J. Pharm. Pharmacol. 1979, 31: 471

COMMUNICATIONS

A comparison of three methods of mounting a linear variable displacement transducer on an instrumented tablet machine

A. HO, J. F. BARKER, J. SPENCE, T. M. JONES*, *Pharmaceutical Development Laboratories, The Wellcome Foundation Ltd., Dartford, Kent, U.K.*

Several authors (Brake 1951; Shotton & Ganderton 1961; Marshall 1970) have reported the instrumentation of reciprocating tablet compression machines, measuring and recording punch pressures applied during compression and ejection. Other authors have employed linear variable displacement transducers (LVDT) to measure the position of the top punch during compression so that the relationship between applied pressure at any stage in the compression cycle and punch displacement can be studied (de Blaey & Polderman 1971; Lammens et al 1977).

The use of LVDTs to measure punch displacement permits the calculation of the work of plastic and elastic deformation during compression (de Blaey & Polderman 1971), and the derivation of Heckel plots for 'in die' compaction (Heckel 1961). Since the volume change of a compact during compression under high applied stress is small, even minor errors in the recorded value of displacement can lead to significant differences in the calculated values of compact density.

In this study, three methods of mounting LVDTs onto a single stroke compression machine have been compared by compressing a steel tablet at known pressure and measuring the position of the top punch from the LVDT outputs.

A Manesty model E2 reciprocating tablet compressing machine was used. Piezoelectric load-washers type 9021 (Kistler Instruments Ltd) were fitted to the top and bottom punches to measure the pressure produced (Marshall 1970). Two types of LVDT were used; model NFL/25 mm and NBR 5·0 mm/S (Sangamo Weston Control Ltd.). Signals from the load-washers were fed into charge amplifiers (model 5001, Kistler Instruments Ltd) and recorded on a Ultraviolet Oscillograph (Series 40,000 Bryans Southern Instruments Ltd). The signal from the LVDT was fed into an amplifier (Instapak ODI, Sangamo Weston Control Ltd) and recorded on the Oscillograph. LVDTs were mounted on the reciprocating tablet machine in three ways:

(1) The outer casing of the LVDT model NFL/25 mm was clamped to the casing of the compressing machine and the armature operated by a bracket bolted to the sliding top punch carrier block (see Fig. 1).

(2) The outer case of the LVDT model NFL/25 mm was clamped to the casing of the compressing machine and the armature operated by a bracket, 12·0 cm long, bolted to the top punch (see Fig. 1).

(3) A specially designed bottom punch assembly consisting of a punch with a long shaft supported by a steel block was used in place of the standard bottom punch and holder. This steel block bridged the overload protection system and was in direct contact with the casing of the compressing machine A load-washer was incorporated for the measurement of the bottom punch force (see Fig. 2).

The outer casing of an LVDT model N8BR 5·0 mm/S was clamped to the shaft. The LVDT passed through a hole drilled in the die table and the armature was operated by a bracket 2·0 cm long, clamped to the top punch.

To examine the accuracy of the three methods of LVDT mounting, a flat disc of hardened steel 0·631 cm

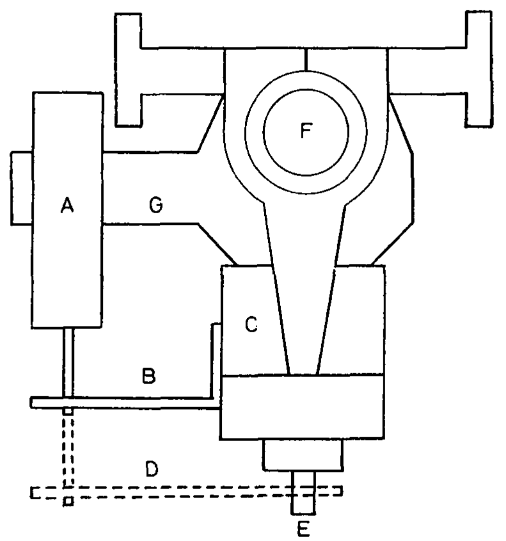

FIG. 1. Methods of mounting LVDT to Manesty E2 tablet machine. A. Linear variable displacement transducer (LVDT). B. Bracket linking the armature of the LVDT to the punch carrying block (first method). C. Top punch carrier block. D. Bar linking the armature of the LVDT to the top punch (second method). E. Top punch of the tablet machine. F. Eccentric cam. G. Machine casing.

