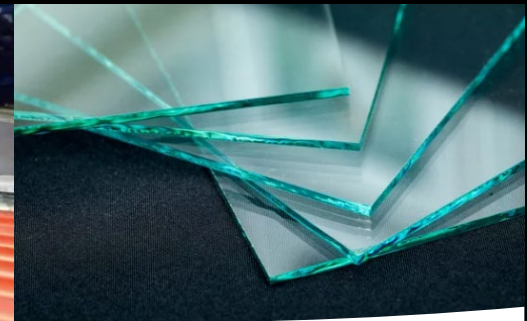
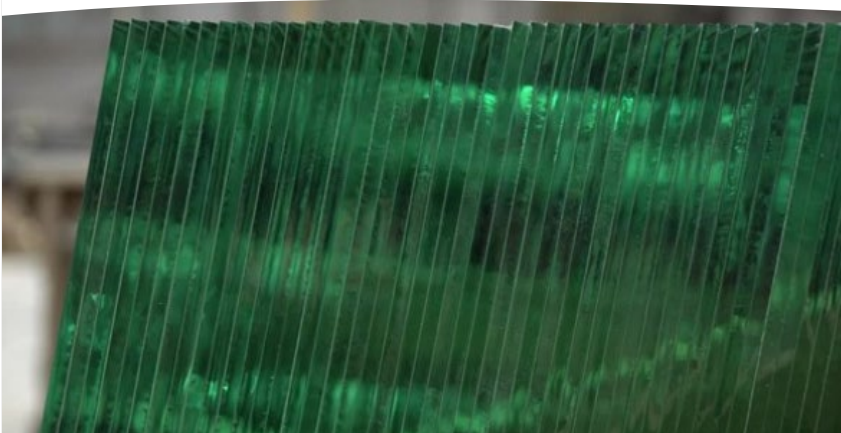




J.M. Canty, Inc. Latest Advancements in Dynamic Image Analysis for Glass Production

Matthew Spink
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Presentation Outline

Historical Uses of Dynamic Imaging in Glass Manufacturing

- Batch Line
- Molten Glass Level
- Pool/Onion Edge
- ADS
- Stone Detection
- Shoulder/Fence
- Exit End Width
- Many others

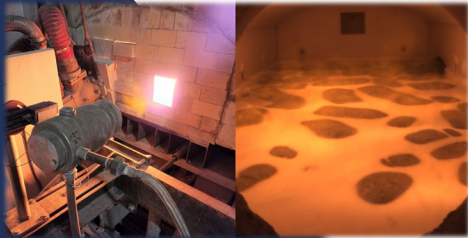
Latest Advancements

- Direct Electronics Cooling (DCE)
- Cullet Size and Color Analysis

What is Dynamic Imaging

- The use of high-speed, high-resolution cameras to acquire images and perform image analysis in order to make measurements that allow for process control.
- Allows for remote visual verification and can replace applications where operators visually inspect.
- Recent advancements in AI have greatly increased the image analysis that can be performed.

Glass Applications Overview



1 - Furnace

- Batch Melt (melter)
- Molten Glass Level (refiner)

