Effects of increasing compaction temperature on tablet strength

Charlotte Cartwright & Elaine H. Stone
Merlin Powder Characterisation Ltd, Brierley Hill, West Midlands, UK.

Introduction

Over time, a standard tablet press heats up during use. The effects are not often seen at development scale but are experienced during production as run lengths increase. Studies have shown a significant temperature rise during tablet compression can lead to changes in tablet characteristics if physicochemical properties of the materials making up the tablet change.[1] During compression, heat is generated through friction, the deformation and fragmentation of materials and change over the length of time of operation.[2] A study by Bechard and Down, 1992, showed surface temperatures of 50°C being recorded after 19 min running time of a rotary press.[3]

In this investigation the effects of temperature was assessed on three placebo formulations direct compression blends. A compaction simulator was used to compress the blends at high speed compaction and a temperature controlled die was used to heat the die to set temperature points to monitor the effects on the formulation. The effect of temperature on key compaction parameters was determined.

Materials and methods

Three direct compression blends were prepared with varying composition of MCC (Dupont, UK) and Lactose (Kerry, UK) (*Table 1).* Blends also contained a superdisintegrant (JRS Pharma, UK) and lubricant (Mallinckrodt, US). The blends were assessed using a Phoenix Compaction Simulator (Brierley Hill, UK) fitted with a jacketed die connected to a water bath with temperature control (Fig.1). A profile designed to simulate a Korsch XL100 press at a speed of 30 rpm. 10 mm flat faced tooling was used with a target weight of 350 mg. Tablets were made at a range of forces and the diametral crushing strength determined (Ihollands, UK). Temperatures of 20, 30, 40, 50 and 60°C were examined. The compaction simulator was used to accurately record the compact strength.

Fig. 1: set up of instrumented die

Tensile strength was calculated using the out of die measurements of the compacts.

The tensile strength against temperature was then plotted at 100 MPa to identify potential differences in the blends with increasing temperature.

Table 1: Formulation composition

Material	Blend 1 MCC: Lactose 1:1	Blend 2 MCC: Lactose 3:1	Blend 3 MCC: Lactose 1:3
Avicel PH102® (MCC)	48.25 %	72.375 %	24.125 %
Fast Flo® 316 (Lactose)	48.25 %	24.125 %	72.375 %
Explotab®	3 %	3 %	3 %
Magnesium stearate	0.5 %	0.5 %	0.5 %

Results- Tabletability

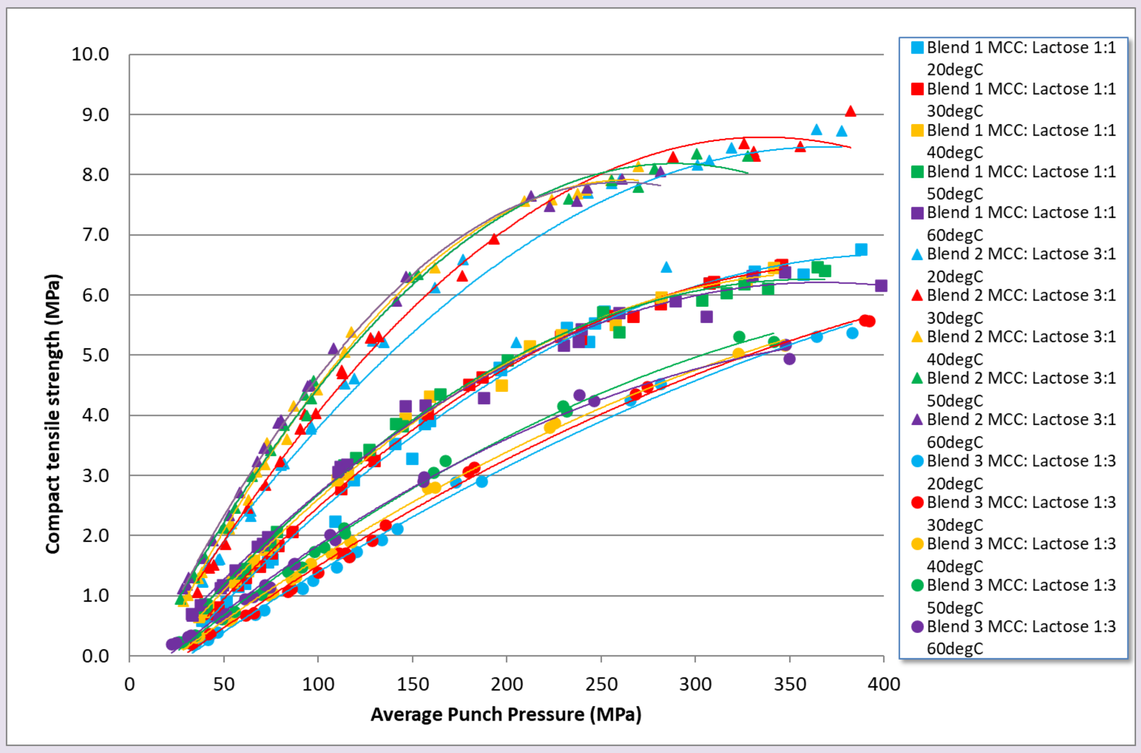

Fig. 2: Tabletability plot for the three formulation blends at 20, 30, 40, 50 and 60°C

Results- Temperature

To explore the differences in tensile strength due to temperature the strength at 100 MPa for all parameters was calculated from the regression lines to compare the strength against compaction temperature (Fig.3)