*Correspondence

thick and slightly smaller in diameter (1·00 cm) than the die diameter (1·02 cm) was used for compression studies. When this disc was subjected to vertical pressure up to 200 MNm^{-2}, no alteration in thickness was found when measured with a travelling microscope.

The compression machine was adjusted to give peak pressures of 50, 100, 150 and 200 MNm^{-2} and five compression cycles carried out at each pressure whilst running the machine under power. The outputs from the load-washers and the LVDTs were recorded for each system of mounting from which the apparent thickness of the steel disc was calculated at the time of peak pressures.

With a completely rigid system the thickness of the steel disc measured from the output of the LVDT at peak pressure would equal the actual value measured by the microscope. The results obtained for each system of mounting of LVDTs are shown in Table 1. Analysis of the results using Student's t-test shows that at $P = 0{\cdot}05$, the apparent thickness of the disc at pressures greater than 150 MNm^{-2} is significantly different from the apparent thickness at 50 MNm^{-2} for mounting system 1 and 2 but is not significantly different for mounting system 3. It has been shown that no reduction in the thickness of the disc can be measured when pressures up to 200 MNm^{-2} are applied. In consequence the apparent reductions recorded in systems 1 and 2 must be due to movement in the machine parts between the top punch and the LVDT armature. This loss of accuracy in measuring the true thickness of a compact is of importance when the results are used for calculating relative density value, Ln (1 — 1/D) in Heckel's equation (Heckel 1961). For example, when compressing lactose (0·4 g) of true density 1·53 $g\,cm^{-3}$ between 1·02 cm diameter flat faced punches at a pressure of 150 MNm^{-2}, a variation of 0·01 cm in the measured thickness of the compact results in over 5% error in the term ln (1 — 1/D).

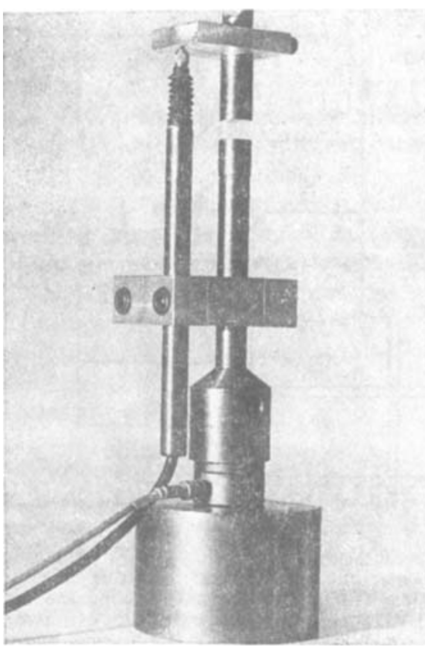

Fig. 2. Bottom punch assembly as used in mounting System 3.

Table 1. Apparent thickness of the steel disc as measured from the output of the three systems.

Applied pressure MNm^{-2}	Mean apparent thickness of disc cm	s.d.	% Error
Mounting System 1			
50	0·608	0·004	3·65
100	0·597	0·002	5.39
150	0·587	0·001	6·97
200	0·578	0·002	8·40
Mounting System 2			
50	0·631	0·001	0
100	0·629	0·002	0·32
150	0·616	0·010	2·38
200	0·608	0·010	3·65
Mounting System 3			
50	0·630	0·001	0·16
100	0·631	0·001	0
150	0·630	0·001	0·16
200	0·629	0·001	0·32

The error for mounting system 1 at a pressure 200 MNm^{-2} was 8·40%, for mounting system 2 was 3·96% and for mounting system 3 was 0·32%. This error for system 3 was within the accuracy of the output trace measurement. These results demonstrate that for accurate measurement, the LVDT outer case and armature must be mounted directly on to the top and bottom punches and as close to the punches as possible.

December 12, 1978

REFERENCES

De Blaey, C. T., Polderman, J. (1971) Pharm. Weekbl. 106: 57–65

Brake, E. F. (1951) MSc Thesis, Purdue University, Ind. U.S.A.

Heckel, R. W. (1961) Trans. Metall. Soc. A.I.M.E. 221: 671–675, 1001–1008

Lammens, R. F., de Blaey, C. T., Polderman, J. (1977) J. Proc. 37th Int. Cong. Pharm. Sci. F.I.P. The Hague, 49

Marshall, K. (1970) PhD. Thesis, University of Bradford, England

Shotton, E., Ganderton, D. (1961) J. Pharm. Pharmacol. 13: 144T