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Measurement of electrical conductivity of DAP fertilizer

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Abstract. Paper deals with the measurement of electrical conductivity of significant size groups of mineral fertilizer DAP divided in the air stream. Samples of these groups were dissolved in distilled water and the values of electrical conductivity recorded. Measurements will be used to monitor the electrical conductivity of other mineral fertilizers and to create a standard for qualitative assessment of fertilizer solutions.

Key words: electrical conductivity, air flow, fertilizer solution, concentration, DAP.

INTRODUCTION

The concentration of fertilizers can be determined on the basis of the electrical conductivity (increasing the electrical conductivity). The value of the electrical conductivity can be used for precise application of fertilizers in liquid form. Monitoring the conductivity and knowing its value for target fertilizer concentrations enables to start the field application of fertilizers at an optimum moment. This would significantly increase the precision compared to the commonly used 'mass percentage method' where the concentration accuracy attains only ±10% according to fertilizer manufacturers. According to the electrical conductivity, the quality of the measured fluid can be assess accurately along with other data such as the level of pollution, the concentration of the various components of the solution, etc. (Kabeš, 1999). In that way, Electrical conductivity is the reciprocal of electrical resistance, is Indicated with the letter G and its basic unit is the Siemens (S).

The effectiveness of mineral fertilizers in crop cultivation depends on the particle stability and speed of their transformation to solution state to be acceptable by plants. This process depends on the particles dimensions, so that the dimension of particles is one of the main parameters that influence the fertilizer effectiveness.

Application of solid commercial fertilizers play important role in precision farming technologies. Quality of fertilization also significantly impacts the quality the final crops (Alaru et al., 2003). The application quality is depended on chemical composition and physical properties of fertilizer. Important from physical properties point of view is the grading of aggregate evaluation that is still performed by standard ČSN 01 50 30. The dimension of particulars only is characterized by this way.

In this paper we continue in the previous research program, in which the granulometric study mineral fertilizers were studied. In contrary to the similar study of other authors seat and airflow sorting were combined.

Experiments with particles can be designed differently. An elutriator was designed and constructed in which an airflow is supplied by a centrifugal fan (Csizmazia, 2000). Methods for measuring the coefficient of friction, the coefficient of restitution, the aerodynamic resistance coefficient, and the breaking force (particle strength) of fertilizers (Hofstee, 1992) were taken into account. The breaking force feature was skipped. The problem of particle destruction was overcome by fertilizer Superphosphate selection. The control of fertilizer discharge was studied for different designs of distributors and an experimental accurate fertilizer distributor with a rotary vessel type feeder was developed (Kudoh, 1989) what shows that dissolution of fertilizer also makes some problems. Consequent logistical problems are the same difficult for both pumping liquids, and transportation of particles by the air.

The size of particles makes the fertilizer's shelf life and stability of particulars behavior in the airflow more stable in storage and better acceptable by the plant. Therefore, experiments studying motion of particles through the air were accompanied by grading of particles.

This paper contains results obtained for DAP using the method developed previously.

MATERIALS AND METHODS

Electrical conductivity was measured device Conductivity inoLab model WTW Cond 720. Instruments for the measurement of electrolytic conductivity, specifically electrical conductivity of liquids, consist of a measuring probe or conductivity sensor, transducer and evaluation unit. According to the manufacturer, accuracy of the device is 0.5% of value when measuring conductivity. Most of the apparatus is adapted for measuring the resistivity and weight concentrations of some components of the solution, which can be derived from the electrical conductivity. They are very sensitive and allow you to measure the content of various substances from small to very high concentrations and is often used to control a wide range of industrial processes. (Kabeš, 1999). Measurement was carried out for mineral fertilizer DAP (alternative trade name NP 18-46; manufacturer LIFOSA – Lithuania). The composition of DAP is the following: NP granular fertilizer with 18% ammonium nitrogen (NH4-N) and 46% water-soluble phosphorus (P2O5) and 2% magnesium (MgO). Fertilizer is suitable for basic fertilization of winter crops and spring crops. Distribution of the air stream was carried out in the laboratory of the Department of Agricultural Machinery using the laboratory air sorting machine K-293 (see Fig. 1).

