ABSTRACT

Swaminathan, Shrikant Ph.D., Purdue University, August 2016. Modeling Picking on Pharmaceutical Tablets. Major Professor: Carl R. Wassgren, School of Mechanical Engineering.

Tablets are the most popular solid dosage form in the pharmaceutical industry because they are cheap to manufacture, chemically and mechanically stable and easy to transport and fairly easy to control dosage. Pharmaceutical tableting operations have been around for decades however the process is still not well understood. One of the common problems faced during the production of pharmaceutical tablets by powder compaction is sticking of powder to the punch face, This is known as 'sticking'. A more specialized case of sticking is picking when the powder is pulled away form the compact in the vicinity of debossed features. In the pharmaceutical industry, picking is solved by trial and error which is an expensive, labor intensive and time consuming affair.

The objective of this work was to develop, validate, and implement a modeling framework for predicting picking in powder compacts. The model was developed in Abaqus™ a commercially available finite element package. The resulting model was used to investigate the influence of debossed feature geometry viz. the stroke angle and degree of pre-pick, and, influence of lubricant on picking.

An important factor vital to the success of finite element modeling (FEM) used in this work is the constitutive relationship used to model the mechanical response of the powders compact when subjected to external loads. In this work, the modified Drucker-Prager Cap (DPC) constitutive relation was used to model the powder compact. The DPC model parameters were calibrated experimentally. The experimental procedure for measuring the (modified) Drucker-Prager Cap parameters is described in this work.

Aditionally, the picking propensity of tablet depends on the adhesive interaction between the powder compact and punch face. An instrumented punch was developed in-house to characterize the adhesive force between a punch face and powder as a part of this work. The influence of the compact solid fraction and blend lubrication on the adhesive interaction was studied. The adhesive traction-displacement data was used as an input for the finite element model.

The picking behavior in the pharmaceutical compact was modeled using a fracture mechanics approach in the FEM model. This model was calibrated using the fracture toughness measurements of the powder. The experimental procedure to determine the fracture toughness using single edge notch bend test and 'inverse FEM'is described.

Experimental validation of the FEM simulation was performed by making tablets with debossed features and imagining the compact using x-ray computed micro tomography (XRCT). The density distribution in the compact and the dimensions of the debossed features in the experimentally produced tablets were compared to the FEM simulations. The post processing algorithms used for the experimental validation of the FEM results have also been discussed in this dissertation.

Lastly, a parametric study was performed to understand the impact of debossed feature dimensions and blend lubrication on picking behavior.