A Parametric Study of the Effects of Roller Compaction Process Parameters on Normal and Shear Stress Distributions Using an Instrumented Compaction Roller

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Introduction

Roller compaction is an important step in the pharmaceutical industry for improving the flow and compressibility of a powder, and for forming tablets. During the process, the powder is conveyed through a pair of horizontal rollers where it is compacted into a thin sheet by pressure applied to the roller surface. This study aimed to determine the effect of process parameters on normal and shear stresses using an instrumented compaction roller.

Objectives

1. Describe the stress profiles in the powder resulting from roller compaction.
2. Understand the effect of process parameters on normal and shear stresses.
3. Explore the relationship between stress and the resulting tablet properties.

Materials and Methods

ACTCD Roller compactor:

- Continuous, high speed, suitable for pharmaceuticals
- Vertical feed screw forces raw powder between 100mm x 35mm cantilever-type compaction rollers
- Custom manufactured by Roland Research Devices, Inc. for Merck & Co., Inc.
- Five sensors are aligned in one row running along the roll, with a 3.5mm separation between the sensors.
- The sensors and roller compaction rollers are commercially available from ACTCD, Inc.

Experimental Setup:

- High speed, twin-roller compactor
- Sensors average normal and shear stress data
- Vertical feed screw forces powder between rollers
- Sensors measure normal and shear stress
- Matlab (Mathworks) was used to analyze data

Results

- Bulk normal and shear stress change significantly from one batch to another.
- Normal stress max decreases with increasing roll gap.
- Normal stress max increases proportional to roll force.
- Shear stress min increases with increasing roll force.

Maximum Normal Stress vs. Total Roll Force

Maximum Shear Stress vs. Total Roll Force

Modeling of Ribbon Density

1. Average ribbon density is represented by total roll force and roll gap.
2. Shear stress has less influence on ribbon density.
3. Use to model ribbon density.

Conclusions

1. The instrumented roller capable of measuring normal and shear stresses is an efficient tool for understanding the underlying mechanisms.
2. Process parameters significantly affect the stress profile.
3. Local and average ribbon density can be modeled as linear functions of roll force and roll gap.

Future Work

1. Further correlation product properties (e.g., process size distribution, tablet strength, friability, compression) with stress measurements.
2. Experimental design to assess the impact of process parameters on stress distribution.
3. Apply model to scaling between roller compactors.

Nomenclature

- R - roll (kN)
- Fd - roll force (kN)
- Az - roll state (MPa)
- FdAz - roll state (MPa)
- ρ - apparent density (g/cm³)
- σN - normal stress (MPa)
- σS - shear stress (MPa)

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References