Non-destructive Analysis of Capsules in Filters Microwave vs X-ray Techniques

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Introduction

The positioning of flavour capsules within filter base rods is critical for final product consistency, if filters have misplaced capsules this will be translated to the final consumer product. The integrity of the capsule is also of great interest and numerous broken capsules indicate a fault in process or components that requires rectification.

Comparisons

There are two available non-destructive methods for determining position of capsules, utilising microwave or x-ray detection, both of which are available in standalone instrumentation configurations and as part of integrated "stacks".
A comparison of the two methods is available in the table below:

	Microwave	X-ray
Measures density	✓	✓
Measures voids	✓ *	✓
Measures capsule position	✓	✓
Measures capsule integrity	✓	✓
Measures moisture content	✓	×
Measures metal features	×	✓
Measures carbon features	✓	✓
Resolving power	3mm	0.5mm

**Position determination in one plane only*

Each system has its benefits and a choice of technique should be based on the product characteristics of the filter rods and the limitations of the technique.

Experimental

A series (A to D see figure) of filter rods were used for these tests; some containing capsules, some carbon segments, some voids.

Each sample was presented in turn to the test equipment – the TEWS MW4420 for microwave and the Cerulean "Q" shelf for x-ray analysis.

The filter rods were selected to understand the influence of voids and carbon segments on the ability to determine capsule position. Results are displayed as a series of image overlays of the MW4420 trace and the x-ray image.

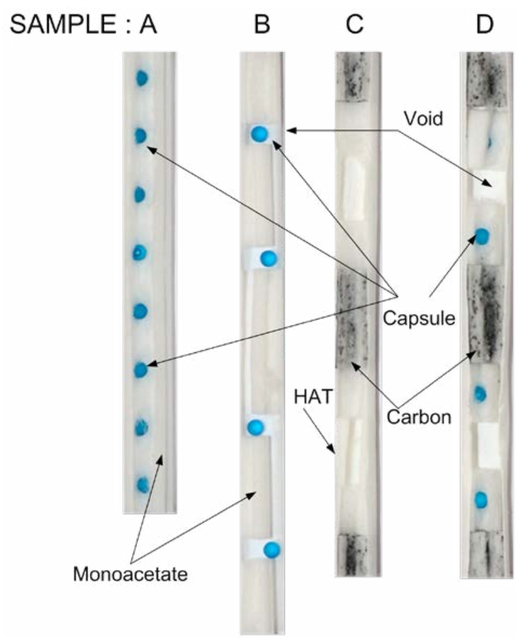

Fig. 1 samples under test A: Monoacetate with flavour capsules, Sample B monoacetate with voids with capsules, Sample C monoacetate, carbon filter and HAT (hollow acetate tube) and sample D: carbon, monoacetate with flavour capsule and voids.

Results

Figure 2 shows the overlay for the simple monoacetate rod with flavour capsules. In the case of the x-ray image the capsule is seen as a dark circle in the image whilst in the microwave trace areas of high density correspond to the capsule position. With the capsule spacing of this rod both systems are equally capable of determining capsule position.

Of note is that the microwave system would not be capable of determining where the capsule is off centre and that capsules near the ends of the rod may be difficult to detect due to end effects of the microwave cavity.

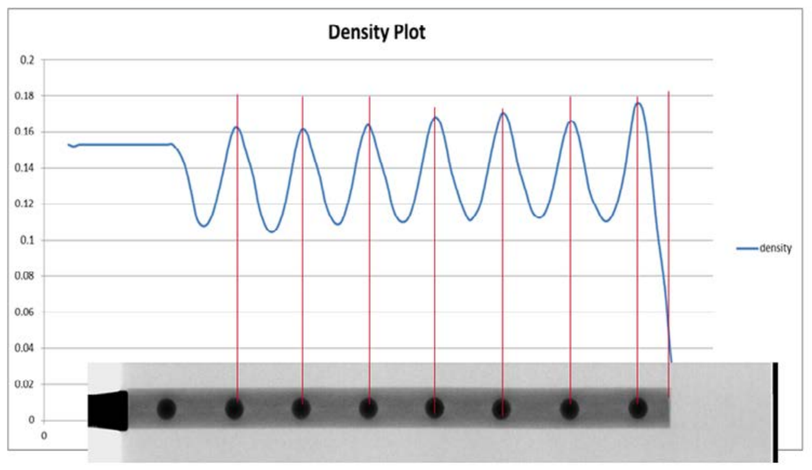

Fig. 2 Density plot and x-ray image of sample A - monoacetate with flavour capsules

Figure 3 shows sample B. Here the x-ray image shows the dark spots for the capsules. In contrast the microwave system no longer shows an increase in density for the capsules but instead shows a decrease caused by the cavity that is then attenuated by the flavour capsules, discriminating between empty and filled cavities can be challenging.

