CANTY

PROCESS TECHNOLOGY

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Colour Analysis of Black Tea Dilutions with an In-Line Colour Analysis System.

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1. Introduction

Dilutions of cold brew black tea were used for analysis to demonstrate the ability of the in-line colour analyser to detect colour differences between liquid solutions.

Figure 1: Canty In-Line Colour Analysis System.

2. How It Works

2.1 Hardware

There are 3 critical components to a Dynamic Imaging Based Analyser;

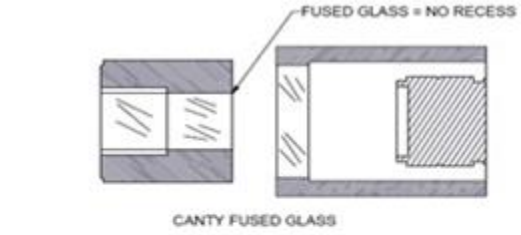
Microscopic gigabit camera

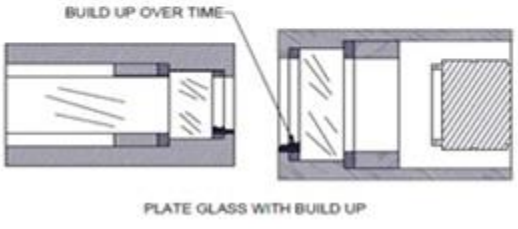
High intensity light source

Flow path between two fused glass windows

The gigabit camera is the simulation of the human eyes in the vision based system. The camera is an IP device with a simple RJ45 connection to allow for easy connection to the analyser network. The camera has the capability to take 30 frames per second, and with the current lens can magnify to a resolution of 0.2µm per pixel, to allow particles as small as 0.7µm to be analysed (maximum magnification dependent on light transmission through fluid, which is usually determined during lab testing phase).

The high intensity lighting consists of a LED light source, focused through the use of a light guide into the area on which the gigabit camera is viewing. This is critical in order to catch any moving particulate in freeze frame as it passes the camera in order for the software to be able to analyse it correctly. Currently the camera can capture particulate moving up to 5m per second within a clear fluid (maximum flow speed dependent on light transmission through fluid, which is usually determined during lab testing phase).





Fusion of glass and metal is a unique process whereby a one piece construction component is produced. BoroPlus™ glass in its molten form is poured into the centre of a metallic ring where it flows to the metal wall. At that point due to the chemical makeup of BoroPlus™ glass, the glass fuses to the metal. As the unit is then cooled, the metal, having a higher coefficient of expansion than the glass, contracts onto the

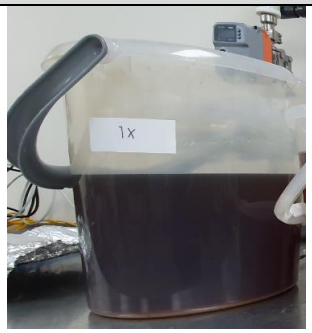
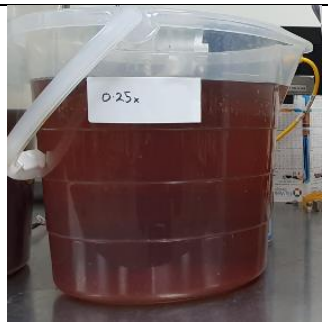
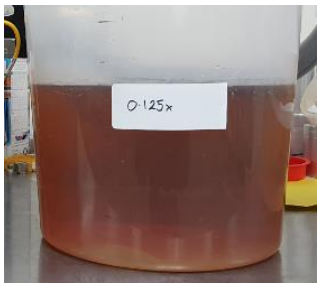
solidifying glass putting it under uniform radial compression. This fused glass and metal surface can then be finely polished to produce a smooth even surface with no crevices.

The importance of the fused glass relates to the ability of the unit to stay as clean as possible which is clearly critical for a vision-based system. Due to the fact that there are no crevices or spaces between the fused glass and metal, there is nowhere for product to begin to build up. Non-fused glass and metal systems would not have a smooth transition from glass to metal, and it is in this step area that product would inevitably build up. The fused glass also allows higher pressure operation of the systems (up to 600 Bar possible) due to the fact there is no danger of the glass and metal separating into 2 separate components.