The measurement procedure was as follows. First the laboratory sorting machine K-293 determined ranges of required amount of air, i.e. the minimum amount of air in which the particles are carried, and in the opposite a maximum amount of air in which the sample is completely sorted. With the help of graduated cylinders, interval of gradually increasing speed of the air flow is selected so that the number of classes was 7 to 10. It is necessary to ensure the right plane for the weights to ensure accuracy. Scales are calibrated and set to zero. Fertilizer is mixed because of the measurement accuracy and a sample of fertilizer weighing 500 g removed. An appropriate, predetermined, air speed is set for the laboratory device using graduated cylinders and adjusting screws. A sample of fertilizer is poured into the tank (1) with pre-set for the damper. With the help

of a vibrator, fertilizer gets into the air flow in a vertical channel (see Fig. 2). Here comes the separation. Granules with larger than the critical speed set fall through the channel into the container (3). Granules with lower critical speeds are vertically entrained in air stream and in the extended portion of the channel are falling into the tray (4). The amount of fertilizer separated using air flow into the tank (4) is then placed in a pre-labeled bowl for later use. Emptied tank (4) is placed back into the machine and the speed of the air flow is checked. Then the fertilizer from the tank (3) is filled back to the tank (1) and the graduated cylinder is set to the next value of air stream speed. In this way, the experiment continues until the entire sample of fertilizer gradually falls into the tank (4).

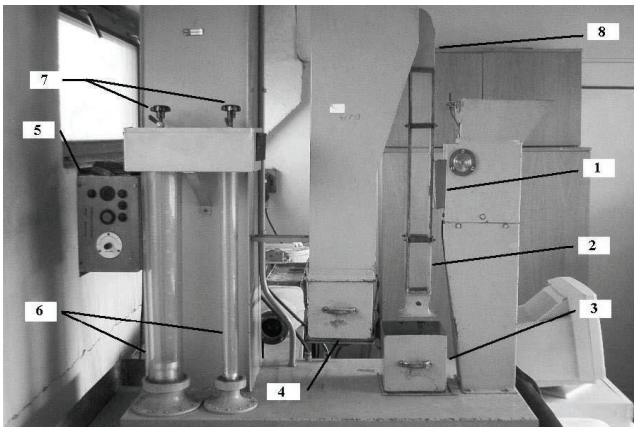

Figure 1. Laboratory Air sorter K-293. Labels: 1 – adjustable damper hoppers; 2 – vertical (aspiration) channel; 3.4 – tanks; 5 – control panel with buttons; 6 – small and large graduated cylinder; 7 – cylinder adjusting screws; 8 – fan.

The whole process is repeated with eight different samples of fertilizers to maintain the accuracy and reliability of statistical data measurements.

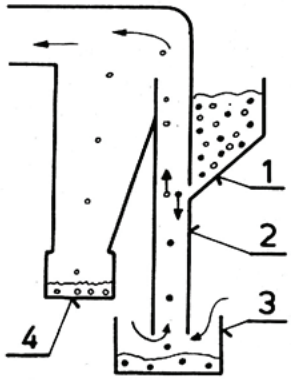

Figure 2. The vertical channel (detailed view). Labels: 1 – tray; 2 – vertical (aspiration) channel; 3 – stack; 4 – tray (particles of lower critical speed are carried into this tank).

Measurement was carried out in an air stream at a temperature of 22 °C and humidity of 22%. Electrical conductivity was measured on the machine Conductivity meter WTW inoLab model Cond 720. The measurements were carried out over ten hours in one-hour intervals. Before each conductivity measurement took place, the sample had been mixed to ensure its homogeneity.

RESULTS AND DISCUSSION

From the samples measured in the air stream, samples weighing 5 grams were taken of significant proportions that were for the air stream 105, 115, 125 $m^3 h^{-1}$.

Therefore, these samples collected samples weighing 5 grams of six replications. Subsequently, 5 g samples were mixed and collected and then dissolved in distilled water to a volume of 50 ml. Table 1 shows the measured values. Conductivity measurements were performed after one hour. Electrical conductance G are given in units of electrical conductivity of G1, G2, G3 corresponding to granules of classes 105, 115, 125 (see Fig. 3).

