Identification of the mechanical behaviour of a hydride powder for hydrogen storage

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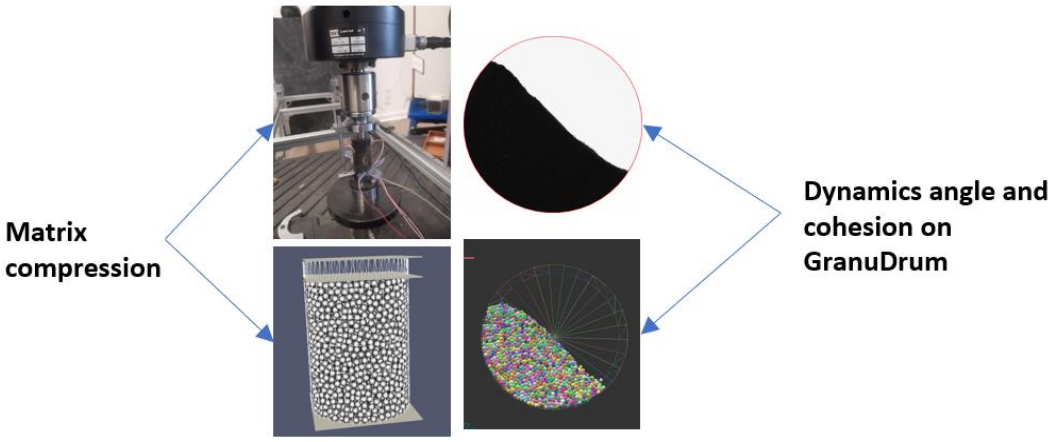
In a solid storage tank, during the respiration (absorption-desorption cycle) of a hydride bed, the powder particles swell, decay, move and segregate [1]. Understanding and modelling these phenomena is essential to guide the engineer in the design of the storage tank. This study focuses on the flowability and compressive behavior of a metal powder, with a view to analyzing the mobility of particles in a confined environment and the transmission of forces. These investigations are carried out through various experimental manipulations, which are also modelled in DEM using YADE [2] in order to identify the behavior laws that can be used to account for these tests.

We are studying the TiFe1-xMnx alloy $x \in [0;0.05]$, for its good reactivity to hydrogen, its gravimetric capacity (1.34 %wH) and its favorable thermodynamic properties. Synthesized by casting and then grinding, three populations of distinct sizes were obtained by sieving: P1 with a diameter $d \in [40;200]$ µm, P2, $d \in [300;500]$ µm and P3, $d \in [710;1000]$ µm. Two other samples are obtained by mixing the first ones in equal mass: P4=P1+P3 and P5=P1+P2+P3.



Digital twins (left) compression (right) rotating drum (Granudrum from Granutools)

Castability tests on Granutools instruments [3] reveal distinct behavior for the 5 populations. Samples including P1 show rheo-thickening behavior, while P2 and P3 show quasi-Newtonian behavior. These tests highlight the variations in cohesion and segregation, especially for P4 and P5, typically a hydride powder in the process of decaying. Alternating compression tests (between 0 and 30 N) are carried out on an electromechanical machine in a cylindrical matrix between two force cells. They show the variation in force transfer as a function of population. The DEM numerical twins in YADE, where the behavior laws include elasticity and friction for all the populations, as well as specific cohesion for groups P1, P4 and P5, enable the parameters of the laws to be identified.
We present here the progress of this work which aims, through the study of flowability and compression, to model and analyse the breathing of a bed of hydride powder confined in an enclosure. Ultimately, the aim is to provide a numerical tool for sizing tanks based on a description of the phenomena induced by respiration.

References :

[1] B. Charlas et al. Journal of Alloys and Compounds, 580 (2013), pp 149-152.
[2] V. Šmilauer et al., Yade Documentation 2nd ed. The Yade Project, (2015)
[3] A. Neveu et al. Measurement, 200 (2022), 111548.