Visualization of compaction behavior of pharmaceutical powders in solid-dosage manufacturing using finite element analysis

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Tablets are the most widely used dosage form for the oral administration of pharmaceutical drugs. To design a tablet formulation, the developer considers a wide range of formulations based on their properties, such as the dissolution rate, disintegration time, tablet strength and so on. However, a very complex relationship between the formulation factors, the process variables and the tablet properties is observed in practice. The physicochemical properties of the active pharmaceutical ingredients (APIs) substantially change the tablet properties. Moreover, various stresses remain in tablets after the tableting process because of the induction of elastic recovery. This type of stress, the residual stress distribution and density distribution affects tablet characteristics and often causes problems during tableting or further downstream processing. A dataset is generated which is composed of over 25 formulation components including several different APIs. The modified Drucker-Prager Cap (DPC) model is one of the most widely used continuum mechanical models, in which the powder is considered as a porous medium. In this study, the finite element method is used in which the powder is modeled using the DPC model. The mechanical behavior of the formulation components is examined in order to visualize and, hence, better understand the die compaction process. We demonstrate that the residual stress and density distribution of tablets is affected by formulation and process variables, and is closely related to the characteristics of the tablets.