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Dynamic Imaging Applications in Sugar Production

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1 INTRODUCTION

Dynamic imaging operates on the basic principle of capturing a real time view of a process, to either support an operator in making process related decisions, or to feed image analysis software which performs specific process measurements. This paper outlines the relevant applications of dynamic imaging within a sugar production facility, and compares it to other industry methods used. Sugar production processes where this technology can be employed include clarifying, crystallisation, centrifuging, and product quality control.

2 DYNAMIC IMAGING – HARDWARE

Every Canty dynamic imaging system is made up of 3 common hardware components, each with their own features and importance. The 3 components are a window / viewing medium, an imaging sensor, and process lighting, and careful consideration must be given to each of these to ensure the imaging system is suitable for the process conditions and application.

2.1 Window / Viewing Medium

All of Canty's range of dynamic imaging systems utilise a unique fused glass barrier through which the imaging sensors views, and the light system transmits. Fused glass is unique to Canty, and is produced by fusing glass to metal on a molecular level to form a one piece construction (no adhesives / seals / gaskets), capable of withstanding high process pressures and temperatures. This technology also provides energy saving advantages when used on a crystallisation process (see section 3.2).

2.2 Imaging Sensor

The imaging sensor or camera is the simulation of the human eyes in the dynamic imaging system. All of Canty's systems used Gigabit Ethernet technology, incorporating high colour sensitivity, and designed specifically for process vision applications. 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 can be utilised with a variety of lenses (micro, macro, standard) depending on the specific application.

2.3 Process Lighting

In any imaging system, the lighting is the key component, and without the correct amount or type of light, the imaging sensor cannot perform to it's highest specification. Canty's background is in vessel lighting, with over 40 years of experience in the field. Each light system uses either halogen or LED technology, and is specifically designed to suit the imaging sensor type it is combined with, and the application it is to be installed on.

3 SUGAR PRODUCTION APPLICATIONS

3.1 Clarifier Outlet Turbidity Analysis

One of the measurements performed in order to determine if the liquor discharged from the clarification process is within specification, is to measure the turbidity of the fluid. Canty's dynamic imaging uses a flow cell mounted in the process line, with a high intensity light source, and imaging sensor on opposite sides of the cell. As the fluid pases through the flow cell, images are captured and sent to the image analysis software for processing. The colour intensity of the fluid is measured, which can be directly correlated to the turbidity value.

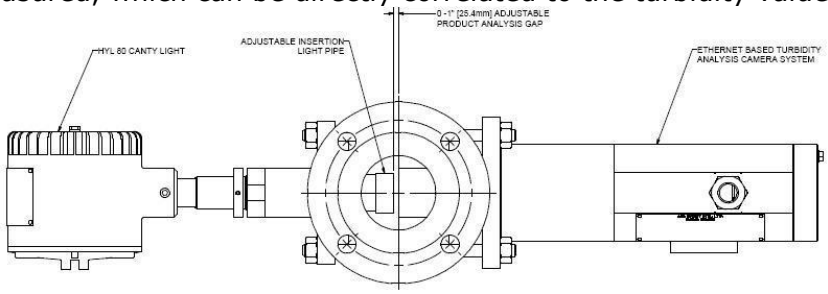


Fig.1 Turbidity FlowCell (InFlow)

A common source of faults for turbidity analysers is gas bubbles within the process fluid which can have an adverse effect on the measurement. However, when Canty's dynamic imaging is used, gas bubbles within the fluid are easily recognisable on the display screen due to their visual characteristics, and so they can be eliminated from the turbidity calculation, giving a more accurate, more consistent measurement.

Traditional methods often employ a light obscuration technique, however this technique regularly has issues with gas bubbles that may be present within the fluid. The below image shows an example of the same fluid being analysed with and without the bubbles filtered from the measurement. The signal graph of the measurement without the gas bubbles filtered out simulates what may happen when using a light obscuration technique. The signal graph of the measurement with the gas bubbles filtered out is a measurement based on the fluid only, which is what is provided by employing Canty's dynamic imaging technology.

