Conference Paper

Evaluation of Morphological Powder Characteristics Based on Uranium Dioxide

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Abstract

At present there is no unambiguous quantitative evaluation of morphological features for the evaluation of powder characteristics including uranium dioxide. The results of such monitoring allow to evaluate the potential possibilities of using powdered material for further use in pressing and sintering The method of quantitative evaluation of the morphology of powders was developed. A comparative analysis of the morphological and technological characteristics of the uranium dioxide powder obtained by various methods is carried out.

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1. INTRODUCTION

Among all the variety of oxide ceramics, uranium dioxide enriched with the isotope ^{235}U, due to its high radiation stability, high melting point, chemical inertness to structural materials, occupies a special place in nuclear power engineering.

The production of ceramic fuel can be conditionally divided into two stages: the production of uranium dioxide powder and the manufacture of pelletized fuel, but nevertheless only the cumulative knowledge of the features of the formation of the powder properties laid down in the first stage of production and obtaining the necessary technological characteristics of the finished product in the second stage can give the required product quality and the maximum yield value.

At present, there are many works devoted to: the study of the properties of uranium dioxide powder depending on the conditions of production (PH, temperature, etc.); influence of physical and chemical (specific surface) and some technological properties of the powder on the density of the sintered tablet. However, until now no single powder characteristic has been found that would unambiguously reflect and predict the density (and other properties) of the final pelletized fuel.

2. RESULTS AND DISCUSSIONS

To characterize the morphology, four factors were used as a quantitative estimate, two of which determined the nature of the surface of the powder being studied, and two other forms. Three dimensional characteristics have already been determined: the reduced diameter, the maximum internal diameter and the average particle diameter. The results were obtained by processing the image using the Scandium program on the SEM-EVO 40.

The final evaluation of the determination of the morphology of powders is: the total value of the surface factor reduced to the granulometric composition for a given powder (SFP) (1), the mean value of the form factor (SZFF) (2) and the standard deviation of the form factor (SDFF) (3). SZFF is normalized to 1.

$$SFP = \sum_{n=1}^{9}(\overline{f}_0 a_0 + \cdots \overline{f}_n a_n) + \sum_{n=1}^{9}(\overline{g}_0 a_0 + \cdots \overline{g}_n a_n) \quad (1)$$

$$SZFF = \overline{\lambda} = \frac{\lambda_1 + \cdots \lambda_k}{k} \quad (2)$$

$$SDFF = \sqrt{\frac{(\lambda_1 - \overline{\lambda})^2 + (\lambda_k - \overline{\lambda})^2}{k-1}} \quad (3)$$

At the heart of the method of assessing morphology is the processing of images of just single particles, but work is already underway to study particles forming double, triple, etc. coupling to evaluate not only the "complex" morphology, but also the strength of the particles. Examples of such particles are shown in Figures 1 and 2.

Analysis of the obtained data on the morphological characteristics and particle size of the powder does not give an unambiguous functional dependence, however, the logarithmic growth of the phase transition and the PV from the reduced and average diameters, the correlation coefficient ~ 0.6, which is shown in Fig. 3, can be considered. This type of dependence is typical for all ADU and SC powders. A comparison of FP and PV between powders of different technologies will be given in the following chapters. The expressed functional dependence of PF on the particle size (reduced and average diameter) for all the processed samples of ADA and SC powder was not found, therefore, we determine the numerical evaluation of the morphology in terms of the average value of the FF and RMS of the FF, the last of which determines the uniformity of the powder in the shape of the particles.

Morphological peculiarity of powders obtained by ADA scheme can be noted elongation (elliptical shape) along one of the directions, which is illustrated in Fig. 4.

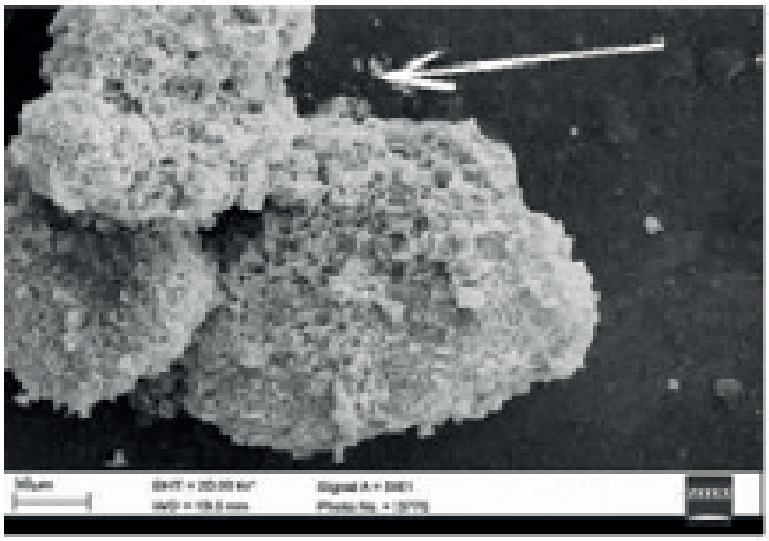

Figure 1: Coupling of several particles.

