THE STYLCAM 200 R, A ROTARY TABLET PRESS SIMULATOR OPTIMISING THE INSTRUMENTATION: CORRECTING FOR MACHINE DEFORMATION UPON MEASURING IN-DIE TABLET HEIGHT

B. Fretter

Department of Pharmaceutical Technologie, University of Bonn, Gerhard-Domagk-Str. 3, 53121 Bonn, Germany

universitätbonn

Introduction

The Stylcam 200 R (Fig. 1) is a single punch press, simulating speed profiles of various rotary tablet presses by controlling the speed of two cams electronically. This press can be used efficiently for trouble shooting in production and R&D by using just the standard force measurement instrumentation of upper and lower punch.

For characterising the compaction behaviour of powders as to their deformation properties, also a high precision in-die tablet height measurement system is required, which will be addressed first in our investigations. For measuring correctly the in-die tablet height, not only the accuracy of displacement transducers as such, reported previously[1], but also the spatial arrangement of the transducers and the deformation of punches and machine must be taken into account.

Materials and Methods

Materials

Compaction simulator

Stylcam 200 R, Medelpharm, France

punches: 11.28 mm, Euro-B

Displacement Measurement System

Inductive displacement transducers:

name	no	stroke [mm]	established accuracy[1]	position
SM210	1	10	± 2 µm	up
SM260	1	40	± 9 µm	lp
SM222.8	2	8	± 2 µm	up add.
SM222.20	2	20	± 5 µm	lp add.

Amplifiers: SM12

all from Schreiber, Germany

Data acquisition system:

DAQ4, Hucke software, Germany

Methods

Originally, the Stylcam is provided with two inductive displacement transducers (SM210 and SM260), one for the upper and one for the lower punch movement, which are not located in the compaction area. In order to investigate the correctness of the in-die tablet height measurement, four additional inductive displacement transducers were clamped directly to the punches, two for each punch (Fig. 2). For comparing the original and the additional instrumentation, the movement of all six transducers at punch-to-punch compactions were recorded with the data acquisition system DAQ4.

Results

Measurementing-setup of the four additional transducers

In order to determine the movement of the punches as accurate as possible, a strict parallel orientation of the four additional transducers to the punches is important. Already small deviations from parallelism lead to larger "measured" distances than actually exist. Fig. 2 outlines this problem. Mounting the upper punch transducer at an angle of 2.9° with respect to the punch a measurement error of +10 µm over the whole transducer stroke (8 mm) will be made. For the lower punch this error will occur at an angle of 1.8°. These angles correspond to a horizontal shift of the plunger-tip of 0.45 mm for the upper punch and 0.63 mm for the lower one. Measuring the distances between the tips of transducer and punch at the exterior positions of the stroke of the transducer, the non-parallelism resulted in angles less than 0.5°. This error lays within the accuracy of the displacement measurement system.

Investigation of punch deformation

With the displacement transducers mounted directly to the punch, precise and correct measurements of the position of the punch tips are possible if the readings of the transducer are corrected for the elastic deformation of the punch parts between tip and mounting clamp. From the geometry of the punches and the Young's modulus, the deformation can be calculated according to Hooke's law. For approximating the deformation of non-cylindrical punch parts, they have been divided in thin cylindrical sections. At equal upper and lower punch force and assuming that Young's modulus of the punch steel is 1.910^5 N/mm^2 to 2.110^5 N/mm^2 [2], this corresponds to a total elastical deformation of 2.7910^{-3} mm/kN to 2.9010^{-3} mm/kN between the clamps.

Additionally, this elastical deformation was also determined from a punch-to-punch compaction experiment, at which the punch tips touched each other directly and the in-die height was measured. By applying a force the distance between the two clamping points decreased linearly with respect to the unloaded in-die height (Fig 3). The deformation averaged over three measurements was 2.9510^{-3} mm/kN.

Because the exact Young's modulus of the punch steel is not known the experimentally determined deformation will be used in futher investigations.

Investigation of machine deformation

Measuring the in-die tablet height with the two original transducers not only the punch deformation but also machine deformation and the play of the machine parts must be taken into account. In Fig. 4 the decreasing distance between the two original transducers with increasing force is visualised similarly to Fig. 3. The machine deformation also averaged over three measurements was 1.62410^{-2} mm/kN. Considering the linearity, the data points differ clearly from a straight line, which is probably caused by the play of the machine parts.

Approximating the data points with a polynom of 4th degree, the residuals to the curve are 10 µm over almost the whole force range (Fig. 5). When the readings of the original displacement transducers are corrected for the machine deformation, it is possible to measure the in-die tablet height between 5 to 45 kN with an error of 10 µm. Of course this uncertainty has to be added to the error due to the accuracy of the displacement measurement system.