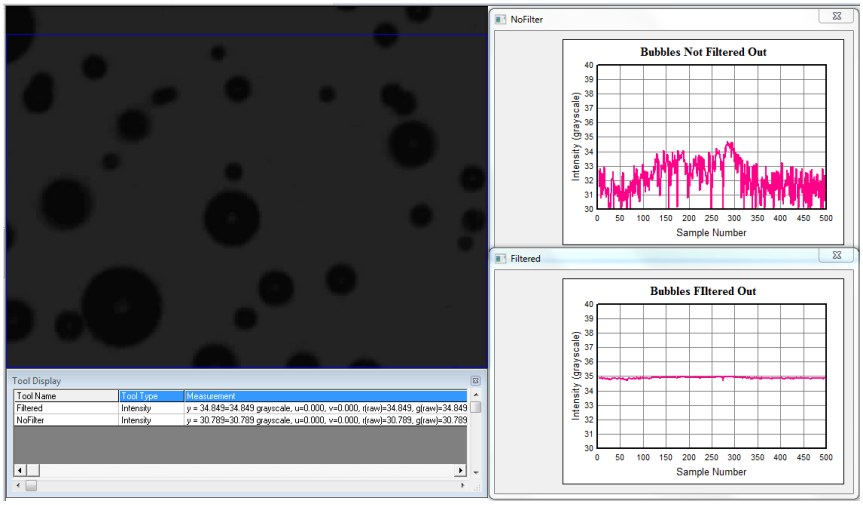


Fig.2 Effect of Bubbles on Turbidity Measurement

3.2 Crystallisation

3.2.1 Manual Viewing – Sight Glass

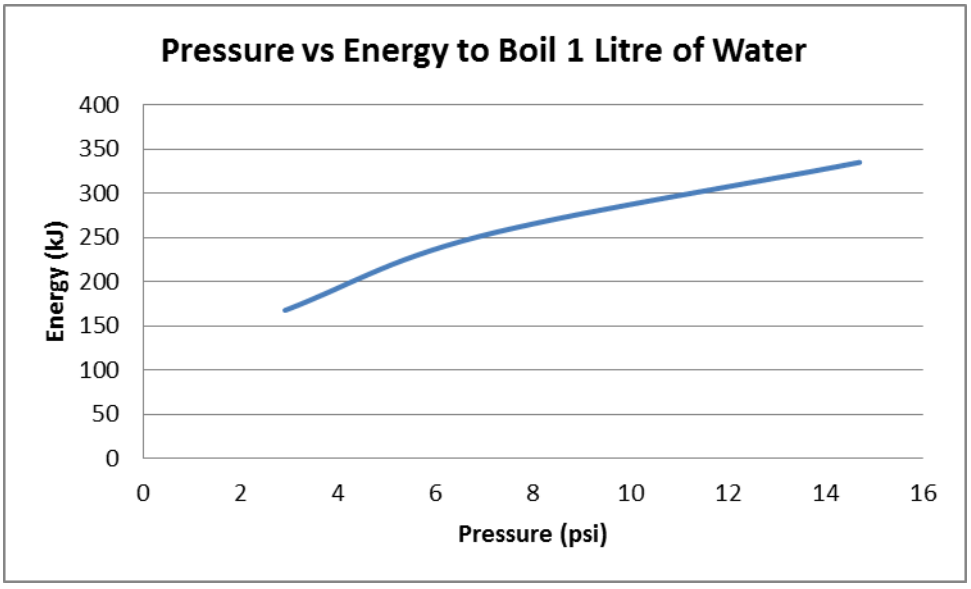
The sugar crystallisation process occurs under vacuum, so it important to have no leak paths in order to boil at a lower temperature, and therefore use less energy. If a tempered glass sight glass is used, it cannot be fully tightened in place due to the risk of cracking the window. An un-tightened sight glass is often noticeable by a sugar residue forming at the base of the outside of the sight glass. By using a Canty Fuseview™ the user is tightening on metal so cannot over torque and damage the window. A full seal is maintained, and so a full vacuum is achieved, resulting in significant energy savings to run the process.