3 - Annealing Lehr

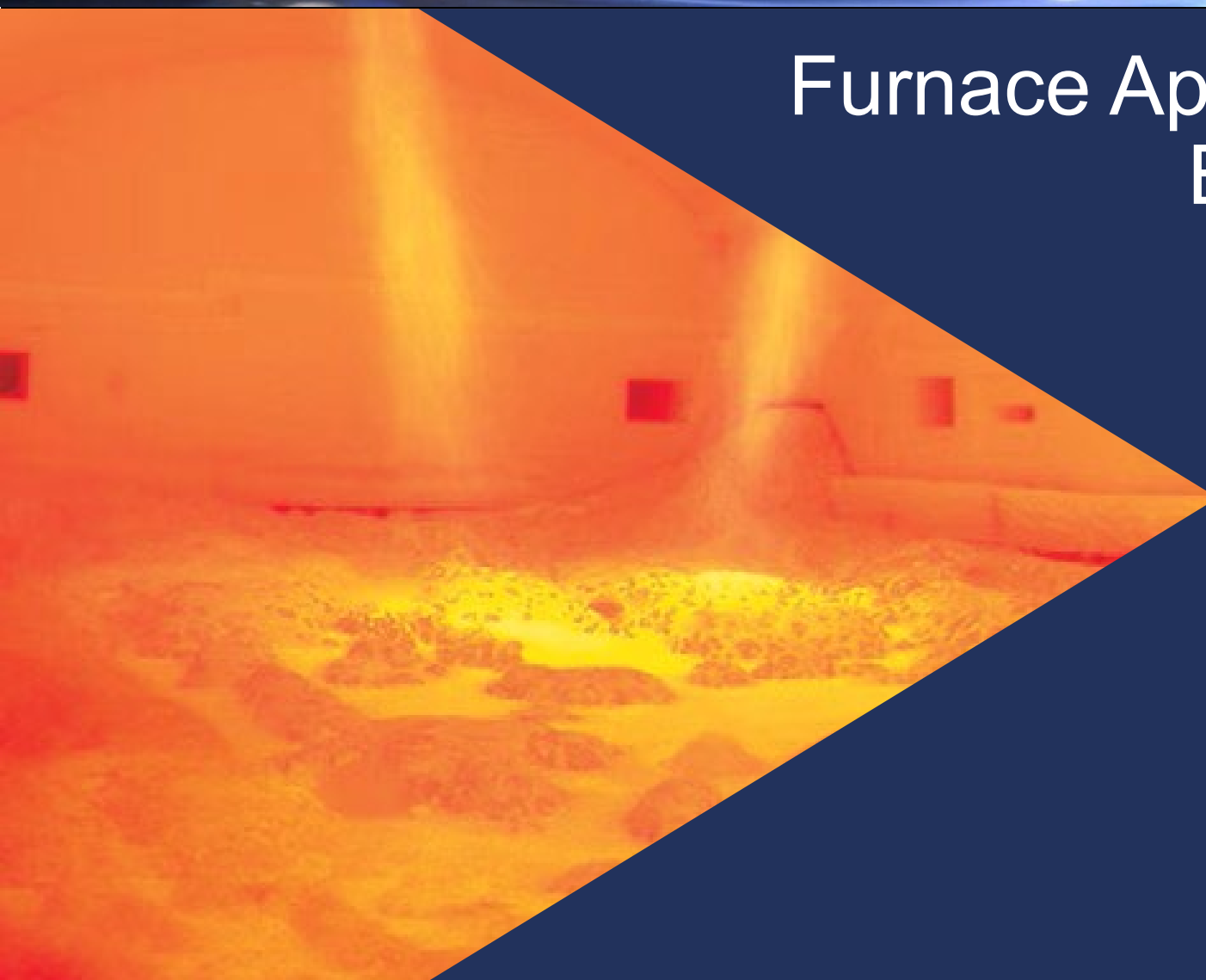
- Exit End Width

2 - Float/Tin Bath

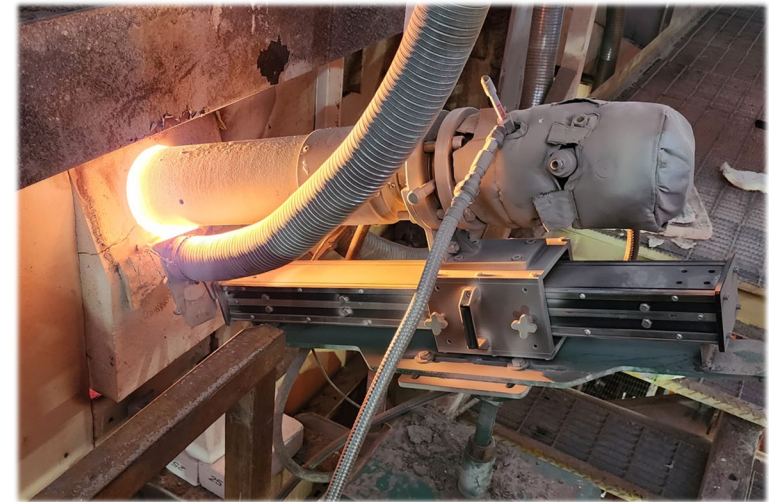