Table 1. Measured values of electrical conductivity G of DAP fertilizer

Time (h)	Temp. (°C)	G1 - for 105 $m^3 h^{-1}$ ($m^{-2} kg^{-1}s^3 A^2$)	Temp. (°C)	G2 - for 115 $m^3 h^{-1}$ ($m^{-2} kg^{-1}s^3 A^2$)	Temp. (°C)	G3 - for 125 $m^3 h^{-1}$ ($m^{-2} kg^{-1}s^3 A^2$)
0:0	22.5	22.7	23.0	26.8	22.8	29.7
1:0	23.0	24.3	22.5	28.2	22.5	30.2
2:0	21.5	29.2	21.9	30.1	21.9	33.4
3:0	22.2	30.4	22.0	34.2	22.4	37.5
4:0	21.5	35.2	22.4	39.4	22.3	42.4
5:0	23.0	39.2	22.3	41.6	22.9	44.8
6:0	22.7	46.2	21.7	48.5	23.1	51.9
7:0	22.2	50.1	22.0	52.4	23.2	55.2
8:0	21.9	58.4	21.8	60.2	23.0	64.7
9:0	22.3	63.2	22.6	65.6	23.0	69.9
10:0	22.9	67.2	22.8	69.7	22.9	75.4

Undissolved residues were detected by using filter paper – the solution was filtered and the solids were weighed and dried in a dryer at a constant temperature of 105 °C to constant weight. These weights are not given here, because we cannot determine the amount of undissolved fertilizer.

This measurement was performed as indicative, and following additional measurements based on it were done where the sample was dissolved until it stopped to change its electrical conductivity, i.e. ended its dissolution. The undissolved remains of fertilizer were weighed. You could determine using nutrient analysis whether undiluted sample contains nutrients, or it is carrier roughage.

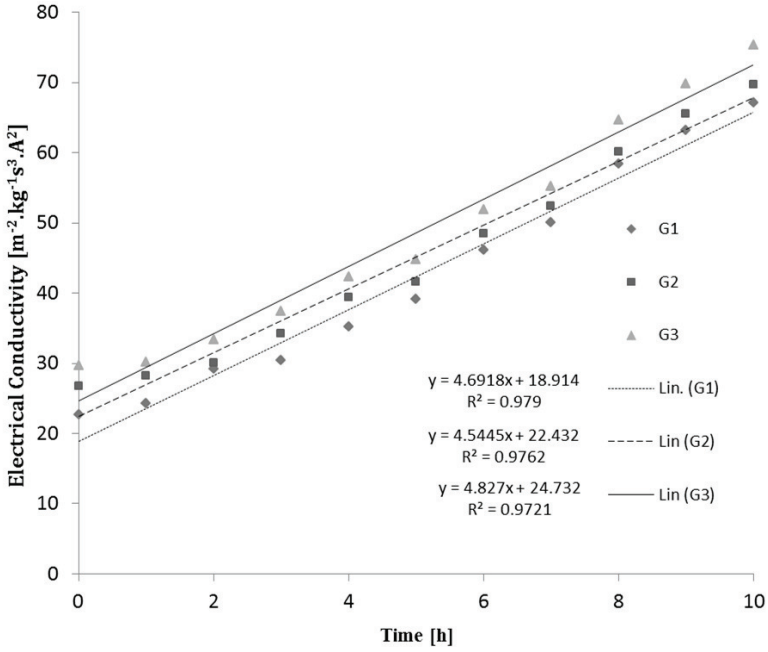

Figure 3. Graph of time dependence of electrical conductivity.

CONCLUSIONS

On the basis of the electrical conductivity, the concentration of dissolved mineral fertilizer can be determined. Fig. 3 indicates that the values for the significant proportions are analogous. These values are crucial for the production of concentrated solutions of mineral fertilizers that can be applied by sprayers. Measurements are taken as the guidance for the methodology verification that will be used to measure other samples of similar fertilizers. These results will be used for the precise application of fertilizers and can be used as a reference for qualitative assessment fertilizer solutions. The research is about to continue with simultaneous measurement of concentrations in order to determine the relationship between concentration and electrical conductivity. Unfortunately, current measurement devices available to authors do not allow such approach.

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