The energy required to heat a volume of liquid from one temperature to another can be calculated using the formula Q=mCp(T2-T1)
Q = energy required
m = mass
Cp = specific heat
T1 = starting temperature
T2 = finishing temperature

To heat 1 litre of water from 20°C to a boiling point of 100°C (ambient; 14.7 psi)
Q=1(4.186)(100-20)
Q=334.88kJ / 0.093kWh per litre

To heat 1 litre of water from 20°C to a boiling point of 80°C (vacuum; 6.9 psi)
Q=mCp(T2-T1)
Q=1(4.186)(80-20)
Q=251.16kJ / 0.070kWh per ltire

To heat 1 litre of water from 20°C to a boiling point of 60°C (vacuum; 2.9 psi)
Q=mCp(T2-T1)
Q=1(4.186)(60-20)
Q=167.44kJ / 0.047kWh per litre



Graph 1. Effect of Pressure on Energy Required to Boil

3.2.2 Crystal Size Monitoring

In addition to using fused glass sight glasses to manually view the process, it is also important to have an indication of sugar crystal size throughout. A rudimentary technique often employed is to simply take a series of small samples from a tapping point on the side of the vessel, and for an operator to manually view the sugar crystals on a glass slide, often without any magnification. This method is clearly very subjective, and does not allow for quantifiable analysis of how the crystallisation process is going. As an alternative, there are a number of systems available in the market which provide remote visualisation of the crystallisation process. However there are certain features which should be sought for when specifying which is most suitable for your process.

Canty's dynamic imaging technology uses of a Sugarscope™ system to remote monitor and measure the size of sugar particles throughout the crystallisation process.

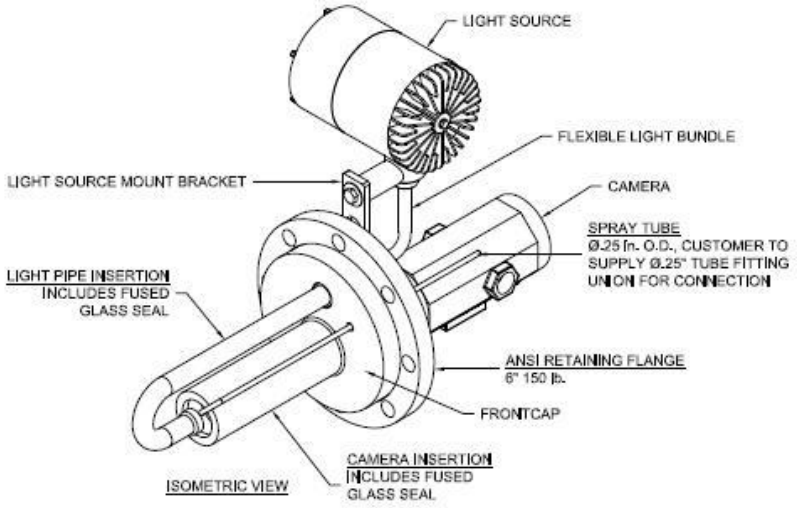


Fig.3 Sugarscope™ system

The imaging sensor mounted to a microscopic lens, combined with fused glass technology (Section 2.1) and the high intensity light source (Section 2.3) allows the operators to visualise sugar crystals from the early seeding stage, right through to full crystal growth. The system has the capability to visualise sugar crystals from 1µm upwards, with the overall range adjustable dependent on product type.

As seen in Fig.3 above the unit is mounted via flange to the crystallisation vessel, with the camera lens system and light pipe protruding into the process medium. This is an important feature as it ensure that the images captured, and any subsequent measurements performed, are representative of conditions in the vessel. It limits the effect of boundary layer conditions, as would occur if the images were captured through a sight glass mounted in the vessel shell.

Cantyvision image analysis software allows for the real time measurement of the particle size distribution throughout the process, though even simply having a real time video stream available to the control room operators, can be hugely beneficial in controlling various process parameters, and improving overall efficiency.

