A HIGH-VOLTAGE MONITORING SYSTEM EMPLOYED FOR EVALUATING THE METAL CONTENT OF GRANULAR MIXTURES PROCESSED IN ELECTROSTATIC SEPARATORS

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Abstract – *High-voltage is known to be one of the main control variables of any electrostatic separation process. The present work describes a high-voltage monitoring system that turned out to be a tool for supervising the overall operating conditions of electrostatic separators. A custom-designed virtual instrument was employed for processing the experimental data provided by a high-voltage probe the output of which was connected to an electrometer. The dispersion of high-voltage measured values was found to increase in the presence of the material. The statistical analysis of the data revealed a significant correlation between the standard deviation of the high-voltage and the concentration of metal in the processed material. These findings could be helpful for the optimization of the operating conditions of the electrostatic separation applications where the metal content in the feed materials is characterized by important fluctuations with time.*

1. INTRODUCTION

Electrostatic separation is based on the electrical forces acting on charged or polarized particles in an electric field [1-4], generated by an electrode system connected to a high-voltage supply. Applied high-voltage (HV) should be adjusted close to the threshold beyond which spark discharges could occur between the electrodes, in the presence of the processed material [5]. In this way, one ensures the highest possible intensity of the electric field which implies best particle charging conditions, and most effective electric separation forces [6-8].

Indeed, electrostatic induction, which is the prevalent charging mechanism of conductive particles in roll-type separators (Fig. 1), depends directly of the electric field strength at the surface of the electrode carrier [9]. Corona charging is also proportional with the electric strength, and hence with the voltage applied to the electrode system [10].

Continuous monitoring of the HV drop between the electrodes is necessary, in order to avoid spark discharges, as is the standard with electrostatic precipitators [11, 12]. Whenever a spark discharge occurs, the HV drop between the electrodes reduces to zero. As a consequence, the electric field is annealed or significantly reduced for a duration which depends on how fast the HV supply is capable to restore the potential at which the electrodes were before the spark. Such an event disturbs the separation process,. as the above-mentioned electric charging processes cease and no electric forces act on the already charged particles.

The aim of the present work is to describe how a HV measuring system, initially developed for detecting spark discharges in electrostatic separators, turned out to be a useful tool for supervising the overall operating conditions of such an installation

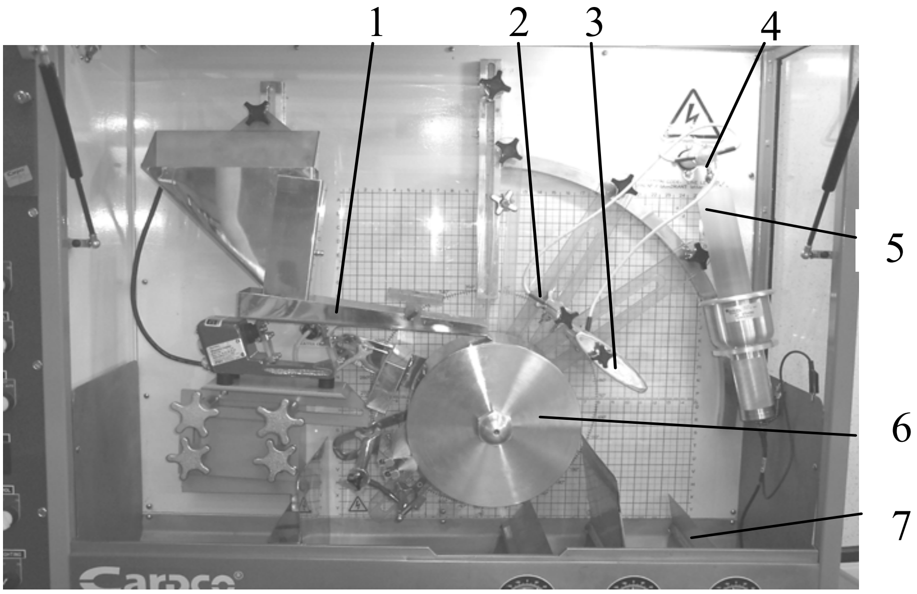

Fig.1 Roll-type corona-electrostatic laboratory separator (CARPCO Inc., Jacksonville, FI) with high-voltage probe; 1- feeder; 2 – corona electrode; 3 – electrostatic electrode;4 - High-voltage connector; 5 - high-voltage probe;6 - grounded roll electrode (carrier); 7 - collector.

