experimental current-voltage characteristics depending on dust particles thickness

In Figure 6 is present a comparison of collecting efficiency, experimentally by different authors, depending on dust resistivity. Starting at a resistivity about $5{\cdot}10^{10}$ Ω·cm the efficiency drastically decreasing [4,7].

In the following figures are present current-voltage characteristics from the industrial ESP connected at a 600 MW coal burning boiler. The ESP has 5 fields, the first one and the last one are equipped with traditional d.c. power supply, while the other 3 fields have d.c. switching power supplies (with low voltage ripple ±1%) [8].

The static current voltage characteristics (Figure 7 and 8) have been measure with slowly speed increasing voltage.

The characteristics from Figure 7 was made for a fly ash resistivity $7{\cdot}10^{10}$ Ω·cm. Under approx. 28 kV, the characteristics are the same, and above this value, the current is higher for the characteristics with dust layer.

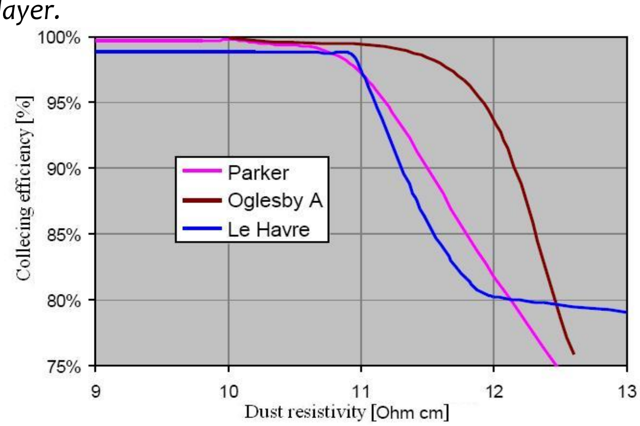

Figure 6. Collecting efficiency depending on dust resistivity

In Figure 8 are present three current-voltage characteristics made from different fly ash resistivity: a. high value ($2{\cdot}10^{11}$ Ω·cm), b. medium value ($7{\cdot}10^{10}$ Ω·cm) and c. low value ($3{\cdot}10^{9}$ Ω·cm).

The presence of the back Corona can be made with dynamic (the voltage rise and fall rapidly) current voltage characteristics. The rise and the fall characteristics (the shape of „8”) identify the back Corona discharges.

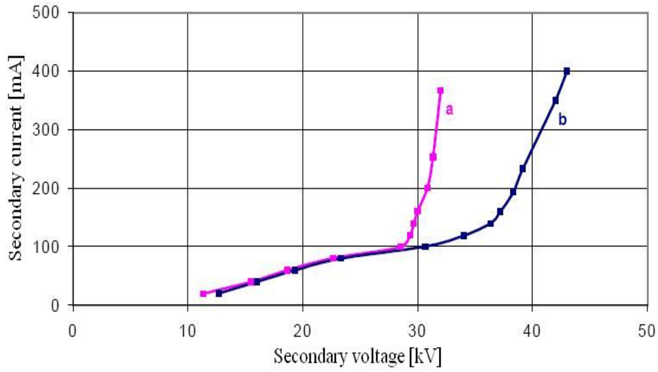

Figure 7. Current voltage characteristics:
a. with dust layers;
b. without dust layers on the collecting plates

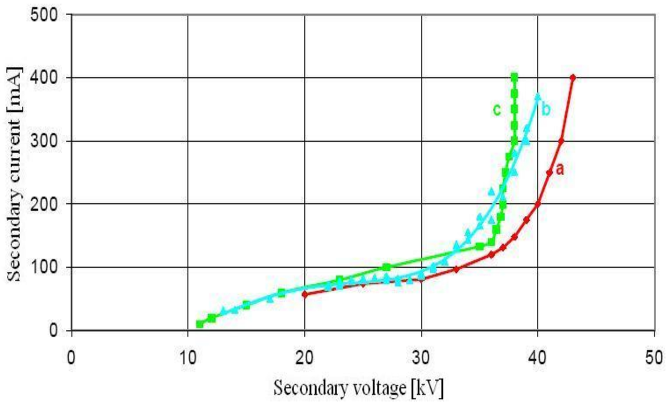

Figure 8. Current voltage characteristics:
a. high, b. medium, c. low resistivity fly ash

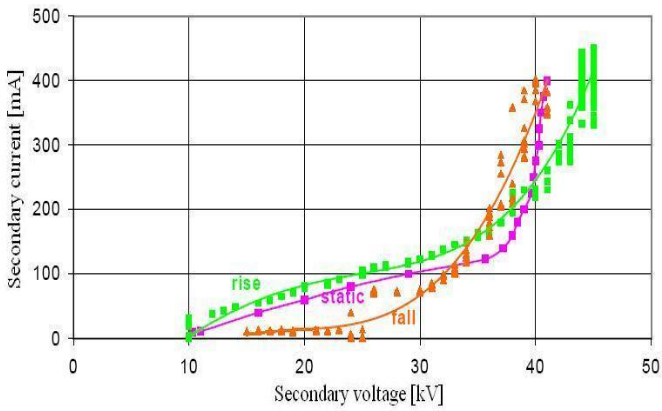

Figure 9. Dynamic current voltage characteristics: at fast rise voltage and at fast fall voltage

In Figure 9, is present the dynamic current voltage characteristic for a high resistivity of the dust. For comparison, on the same graph is the static current voltage characteristic.

CONCLUSIONS

For an ESP that collects high resistivity dust the presence of back Corona discharges is inevitable problem. The negative resistance area from a current voltage characteristics (if the characteristics depending on minimum voltage) is a result of back Corona discharges. With modern control techniques and with adapted algorithm the back Corona may be detected.

The back-Corona phenomenon is diminish if is burn coal with better characteristics. Another solution to diminish back Corona discharges is to modify the dust resistivity by condition the flue gas (with sulphur and ammonia). Using another control technique, intermittent energisation or pulse energisation will be decreasing the back Corona discharges.

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