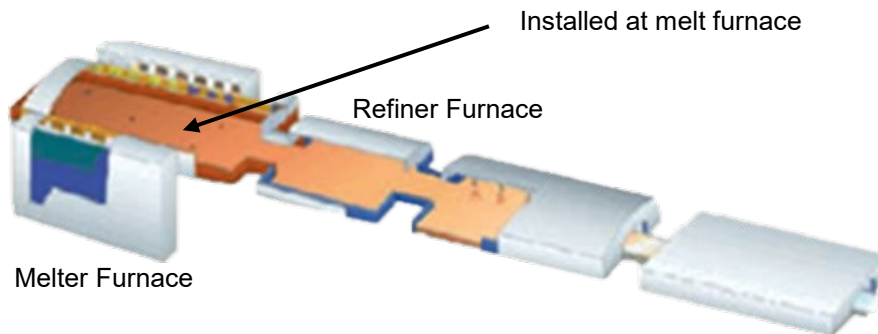
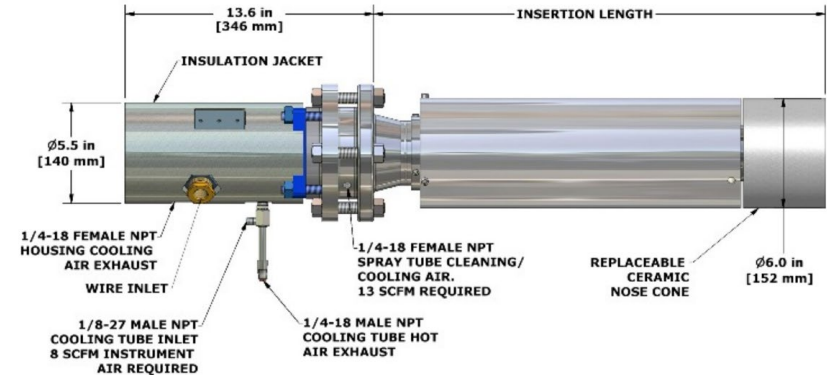
- Pool/Onion Edge
- ADS
- Stone Detection
- Shoulder/Fence



