X-ray as a tool for measurement of variability of multicomponent sticks

Cerulean, Milton Keynes, UK

INTRODUCTION

Whilst traditional cigarette rods are only composed of two elements, a filter and tobacco column, Heated Tobacco Products (HTP) are manufactured using a complex arrangement of segments, capsules, and other metallic and non-metallic components. The intricate construction of HTP sticks makes it impossible to physically measure the dimensions of internal features in a non-destructive way unless penetrating radiation techniques are employed.

The use of X-ray systems in laboratory settings is widespread, however in-line systems intended for routine quality control (QC) at the factory are necessary to ensure quality standards are maintained in the fast growing market of HTP products.

This study investigates segment variability for three different brands. For each brand, the products measured were taken from a single batch.

METHODS

Three different HTP brands were examined and the segment lengths measured using the Quantum Neo Q shelf.

The Cerulean Quantum Neo Q-shelf (supplied either as a standalone unit in the Quantum Solo or as part of a fully integrated stack that includes pressure drop, weight, size and hardness measurements), is an X-ray system for physical measurement that can measure internal segment lengths with 50 µm precision.

10 sticks per brand were measured to gauge the variability of manufacture.

A total of four segments per stick were measured resulting in 40 measurements per brand.

A comparison of lengths between and within brands was made for four different segments in each stick; monoacetate, Hollow Acetate Tube (HAT), Polylactic Acid filter (PLA), or cardboard tube, and tobacco column.

The variation in absolute segment lengths was used as the determinant of product variability.

THE QUANTUM NEO Q SHELF

The Q shelf used in this study is fully integrated into the design of the Quantum Neo product, it fits within the Quantum Neo enclosure and is operated using the same control system.

The X-ray detection system used in the Q shelf consists of a low energy focussed X-ray beam and a linear imaging array. The shelf is a fully shielded enclosed system with fail safe interlocks that prevent the operator being exposed to any harmful X-rays in use or even when servicing or calibrating.

A sample under test is scanned between the source and imaging array and a full picture built of the product. A series of measurements are taken which are displayed and stored in the 21CFR Part 11 compliant database. Internal standards are used to calibrate the linear dimensions of the device giving a high degree of accuracy in measurement (better than 50 microns).

EXPERIMENTAL

Figure 1 represents representative X-ray images of the sticks used in the experiment. These are four-component rods, comprising from top down, tobacco, HAT, PLA and monoacetate for brands 1 and 3. The components used in brand 2 are from top down; tobacco, carboard tube, HAT and monoacetate.

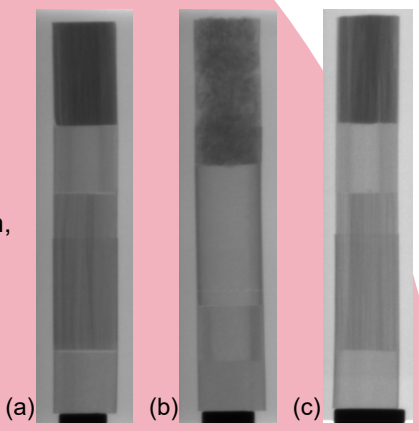

Figure 1: X-ray images of the three brands; (a) brand 1, (b) brand 2, (c) brand 3

RESULTS

Figures 2 (a), 2 (b) and 2 (c) show the measurement results of the tobacco component measurement in brand 1, brand 2 and brand 3 respectively. The error bars in each graph represent the standard deviation (SD) of the measurement for the group of products in the respective brand.

It can be seen that brand 1 exhibits the lowest variability with a maximum range of 0.4mm between the sticks. Brand 2 on the other hand exhibits the highest variability with a maximum difference between sticks of approximately 1.4mm. Finally, the range for the tobacco plug lengths in brand 3 is 1mm.

Figure 2: Brand 1 tobacco plug lengths for 10 products from the same batch

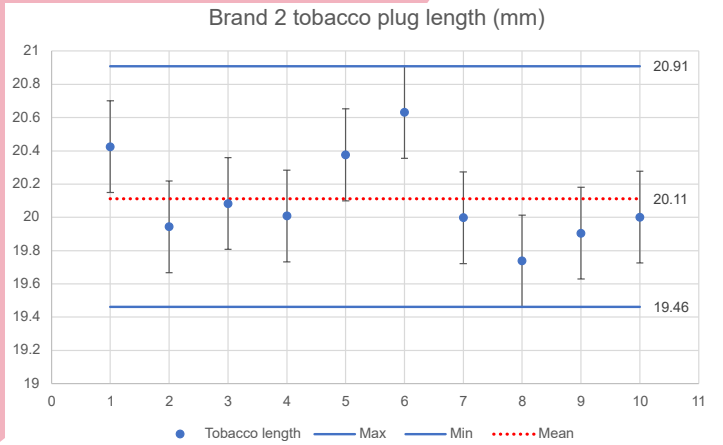

Figure 3: Brand 2 tobacco plug lengths for 10 products from the same batch

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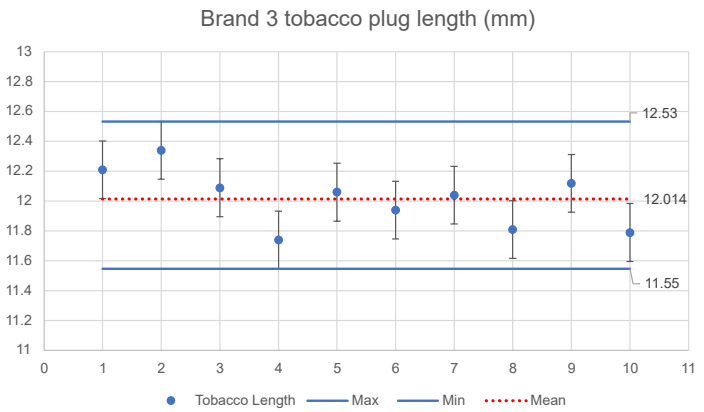

Figure 4: Brand 3 tobacco plug lengths for 10 products from the same batch

Table 1 shows the variability data for all four segments for the three brands in this study.

The between brand analysis shows that HAT variability is best in brand 3 (0.46 mm) and is 1 mm for brand 1 and 1.34 mm for brand 2.

For the monoacetate component, the variability is least for brand 1 (0.7 mm), 1.66 mm for brand 3 and 1.69 mm for brand 2.

Since the PLA component is not present in brand 2, the comparison is limited to brand 1 and brand 3 respectively where the results are 0.29 mm for brand 1 and 0.7 for brand 3.

Component	Brand 1 variability (mm)
Tobacco	0.42
HAT	1
PLA variability	0.287
Monoacetate variability	0.715

Component	Brand 2 variability (mm)
Tobacco	1.4
Cardboard tube	0.9
HAT variability	1.34
Monoacetate variability	1.69

Component	Brand 3 variability (mm)
Tobacco	1
HAT	0.46
PLA variability	0.711
Monoacetate variability	1.66

CONCLUSION

In this study, product variability for three different brands was investigated by measuring HTP segment lengths using the Cerulean Quantum Neo Q-shelf with a precision of 50µm.

The segments measured included Monoacetate, PLA, HAT or cardboard tube (Brand 2) and tobacco columns.

There was significant differences in segment length variability between the 3 brands investigated. Brand 1 exhibited the least variability for the tobacco, PLA and monoacetate components. Brand 3 in particular showed the least HAT variability, 0.46 mm.

The variation in segment lengths within some brands suggests a need for improved control during manufacture. The ability of a brand to hold tighter tolerances is a key determinant of cost saving and may influence consumer perception although the latter could also be affected by heating and puffing regimes.

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