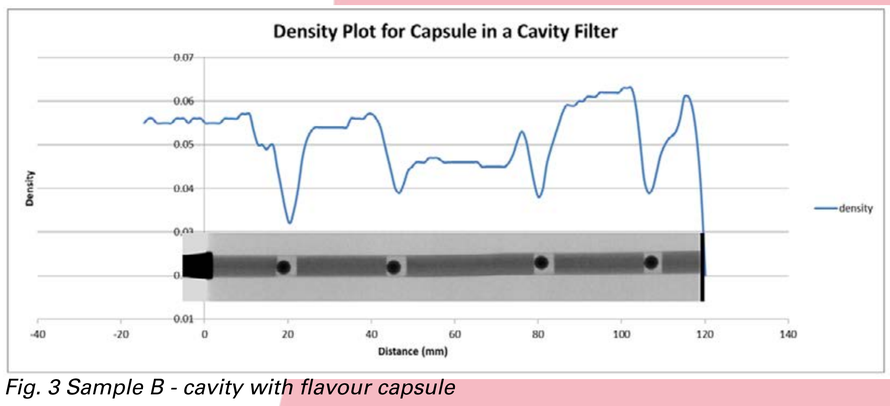

Fig. 3 Sample B - cavity with flavour capsule

Figure 4 shows the strong response from the microwave system for the carbon filled Dalmatian segments when compared to the monoacetate. Also of note is the high density of the hollow acetate tube (HAT)

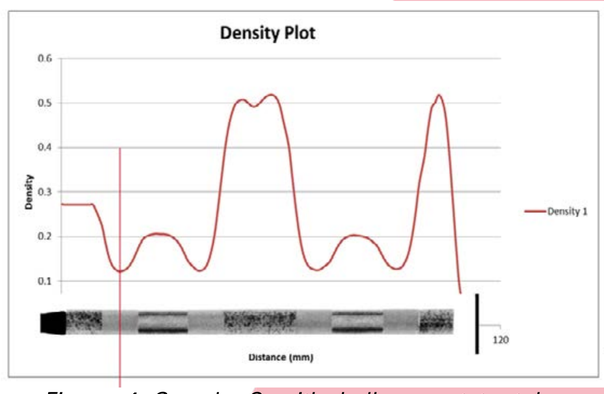

Figure 4 Sample C with hollow acetate tube, Dalmatian filter and monoacetate segments

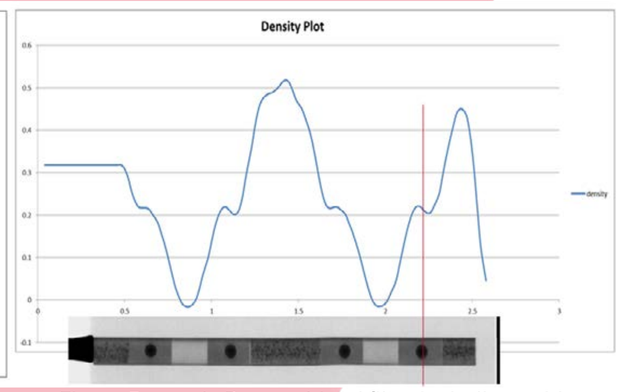

Figure 5 sample D a combined filter including voids, capsules in monoacetate and carbon segments

The final figure 5 illustrates the challenges faced by the microwave system when there are complex combinations of filter elements.
Voids show a decrease in density and the carbon segments and flavour capsules show an increased density. However the strength of the carbon segment signal tends to encroach on the capsule signal as does the void signal.

Separating capsule signal from the effects of the surrounding filter elements is possible but challenging.
In practice this overlap of microwave signal limit the practical resolving power of the microwave technique when used with these filters types. The x-ray system is unaffected by adjacent segments.

Conclusions

Both x-ray and microwave offer non-destructive measurements for capsule positions in filter rods and form a useful tool in the QA armoury. Both techniques have limitations, x-rays provide only density information whilst microwave gives moisture and density data. In contrast the spatial resolution of microwave systems are more limited.

Where complex filter combinations are present, or there is need for determining radial location or high spatial resolution (sub 1mm) the x-ray system is to be preferred over the microwave system.

About Cerulean
Based in Milton Keynes, UK, Cerulean manufacture quality assurance test equipment for the tobacco industry.

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