Furnace Applications: Batch Melt

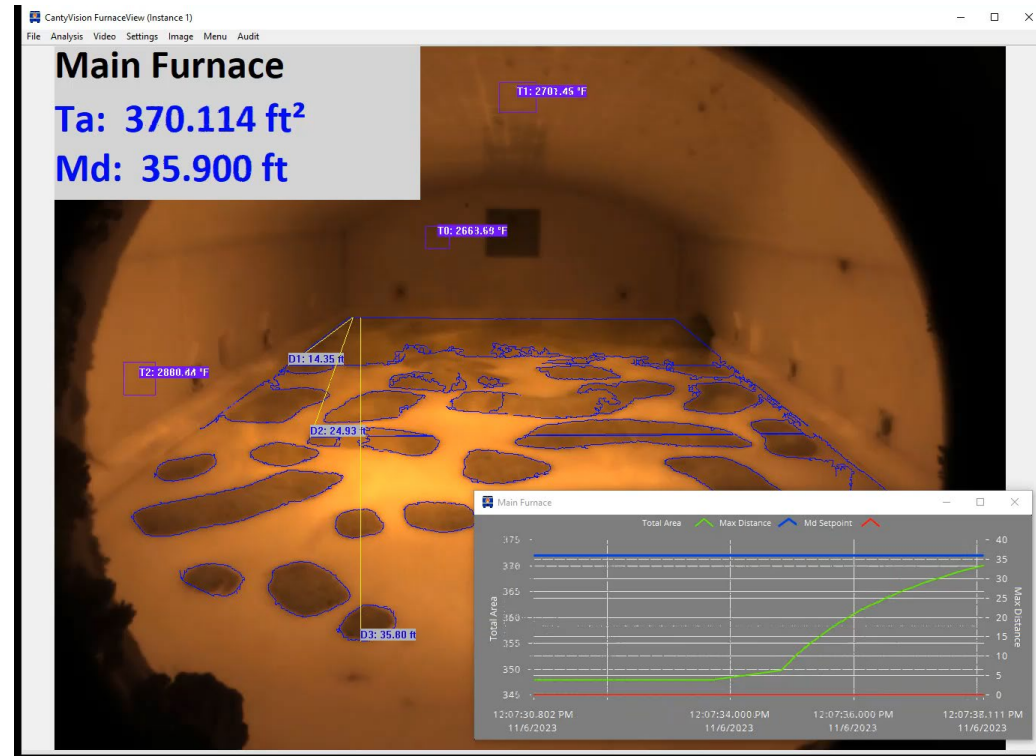


- Insertion Camera (process temperature up to 3000°F)
- High-resolution view inside of the melter
- Camera is typically installed at the crown of the melt furnace and is used to measure the total area of unmetered piles and how far along they are in the melt furnace



Manual retraction system for easy service

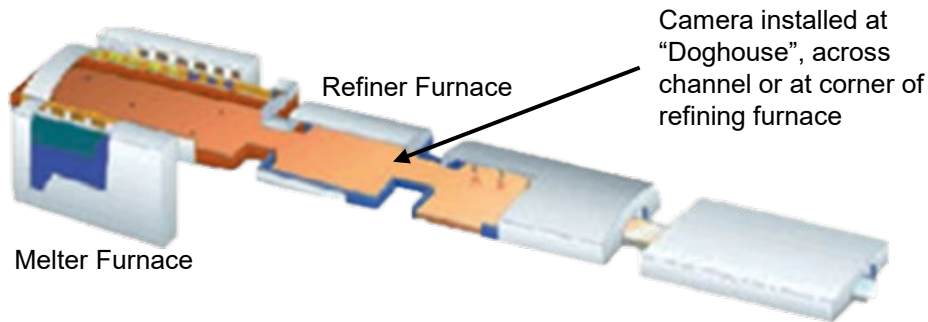
- Custom FurnaceView Software
- Measures total area of un-melted batch
- Distance from back wall to furthest un-melted pile
- Measure multiple temperature zones within the melt furnace
- Custom alarms for max pile distance and total un-melted area.
- High resolution view inside of melt furnace.
- Multi point perspective calibration for accurate measurements