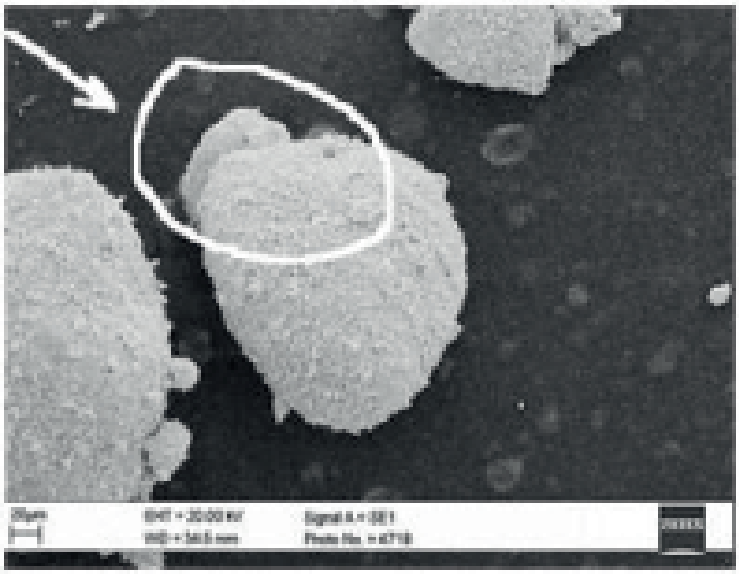

Figure 2: Possible image from two particles.

In [1, 4], the authors indicate the relationship between the morphology of the precipitate of ammonium diuranate and the uranium dioxide powder. Preservation of morphology after drying, calcination and reduction was noted.

The results of the conducted studies show a general picture of the stepwise change in the size and shape of crystallites. The crystallite size of the oxide-oxide is 450-600 nm, with a FN ≈3.5. Oxy-oxide is characterized by the absence of internal discontinuity and porosity of the structure. With the restoration of OZ and the transition to uranium dioxide, the crystal lattice is restructured (from the tetragonal to the cubic lattice). The disruption of energetically unstable bonds is replaced by the formation of a stable

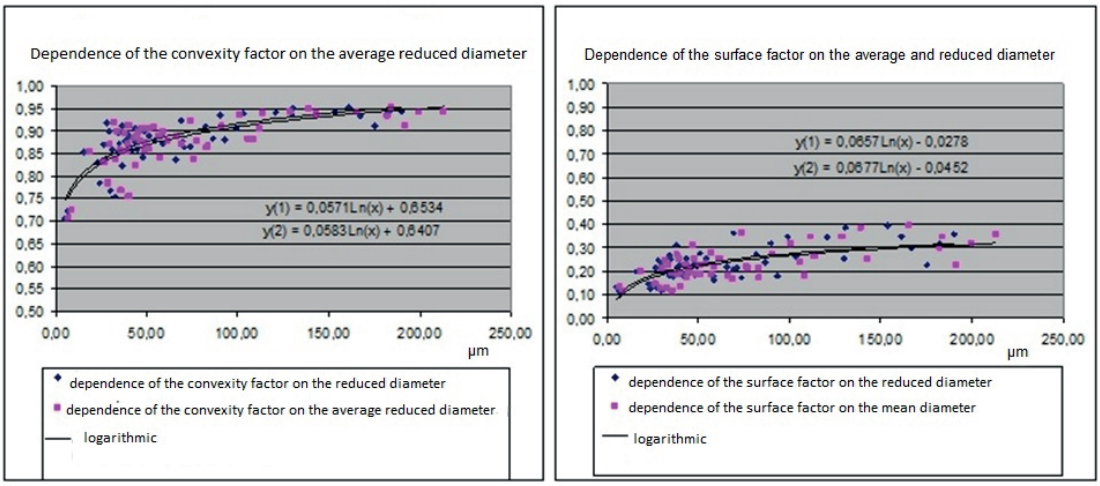

Figure 3: Dependences of the convexity factor (left) and the surface factor (right) on the reduced and average particle diameters, using the ADU powder as an example.