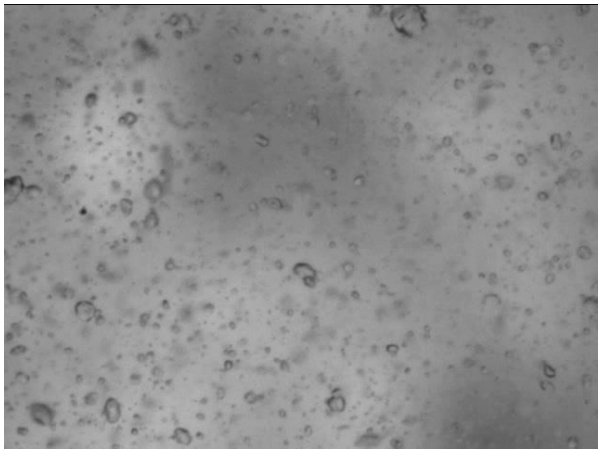


Fig.4 Seeding

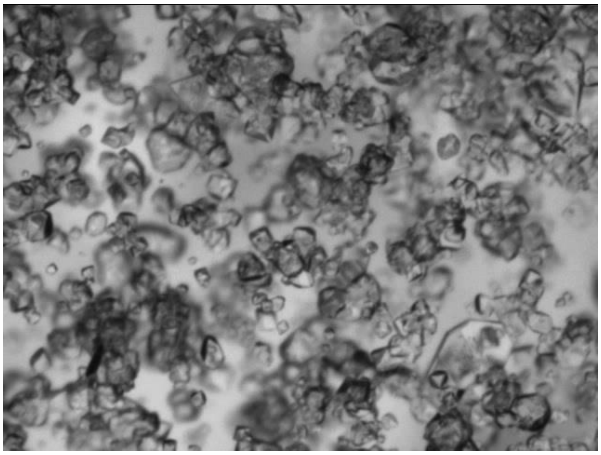


Fig.5 Seeding + 30 Minutes

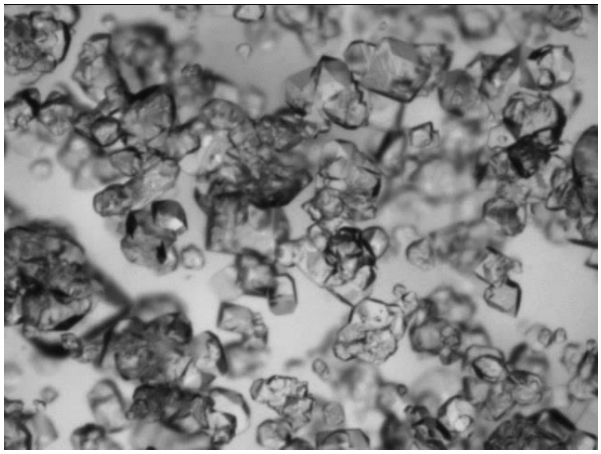


Fig.6 Seeding +60 Minutes

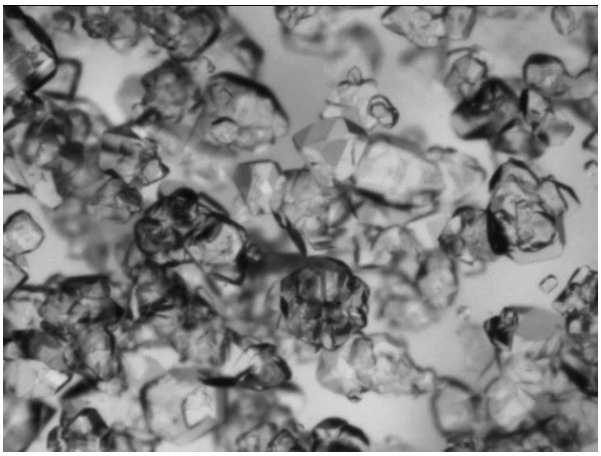


Fig.7 Seeding + 90 Minutes

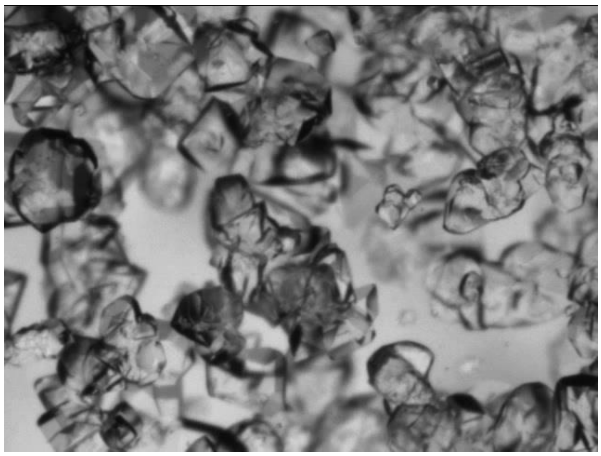


Fig.8 Seeding +120 Minutes

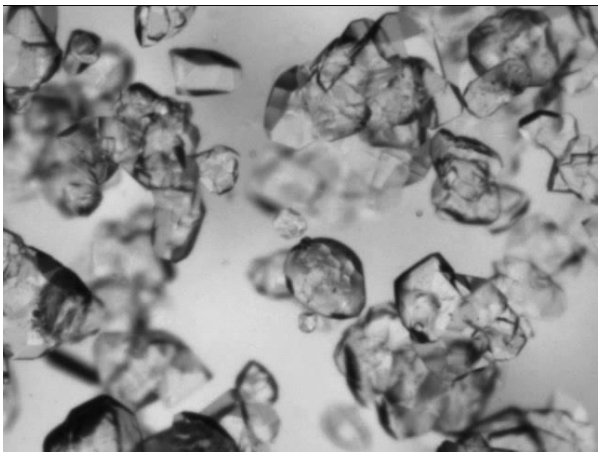


Fig.9 Seeding +150 Minutes

3.2.3 Sample Return on Investment - Sugarscope™

The below is a return on investment calculation performed by a sugar production facility, based on the installation of a Sugarscope™ on 2 of their vacuum pans;

With the annual increase in the production of large grain sugars, it is critical that we optimize our Pan Yields, Crystallization Times and Utilities in producing these products.By having operator's continuously view the crystallisation process, it is felt that the below can be achieved;

- *Reduce boiling times by 33% thus increasing number of batches*
- *Overall increase yield by 10% (250,000 lbs/day)*
- *Reduction in annual water / steam usage by 33% (3,200 gals to 2,110gals per strike, 545,000 gals/4,523,500 lbs. of steam per year*

Increasing by 250,000lbs/day, would save ½ a shift of processing labour per week, which is 9 less melt days required per year. This gives a saving on staff payments of ~$22k per year.

Reducing water / steam usage by 4,523,500 lbs would give a saving of ~$30k based on current enery costs.

Total savings for 1 year:	*~$52k*
Estimated total procurement / installation cost:	*~$25k per unit (x2)*
Payback duration:	*<12 months*

3.3 Centrifuge

After crystallisation, a centrifuging process (either batch or continuous) is commonly used to separate the solid crystals from the remaining mother liquor.

In a batch centrifuge, one of the most important measurements is the product or "cake" thickness as it builds up on the centrifuge basket walls. This parameter is often measured through the use of a mechanical paddle. However this technology is susceptible to coating, which can have a significant effect on the system accuracy.