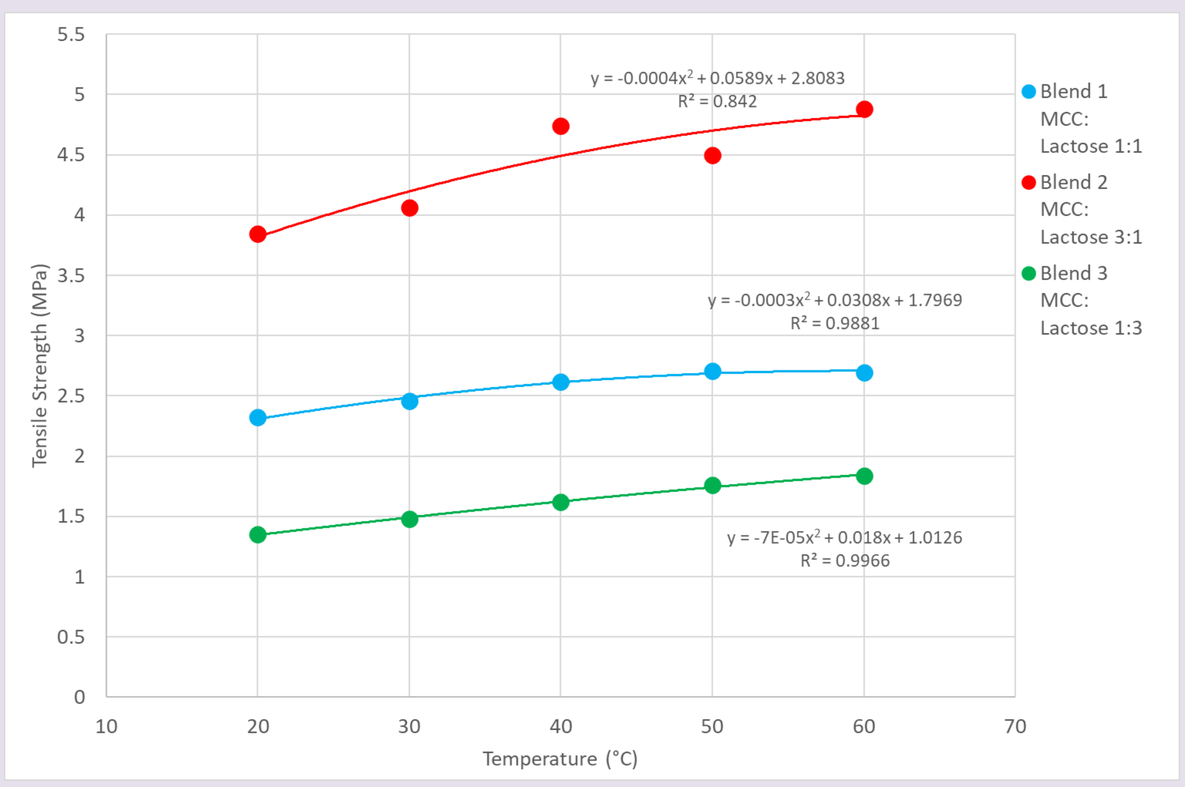

Fig. 3: Graph showing the effects of temperature on tensile strength at 100 MPa compaction pressure of three direct compression placebo blends.

The formulation blends showed good strength exceeding the 1.7 MPa target.[4]The measured tensile strength changed with blend composition. Blend 2 with the highest concentration of MCC achieves the highest tensile strength and Blend 3 with the highest concentration of Lactose had the lowest strength (Fig.2).

Temperature increases the strength of the compacts. From room temperature to 60°C, the increase was 0.4 MPa for Blend 1, 1.0 MPa for Blend 2 and 0.5 MPa for Blend 3. Blend 3 shows a consistent increase of tensile strength with increasing temperature whereas Blend 1 shows a plateau after 50°C and Blend 2 shows an increase in variability after 40°C.

It can be seen from regression values that as a greater concentration of MCC is introduced there is a greater variability of tensile strength whereas increasing the concentration of Lactose reduces this variability. Possibly due to the materials properties of MCC being a soft ductile material and lactose being a brittle material. From the graph it is not easy to see which blend causes the biggest difference with temperature apart from the larger degree of variability seen with Blend 2 after 40°C compared to the other blends which had a higher concentration of lactose. Percentage increases were worked out to magnify this effect. Blend 1 showed a 16% increase in tensile strength, Blend 2 with a 27% increase in strength and Blend 3 with a 36% increase in strength.

Conclusions

The temperature of the tablet press and die was shown to have a large effect on tablet strength. It increases the strength of tablets. The extent of increase depends upon the formulation composition.

As MCC was more affected than Lactose, it suggests that ductile materials appear to be more affected by temperature changes than brittle materials.

This suggests differences in the bonding mechanisms that are occurring and both the formulation composition and the temperature play a part in this.

Further work would focus on looking at the differences in the particles in the blends as temperature is increasing to observe any changes to identify reasons for increased variability with increased MCC concentration and bigger percentage change in tensile strength with increased Lactose concentration.

References

1. Ioannis Partheniadis, Alexandros E. Karantzalis et al, Chemical Engineering Research and Design, 2020, 156, 64-75.
2. Hannah Dorothea Grumann, Stefan Klinken, Peter Kleinebudde, International Journal of Pharmaceutics, 2022, 628, 1-11.
3. S.R. Bechard, G.R.B Down, Pharm.Res, 1992, 9, 521-528.
4. Michael Leane, Kendal Pitt, Gavin Reynolds et al, Pharm Dev Technol, 2015, 20, 12-21.

info@merlin-pc.com