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MEASURING THE STRENGTH OF BRITTLE MICROSCOPIC SPHERES BY MEANS OF COMPRESSION TESTS

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The strength of particles is an important property relevant to many industries; in materials science, a wide range of composites and alloys contain small particulate phases, whose microscale strength distribution affects strongly the macroscopic properties of the composite or alloy in question. Yet, despite its importance, the strength of microscopic particles has remained difficult to measure. The most common method used to measure the strength of individual particles is the compression test, conducted by squeezing individual particles between two parallel platens. Progress in nano- and micromechanical testing in recent years has enabled to expand the application of this method to test hard brittle particles at the microscale. The test is generally realized by using hard platens, typically made of diamond; however, in this configuration the compressed particle often fails predominantly due to presence of microcracks that develop, as a result of high stress concentration, at the contact region between the particle and the platen. Pre-existing intrinsic flaws within the particle or along its surface are therefore not probed, such that it is questionable whether the data generated by the test can represent the true strength of particle. One solution to avoid the development of the microcracks and to reduce the stress concentration at the platen/particle contact is to use elasto-plastic platens, which deform plastically during the test where they contact the particle. This allows particle indentation into the platens and with this an increase of the contact area over which the compressive load is applied. If the platens are hard enough to prevent the particle from completely sinking into the platens, then the tensile stress that develops within the particle and/or along its surface can cause failure from pre-existing flaw in regions of the particle that are not in direct contact with the platens. In this study we present a particle-crushing testing approach in which elasto-plastic platens are used. As a testbench particle material we use fused silica microspheres with diameter between 20-40 micrometers. We demonstrate the method on a custom-built instrumented crushing apparatus designed to work in displacement-controlled mode (i.e., that has a stiff load train), using adaptations of the test so as to allow for fractography. Using analytical solutions in combination with extensive FEM analysis of the sample as it is compressed by the elasto-plastic platens, we show how this modification of the crushing test can be used as a means of measuring the intrinsic strength of brittle microscopic particles, as dictated by the internal flaws they might contain.