Summary

It is possible to measure the in-die tablet height correctly with the four additional transducers. If the height measurement is not corrected for punch deformation, an error of about 150 µm at 50 kN occurs. By correcting data for the machine deformation the height can be measured with the two premounted transducers but a higher measurement error has to be accepted.

References

[1] Fretter, B. et al., Tablet Tech, Brussels (2007)

[2] Blachnik, R. (ed.), D'Ans-Lax, Taschenbuch für Chemiker und Physiker, vol 3, 4th edition (1998)

Fig. 1: Stylcam

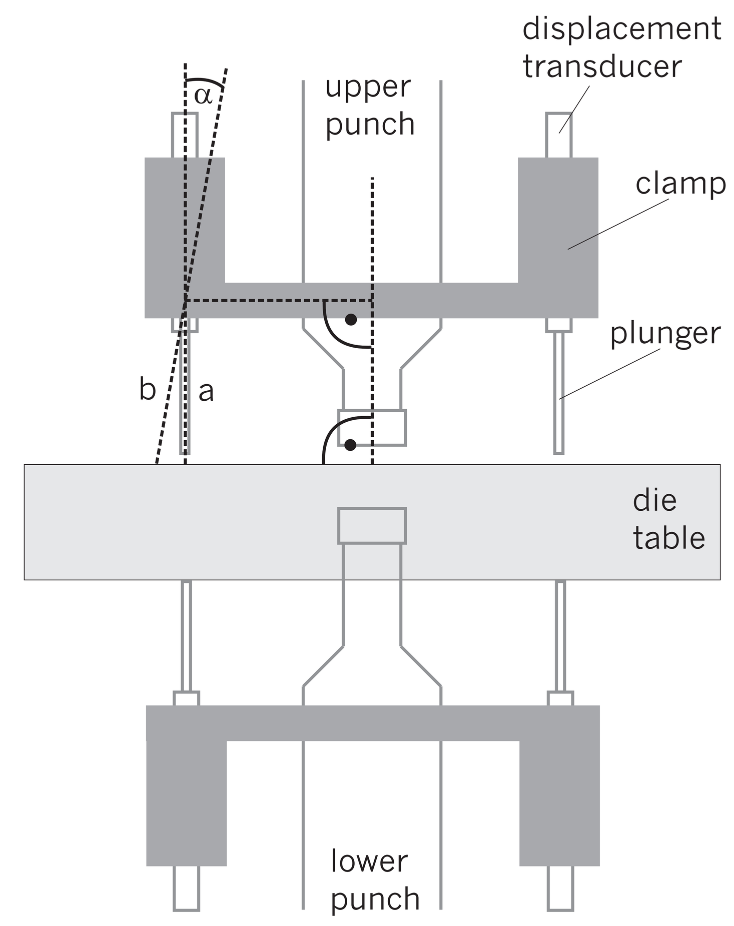

Fig. 2: measurement-setup of the four additional displacement transducers with clamps