2. EXPERIMENTAL PROCEDURE

A laboratory roll-type corona-electrostatic separator EHTP 25-36 (CARPCO Inc., Jacksonville, Florida) [13], was employed for the experimental study (Fig. 1). The separator was provided with two HV electrodes: a wire-type corona electrode and a tubular (non-ionizing) electrode. Both electrodes were connected to a same D.C. HV supply, by means of a multi-pole HV connector, the potential of which was measured by a HV probe (model PVM-5, North Star, Albuquerque, NM) as shown in Fig. 2.

In this first group of experiments, the output of the HV probe was connected to a digital electrometer (model 6514, Keithley Instruments, Cleveland, Ohio), by means of a calibrated resistor of 1 MΩ, which ensured impedance matching. A GPIB cable connected the electrometer to a PC, provided with a data acquisition card IEEE488. A virtual instrument was developed using the LabView 6.0.i environment [14].It enabled the remote control of the electrometer, the real-time transfer of the data to the computer, and their processing in accordance with the diagram presented in [15].

The sampling rate was established at 20 samples/s, as the outcome of the measuring procedure was not sensitive to this parameter. Each time, 1000 values were displayed on the front panel of the virtual instrument, and saved in a .txt file for further processing. Thus, the average value and the standard deviation (σ_{HV}) were evaluated for each such series of measurements.

The granular material employed in the experiments was obtained from genuine chopped electric wire wastes processed in the recycling industry (diameter: 0.25 mm; length > 1 mm and < 5 mm). In one experiment, the stranded copper was replaced by massive copper wire. Six sets of experiments were performed in order to evaluate the effects of the factors that might affect the value of the potential measured by the HV probe. The first two experiments (#1 and #2) were effectuated at positive polarity, at o constant value of the high-voltage with different concentration of stranded copper and massive copper. Experiments #3 and #4 were done at negative polarity, with and without the electrostatic electrode connected at the high-voltage supply The last two experiments (#5 and #6) were performed at positive polarity, but on different samples of granular materials: one containing 100% and the other 0% of stranded wire.

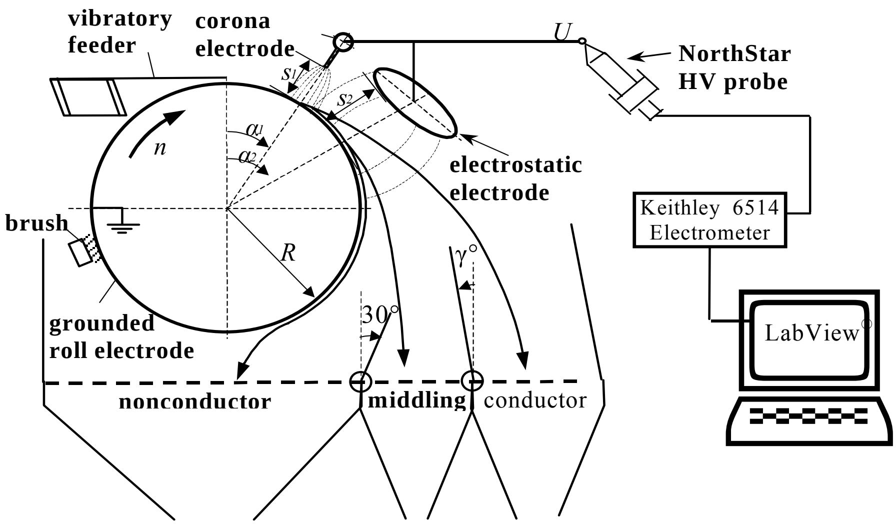

Fig. 2 Experimental set up for HV monitoring, using a digital electrometer and a virtual instrument developed in a LabView environment

3. RESULTS AND DISCUSSION

Fig 3 shows the front panel of the virtual instrument displaying the measured values of the HV before and after particle admission in the electric field zone. The standard deviation σ_{HV} increased from less than 1 V to about 6 V, during the six sets of experiments. We observe that the variation is different; before the admission of the material the values are little and after the particles were admitted he values are big.