3. Experimental Method

3.1 Tea Sample Preparation

Table 1: Sample Legend

Sample Number		Sample Description
ESAM718-1		1:1 Concentration of Black Tea
ESAM718-2		4:1 Concentration of Black Tea Diluted in Water. 2l H2O 6l 1:1 Tea
ESAM718-3		8:1 Concentration of Black Tea Diluted in Water. 1l H2O 7l 1:1 Tea
ESAM718-4		16:1 Concentration of Black Tea Diluted in Water. 0.5l H2O 7.5l 1:1 Tea

30 black tea bags were suspended in 13 litres of water and covered. The sample was left to brew for 72 hours at room temperature. After this initial 72 hour brew period the tea bags were removed. This source sample was labelled ESAM718-1, a 1:1 concentration of black tea. Dilutions of this sample were then prepared as described in Table 1 to give a series of solutions that provide a colour gradient for analysis.

3.2 Sample Analysis

For each round of analysis one of the four samples was pumped into the reservoir atop the inline colour analyser configuration. All valves were set to closed for this initial step. The camera of the analyser was connected to the CVIT Software with the exposure configured for optimal image capture with respect to light transmission through the samples. The darkest sample ESAM718-1 was used for this initial calibration. The colour tool of the CVIT software was used to analyse the red, green and blue colour values of the live image throughout a sample run. Once the full sample was pumped into the reservoir the first valve was opened to allow the sample to fill the flow cell. Live analysis was then initiated before opening the second valve to allow sample flow through to a collection reservoir below the analyser. The colour tool recorded values for red green and blue light intensity for the duration of the sample flow through the flow cell. This data was correlated to a scatter plot of colour intensity versus time in real time during analysis. The total data acquired was then used to gain an average colour value for each of the samples. An intensity tool was also used in conjunction to these sample runs to gain average light intensity values for each sample.

4. Results

4.1 Colour Analysis

Table 2: Average Colour Data of Tea Dilution Samples

	1:1 ESAM718-1	4:1 ESAM718-2	8:1 ESAM718-3	16:1 ESAM718-4
Red●	184.5287	149.8989	113.3103	106.4169
Green●	61.84812	97.39234	93.23321	102.5486
Blue●	6.658063	24.95506	40.1186	70.11112