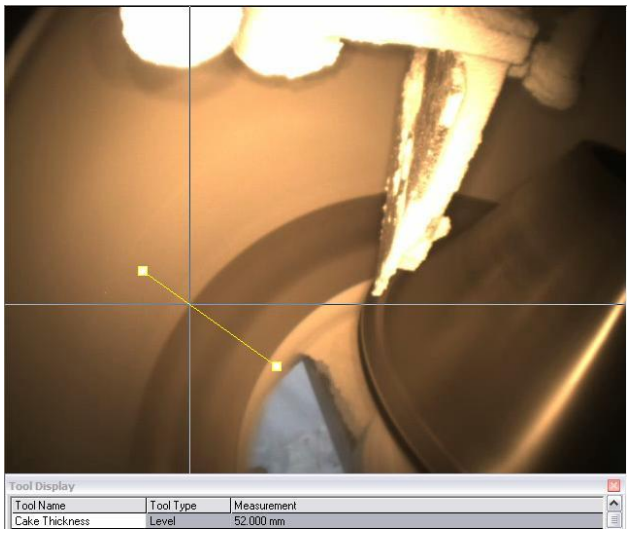


Fig.10 Edge Detection Software

Canty's dynamic imaging technology uses a combined camera & light system mounted to the top of the centrifuge, to provide a remote view of the process conditions to the control room, but also to measure the product or "cake" thickness on the basket wall. This is achieved by tracking the position of the edge of the product on the base plate of the basket, based on the colour difference between the two.

In a continuous centrifuge, in order to increase capacity / throughput, there is a constant feed of the solids / liquid slurry, and a constant discharge of the washed solids, and of the mother liquor / wash solution.

Again, a Canty dynamic imaging system can provide a constant real time view to the operators in the control room, but using the same edge detection software as mentioned above can be used to monitor and track the position of the colour line. This allows the operator to adjust the feed conditions to maintain a relatively stationary colour line position. This also helps to avoid washing above the colour line which is typically inefficient as the crystals are dispersed on the screen and a significant amount of the wash solution may not come into contact with the sugar. Washing too high up the basket wall, can also result in liquid carry over and an increase in moisture content in the recovered sugar crystals.

3.4 Final Product QA/QC

Canty's dynamic imaging technology can be employed in 2 areas of final product QA/QC. A SolidSizer™ system can be used to measure the particle size distribution of the finished product, and / or the concentration of black speck / dis-coloured sugar crystals. The process works by loading a sample into the system hopper, where it lands onto a vibrating feed tray. This separates and transports the product in one even layer to the analysis zone.

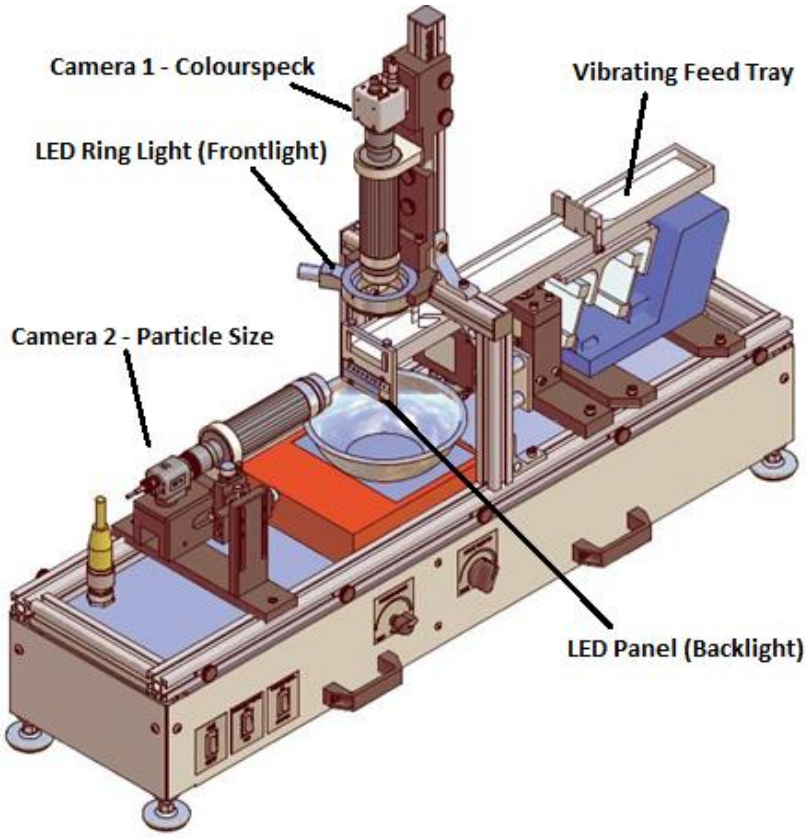


Fig.11 SolidSizer™ with Black Speck Detection – System Cover Removed

The first camera (see Fig. 11) uses a front lighting system and captures images which are sent to the analysis software for black speck detection. This provides a repeatable, subjective detection method, which requires limited operator / lab technician input.