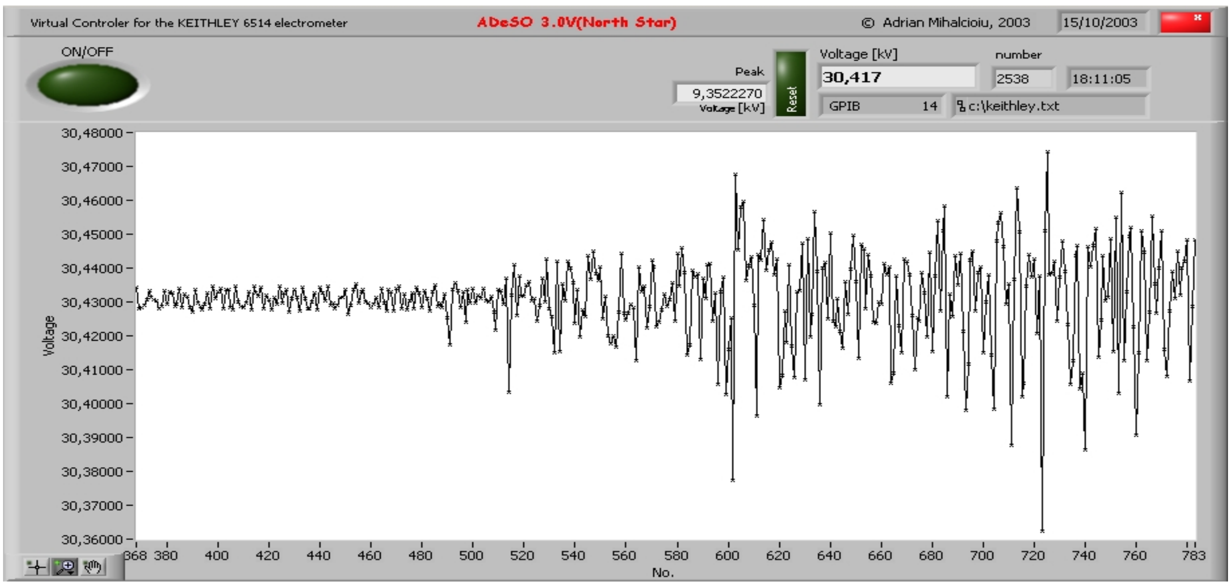

Fig.3 HV variation before and during granular material processing

The results of the experiment #1 and #2 are given in the table I. These experiments confirmed the effect of metal concentration on the standard deviation, σ_{HV}. When we use stranded copper, the variation of the voltage increase.

The standard deviation σ_{HV} increases with the high voltage applied. This implies that would be easier to predict the correct composition of thy material if working at higher voltages.

The high-voltage applied to the electrode system in the experiments #3 and #4 was limited to 20 kV (absolute value). Beyond this limit, the number of spark discharges becomes excessively high (more than 1 per second).

Therefore, a straightforward comparison between the results obtained at positive and negative polarities was not possible (the value of determined σ_{HV} in several experiments at U = + 20 kV with the c = 45 % product did not differ significantly from those obtained at the same applied voltage in the absence of the material).

No significant difference exists between the results of the experiments #3 and #4 (table II), indicating that the presence of the electrostatic electrode in parallel to the corona electrode has little effect, if any, on the value of σ_{HV}

The fact that of σ_{HV} is quasi proportional with the concentration of metallic particles suggests that the variation of the measured voltage is related to the back corona that can occur from such particles in an electric field characterized by relatively 100 % and 0 % stranded copper, confirmed this fact.

Table I. Results of the experiments #1 and #2

Copper content (%)	Response σ_{HV} (V)	
	Experiment #1	Experiment #2
5	1.78	0.45
45	4.30	2.15

Table II. Results of the experiments #3 and #4

High-voltage *U* (kV)	Response σ_{HV} (V)	
	Experiment #3	Experiment #4
-16	0.248	0.278
-18	0.392	0.318
-20	1.131	1.271

Table III. Results of the experiments #5 and #6

High-voltage *U* (kV)	Response σ_{HV} (V)	
	Experiment #5	Experiment #6
26	2.334	0.450
28	3.247	0.457
30	6.340	1.510

4. CONCLUSIONS

HV monitoring could provide useful information for electrostatic separation process control. By comparing the measured value of the high-voltage to the imposed level, any unconformable operation could be readily detected.

The paper describes the correlation that was evidenced between the standard deviation of the measured high-voltage (σ_{HV}) and the composition of the material passing through the active zone of the separator. A change in the measured σ_{HV} could point out an alteration in the composition of the processed material, and indicate that appropriate corrections should be made for optimal operation of the overall system.

5. REFERENCES

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