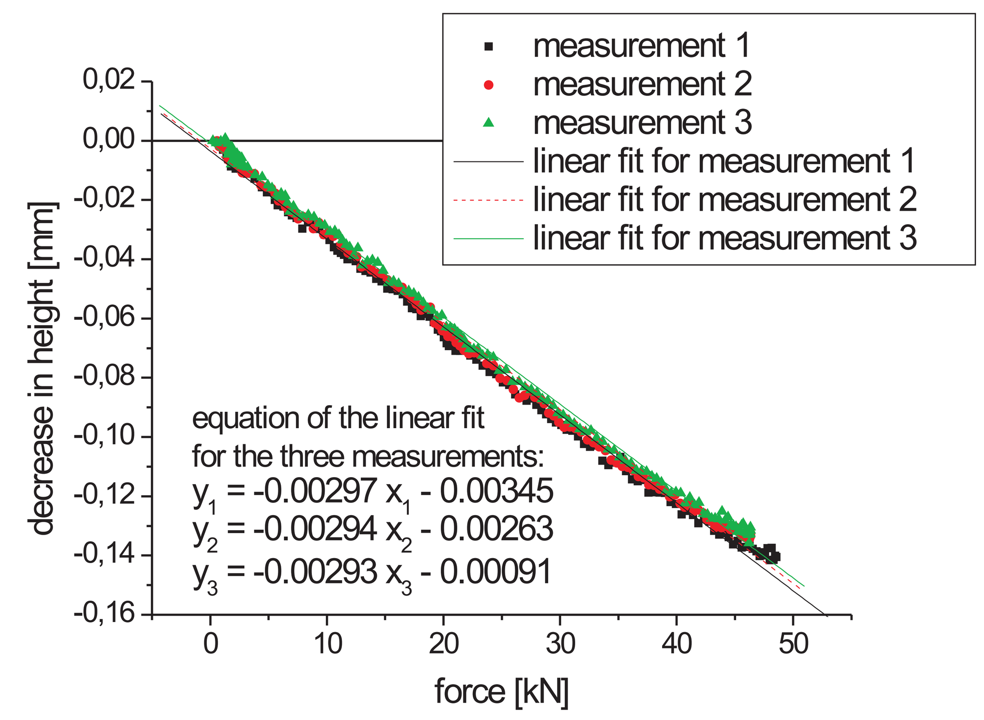

Fig. 3: punch deformation during punch-to-punch compaction

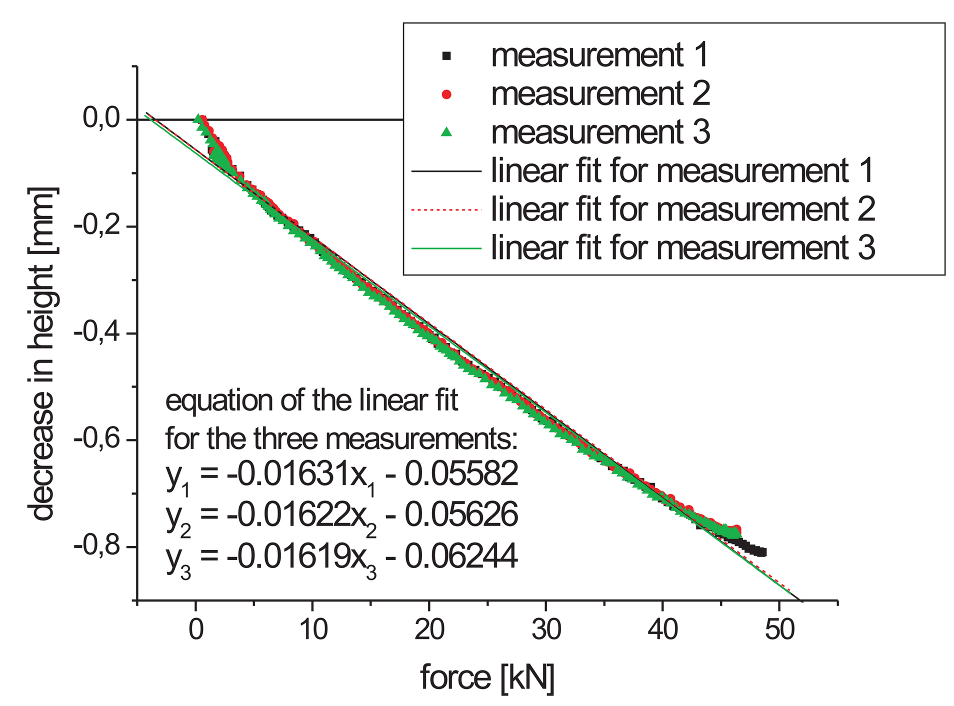

Fig. 4: machine deformation during punch-to-punch compaction

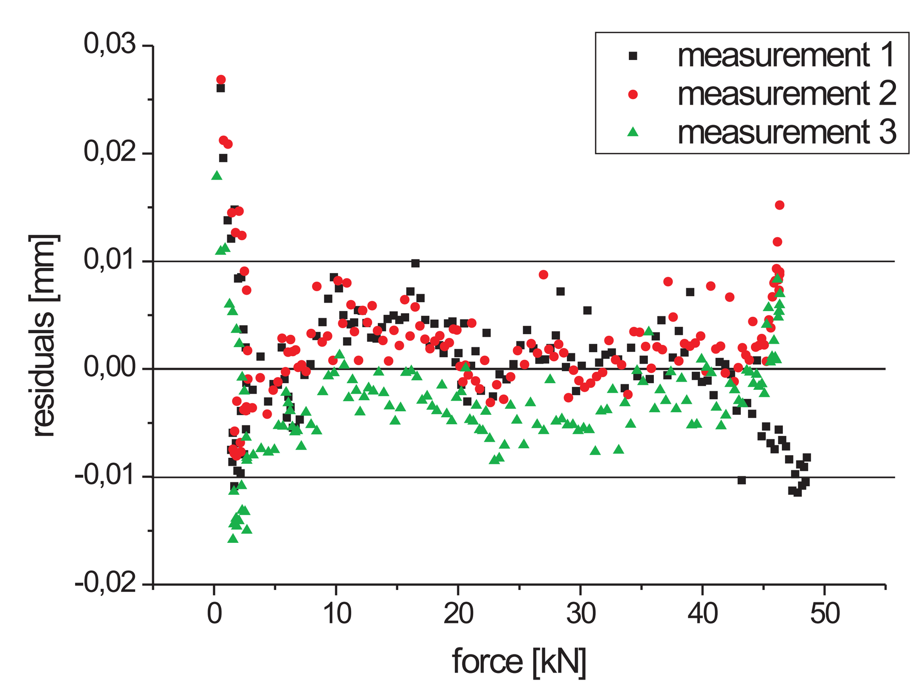

Fig. 5: residuals of polynomial fit 4th degree for the data of machine deformation

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