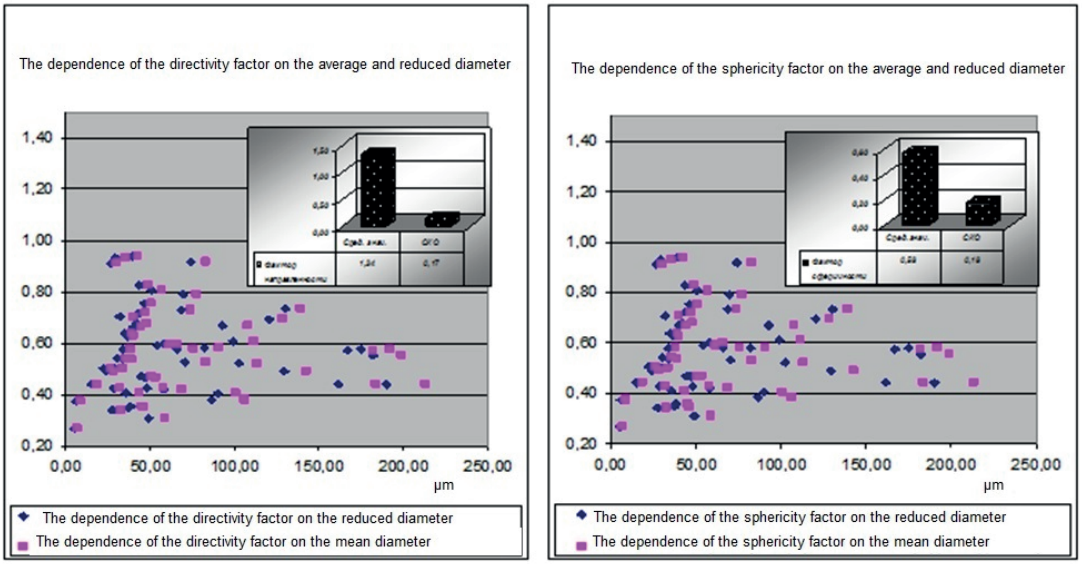

Figure 4: Dependence of the directional factors (left) and sphericity factors (right) on the reduced and average particle diameter.

structure. The structure of uranium dioxide with the crystallite size of 150-200 nm, FN ≈ 1.5 for the powder ADS is shown as loose (because of the difference in lattice types) in comparison with OZ Fig. 5. The crystallite size of the SC powder is characterized by a 20-30% increase in the crystallite size and is 250 nm.

With the help of electron microscopy it is rather difficult to determine the internal porosity of the powder of various technologies, however, metallographic studies indicate a difference in the strength of agglomerates of ADU and SC powder.

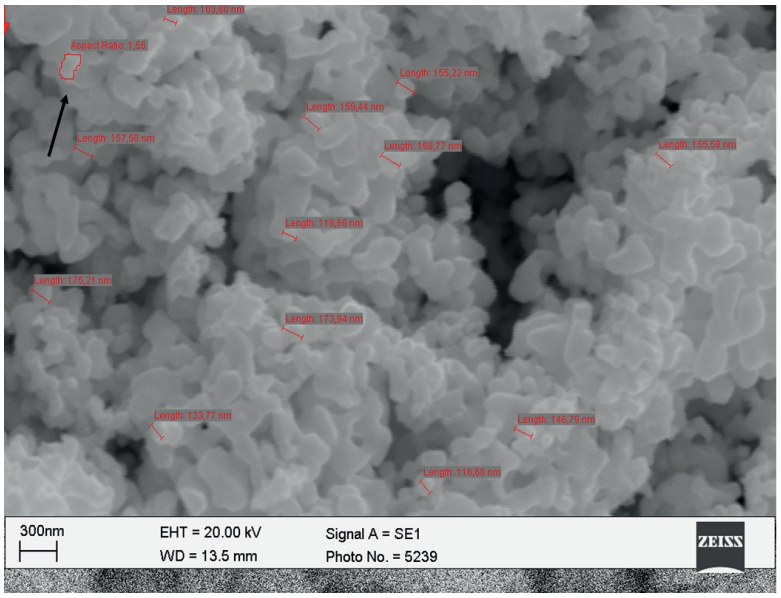

Figure 5: Uranium dioxide, × 50000.

3. CONCLUSION

Preliminary results of the study of the dynamics of the change in the size of crystallites in a powder:

1. The morphological properties of crystallites vary from ammonium diuranate to powder, namely, the FN decreases from 5.5 to 1.5 in the powder. FN = 1,5 mean value of the form of all ADO powder agglomerates.
2. The minimum particle size from diuranate to OZ varies and becomes 450-600nm, then it decreases to uranium dioxide and becomes equal to 150-200nm for powder ADU and 200-250nm for SC
3. The morphology of the particles in the crude tablet does not change with respect to the morphology of the particles of the prescaler.

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