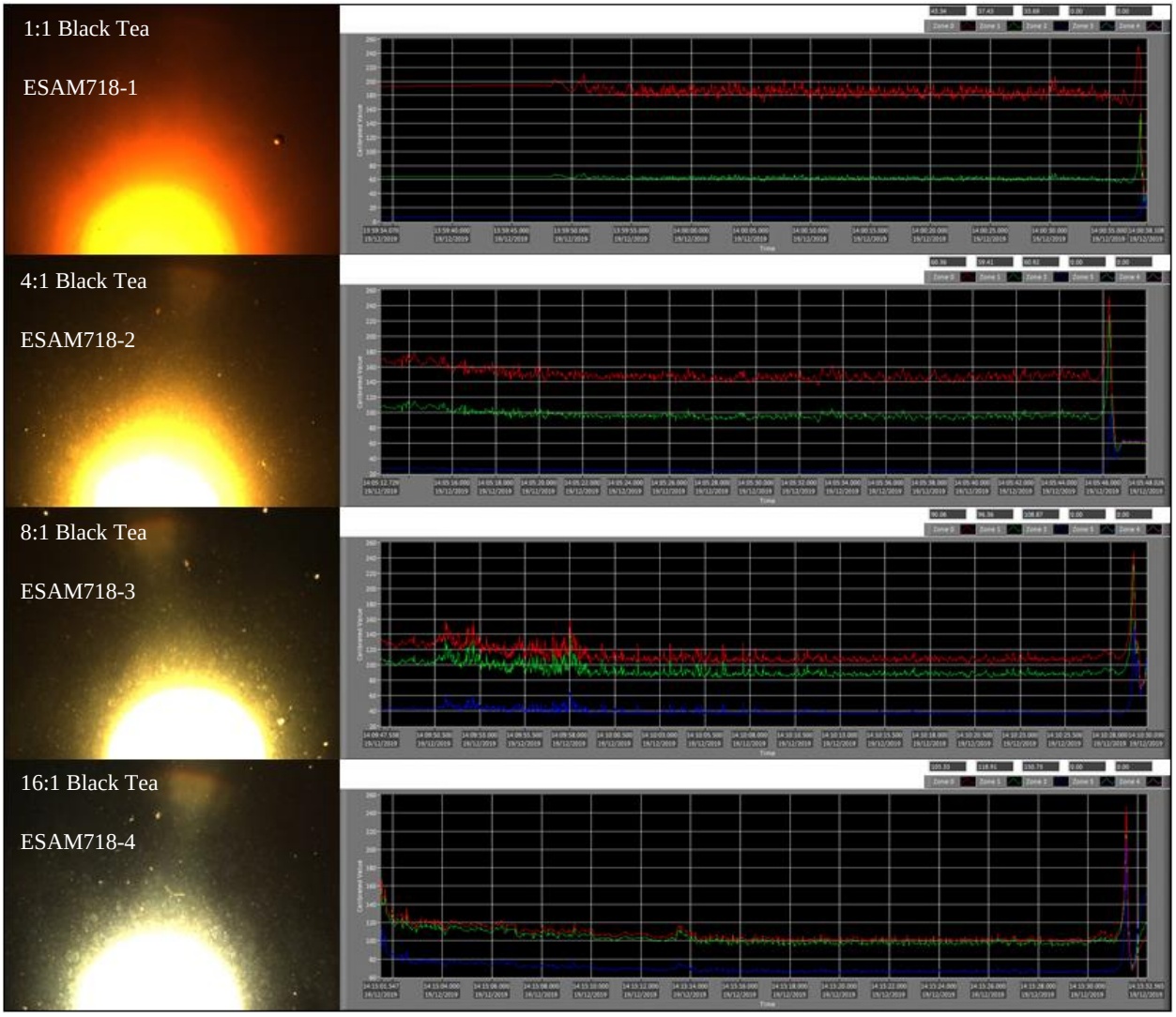


Figure 2: Trendline (Right) of colour analysis data as it progresses through a sample run with image capture taken during analysis (left) of each associated sample. Trendline indicates average red (red line), green (green line) and blue (blue line) colour intensity values of each frame analysed over the course of a sample analysis. Trendlines were taken from the CVIT software after analysis.

4.2 Intensity Analysis

Table 3: Results of Light Intensity Analysis

Sample	1:1	4:1	8:1	16:1
Intensity	62.28782064	81.5528431	82.63737498	77.71886073

5. Conclusions

The black tea dilution samples prepared were clearly distinguishable based on colour. As The samples become more dilute, less light is absorbed and thus they progressively appear brighter and more translucent (Table 1). The capability of the Canty in-line colour analyser to monitor colour in these samples was demonstrate. Each sample was identified with a different red green and blue

light value profile (Table 2, Figure 2). The analyser and software together also have the ability to detect minute colour variations that would otherwise prove difficult to see. This was observed during testing of the medium diluted samples (ESAM718-2 and ESAM718-3). It was difficult to discern any visible differences between these samples upon inspection with the naked eye. The software monitors three distinct intensity values for red green and blue light which facilitates a much more accurate colour analysis. These samples were thus found to have distinct colour profiles in both red and blue light intensity.

The software was also used to determine the trend of colour component change across the samples. The colour constituents that contributed the majority of the colour change were red and blue light. As the samples become more dilute the red light intensity diminishes while the blue light intensity becomes more pronounced with a further marked increase in green light intensity. These details give a considerable advantage over a simple light intensity measurement that would encounter issues in this analysis. As the samples are diluted the overall intensity would be increased as the red hue becomes weaker and more light passes through the sample to the camera. At a certain point however at a middle dilution the increased light transmission from the LED would cause an increase in the blue light penetration through the sample, reducing the red colour in the image, which would be detected as decrease in overall light intensity. A simple light intensity tool would thus be expected to detect two dilutions, both at equal levels of dilution away from the midpoint, as the same sample. These predictions were seen in the results of the intensity analysis (Table 3). There is an initial increase in intensity before a detected decrease in the final dilution. The intensity tool also didn't detect much of a disparity between the middle samples ESAM718-2 and ESAM718-3. The detailed colour analysis tool employed did not encounter these issues.

The colour analysis systems capability to detect colour changes in an aqueous solution was successfully demonstrated. This system, combined with the colour analysis tool of the CVIT software has a broad range of potential process applications such as batch timing optimisation due to the ability to integrate the system on-line without any process interference. No additives were needed to enhance or modify in anyway the solutions analysed.