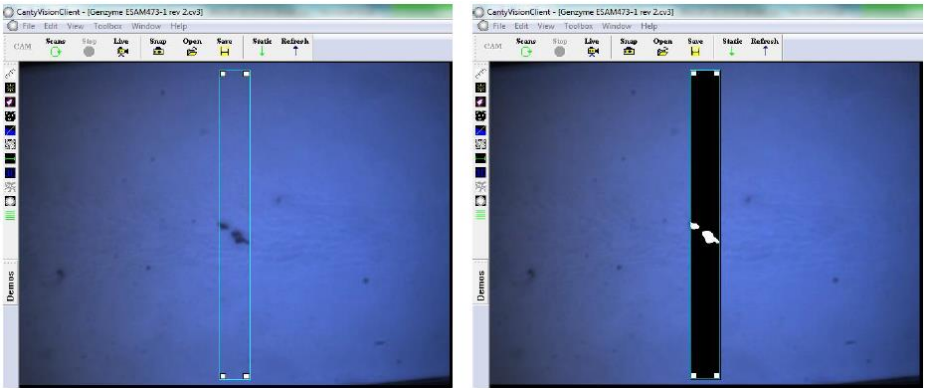


Fig.12 Black Speck Detection

After passing the first camera, the crystals reach the end of the vibrating feed tray where they free fall, or slide over and angled stage between the second camera and an LED panel. This results in sharp images of the crystal shapes being captured, which are then processed by the analysis software to provide size distribution and shape characterisation data

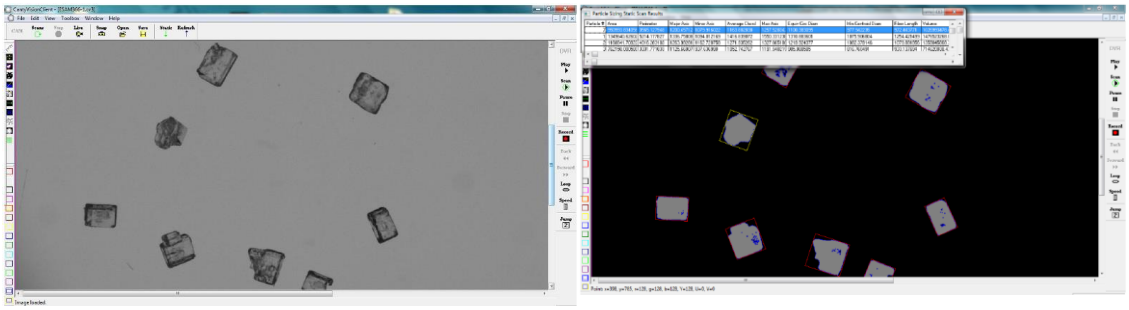


Fig.12 Analysis Screenshot – Sugar Crystals

As the system measures the crystal size under a large number of size and shape parameters, including minor axis (width), the data can be directly correlated to sieve analysis which is often used in sugar QA/QC labs. Using the SolidSizer™ system however, minimises the input required from the operator / lab technician and automatically generates the relevant data avoiding time consuming activities such as weighing sieve screens, and performing manual calculations.

4. CONCLUSIONS

While crystallised sugar has been around for close to 2000 years, and the basics of mass sugar refining have not changed significantly in the last 200 years, it is important to take advantage of relatively newer technology to allow the production processes to run more efficiently and produce a higher yield. Canty's range of dynamic imaging systems can be used to do just that, by providing unparalleled views into the process, and generating useful data that can be used for process control and optimisation.