Material parameter characterization of multicellular granules as crash absorber with application in ship building

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ABSTRACT

To improve the crashworthiness of double hull ships, without changing the ship structure, the application of multicellular granules as crash absorber was suggested in [1]. It is recommended to use lightweight, environmental safe granules to fill the voids between the outer and inner ship hull. The basic idea consists of two aspects: On the one hand, the usage of granules as filling material supports the load transfer from the outer to the inner ship hull. In this way, the inner hull can also contribute to the absorption of kinetic energy. On the other hand, the crushing of the multicellular granules also contributes to the dissipation of kinetic energy. The modelling of this behaviour is a challenging task. To this end, a coupled DEM-FEM [2] approach is currently under development. In order to do so, the material parameters for the DEM and FEM have to be determined. Here, we will focus on the parameters for the DEM, where the Young's Modulus, crushing strength, and diameter are of particular interest.

To determine these material parameters, a uniaxial single particle test is performed. It can be observed, that the parameters of granular materials vary in a wide range, due to the cellular structure. To model this behaviour, a statistical model is introduced based on [3]. There, a logistic distribution is utilized to model the Young's modulus and crushing strength. Introducing a distribution for the diameter, we adopt this method and extend it to a multidimensional model [4]. In doing so, in a first step, we obtain two two-dimensional models covering the diameter/Young's modulus and diameter/crushing strength, respectively. In a second step, the three parameters of interest are combined to a three-dimensional model. The resulting model consists of nine parameters which are determined from experiments.

Using an inverse transform sampling to derive sample numbers from the developed model, we can use these as input values for a simulation based on DEM. For doing this, we will present experimental test results, such as oedometer or triaxial test, which can be used for validation.

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