Proposal for Ultrasonic Technique for Evaluation Elastic Constants in UO_2 pellets

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Pellets of uranium dioxide (UO_2) are used as fuel in nuclear power reactors, in which are exposed to high thermal gradients. The expansion of the uranium dioxide pellets (UO_2), resulting from fission products, can cause fissures or cracks, therefore, the study of their behavior is important. This work aims to develop and propose an ultrasonic technique to evaluate the elastic constants of UO_2 pellets. However, because of the difficulties in handling nuclear material, we proposed an initial study using alumina (Al_2O_3), because alumina pellets are also ceramic material and their porosity and dimensions are in the similar range of UO_2 pellets. They were fabricated and used in two different sets of 10 Al_2O_3 pellets with densities of 92% and 96%. The developed ultrasonic technique evaluates the traveling time of ultrasonic waves, longitudinal and transverse, and correlates the observed time and the elastic constants of the materials. Equations relating the speed of the ultrasonic wave to the elastic modulus, shear modulus and Poisson's ratio have led to these elastic constants, with graphics of correlation that showed excellent agreement with the available literature for Al_2O_3.

Table 1 - Values found for the elastic constants determined experimentally.

Pellet (%)	υ	E (GPa)	G (GPa)
96	0.2556	326 ± 21	130
92	0.2859	259 ± 17	101

Due to difficulty in performing mechanical testing of ceramic specimens, the determination of reference values for the modulus of elasticity of the specimens used in this study were obtained from the interpolation of the results from reference [1] to alumina 100 % of theoretical density, and in reference [2] to 85% alumina and 94% of the theoretical density, all obtained by the conventional process from mechanical tests (Table 2).

Table 2 - Elastic constants for alumina from literature for pellets with 85%, 94% and 100%.

Relative Density (%)	E (GPa)	G (GPa)	μ
85	220	90	0.22
94	277	117	0.21
100	421	171	0.24

Figure 1 shows a polynomial second order fit for the values of E shown in Table 2.

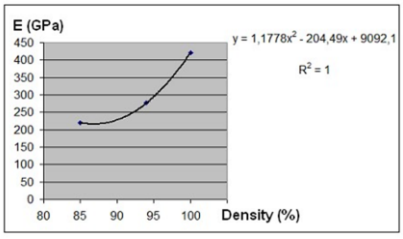

Figure 1. Interpolation of E values.

Figure 2 graph shows a second-order polynomial fit to the G values shown in Table 2.

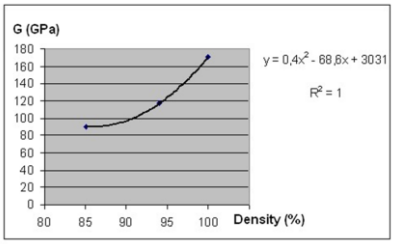

Figure 2. Interpolation for G values.

According to the results and considering the ease of implementation of this technique, we believe that it should be applied for UO_2 pellets, justifying further studies for that application.
The results of study showed that the use of ultrasonic technique for the determination of elastic constants alumina ceramic pellets gave results compatible with those found in the literature for the porosity range evaluated.

References

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