

EXPERIMENTAL CHARACTERISATION AND NUMERICAL MODELLING OF DENSITY DISTRIBUTION IN TABLETS

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INTRODUCTION

Density gradients in pharmaceutical tablets are important for they affect the local properties of the material which in turn influence the mechanical response of the tablet during post-compaction operations, such as coating, packaging, transport, storage or use.

Experimental density maps obtained using techniques such as indentation hardness and X-ray computed tomography (CT) are presented.

Constitutive models have been developed to describe the compaction behaviour of the powder and the friction interaction between powder and die wall. The models were calibrated for microcrystalline cellulose using data from a compaction simulator and a die instrumented with radial stress sensors. The results are implemented in the finite element program ABAQUS/Standard. The predictions of the model for a selection of tablet images and given die wall lubrication conditions are compared with the experimental density maps generated for various stages during compaction.

The agreement between the experimental data and simulation results gives confidence in the predictive capabilities of the model. The applicability of the technique to formulation design, process development, tablet image and tool design is discussed.

The experimental and numerical methodologies presented are applicable for any powder system in general.

EXPERIMENTAL METHODS

Indentation tests

Indentation hardness tests were carried out on cross-sections of tablets manufactured under controlled die wall lubrication conditions. Density distribution maps were obtained using an empirical relationship [1] between indentation hardness and density.

X-ray CT

For a given material the X-ray attenuation energy is approximately proportional to the density. X-ray CT density maps obtained using a 250 kV X-ray cabinet (X-Tek Systems) with TOMOHAWK CT [2] (AEA Technology) are presented for two capsule shaped tablets having different curvatures, break-line and embossing.

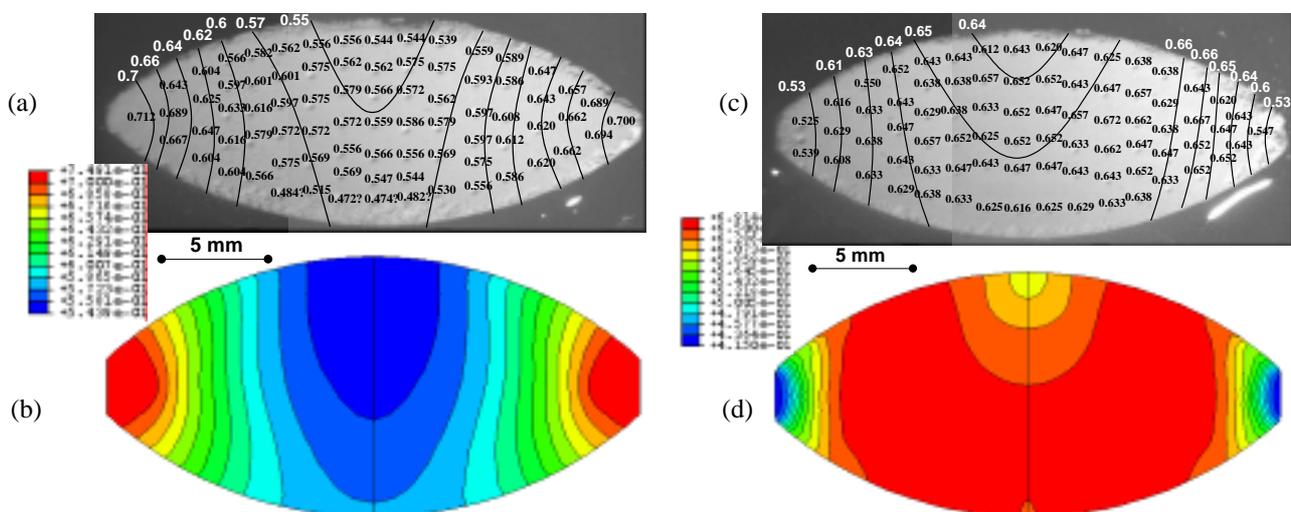


Figure 1 Indentation hardness density maps for tablets compacted in unlubricated (a) and lubricated (c) die, respectively and the corresponding numerical predictions (b) and (d), respectively.

RESULTS AND DISCUSSION

Indentation hardness

Experimental and numerical results presented in Figure 1 indicate that by manipulating the die wall friction conditions opposite density distribution trends are induced.

X-ray CT

X-ray CT for capsule shape tablets with different curvatures and break-line geometry (Figure 2) indicate the importance of the details of the tablet geometry.

Quantitative and qualitative results from friability, abrasion and disintegration tests indicate that the low density zones around the lettering (at the bottom of the tablets) or close to the break-line are prone to erosion.

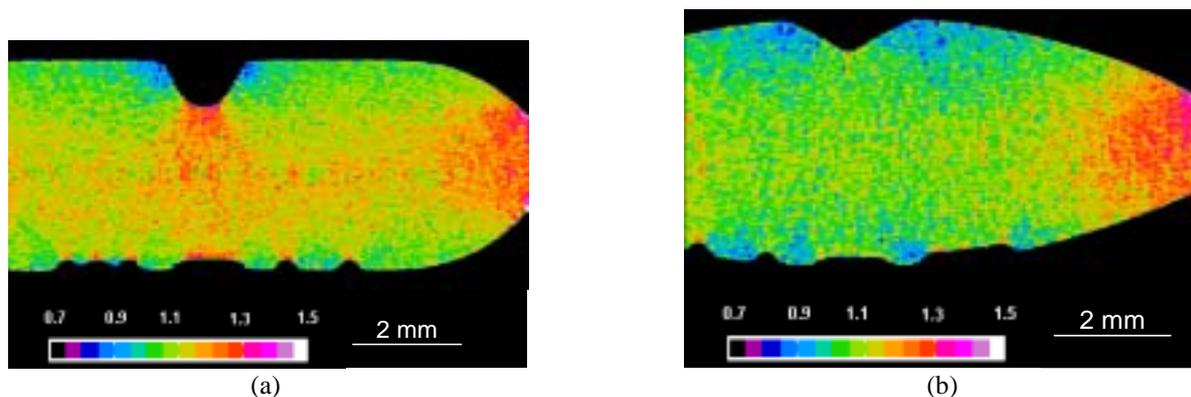


Figure 2 X-ray CT density images

FACTORS INFLUENCING TABLET COMPACTION

Numerical analysis of tablet compaction [3] require detailed knowledge of:

- Constitutive behaviour of powder
- Friction between powder and die wall
- Geometry of die and punches
- Sequence of punch motions
- Initial conditions from die fill

CONCLUSIONS

The factors influencing tablet compaction were characterised experimentally and numerical analysis was carried out. The model predictions are in good agreement with the experimental data.

It is shown that different die wall lubrication conditions induce opposite density distribution trends in identical tablets (weight, height and material) and this affects the break force, failure mode and friability: it is then demonstrated that for a given average tablet density the break force and failure mode are not unique [4]. Also, tablet regions having lower density locally have higher propensity for damage.

The application of numerical analysis for optimising tablet formulation, process development and tablet image is discussed.

References

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