Furnace Applications: Glass Level

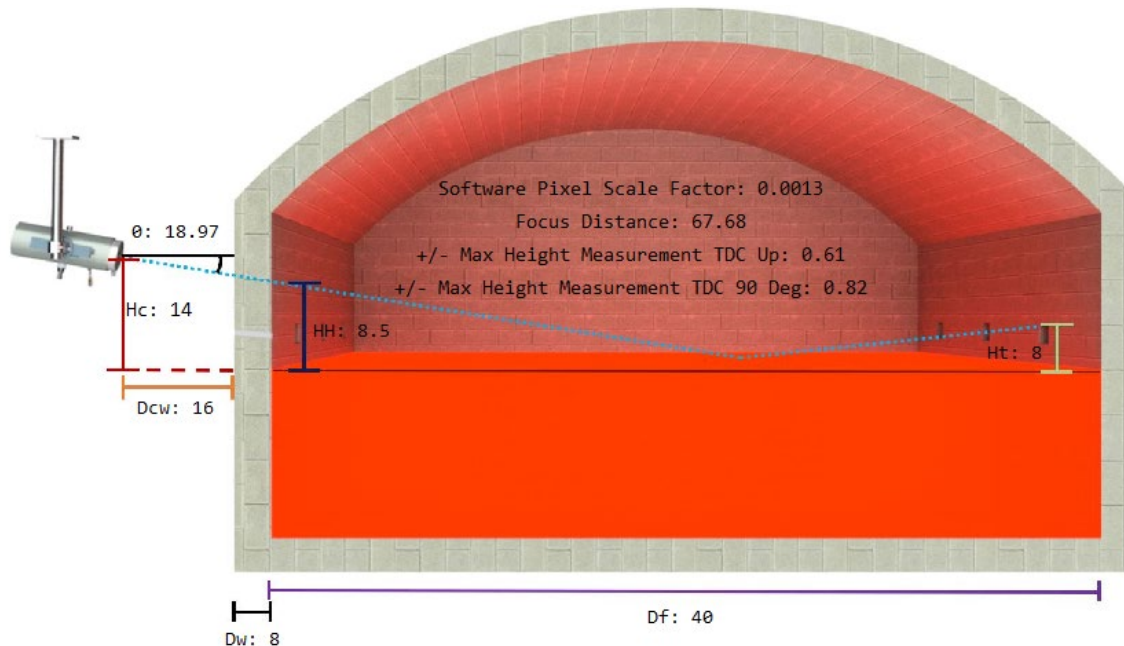


- High temperature camera (water or air cooled, ambient $<200^{\circ}\text{F}$)
- Replaces platinum dipping probe, nuclear level, and laser level instruments.
- Provides continuous real time molten glass level measurements which can be output to PLC or DeltaV data historian.
- Measurement accuracy down to .001".
- Easy installation and calibration.



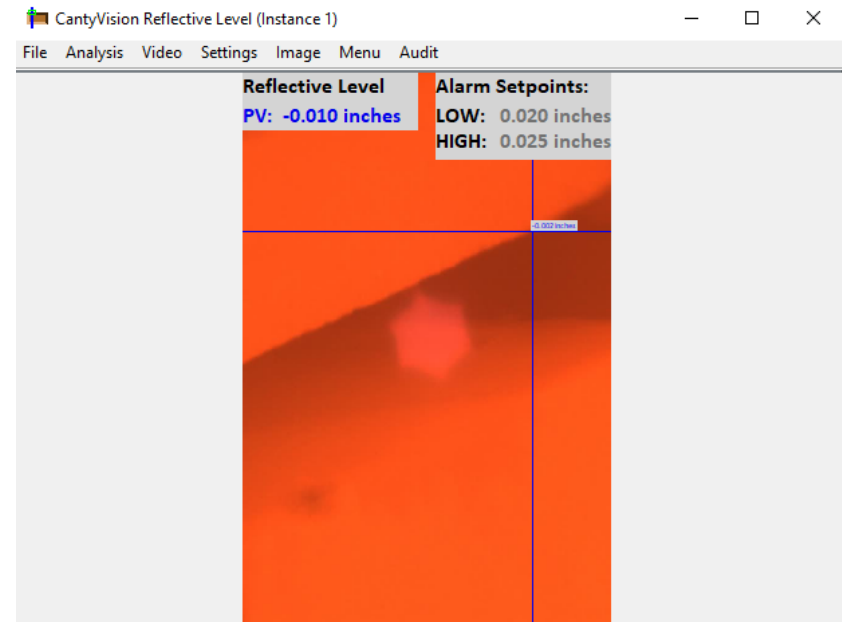
Water Cooled System

- Reflective level measurement technique utilizes the reflected image of a drilled hole or removed brick/dead burner.
- Reflection of this object is seen and measured in the molten glass.
- Calibration is generated based on camera mounting and furnace measurements.
- No signal generators, reflectors, hazardous materials used in measurement, 100% image based.

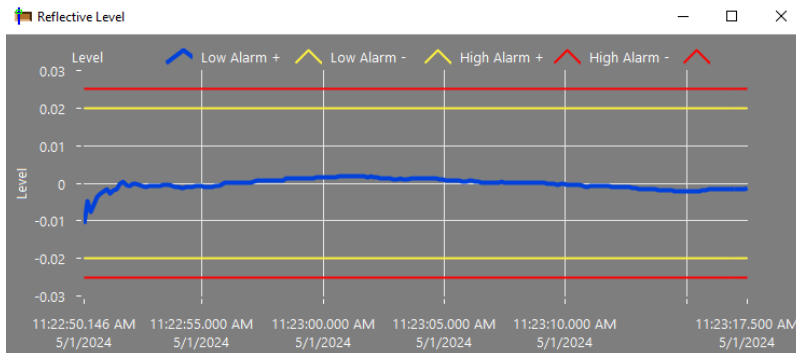


Calibration and view hole placement is automatically calculated based on camera mounting and furnace parameters

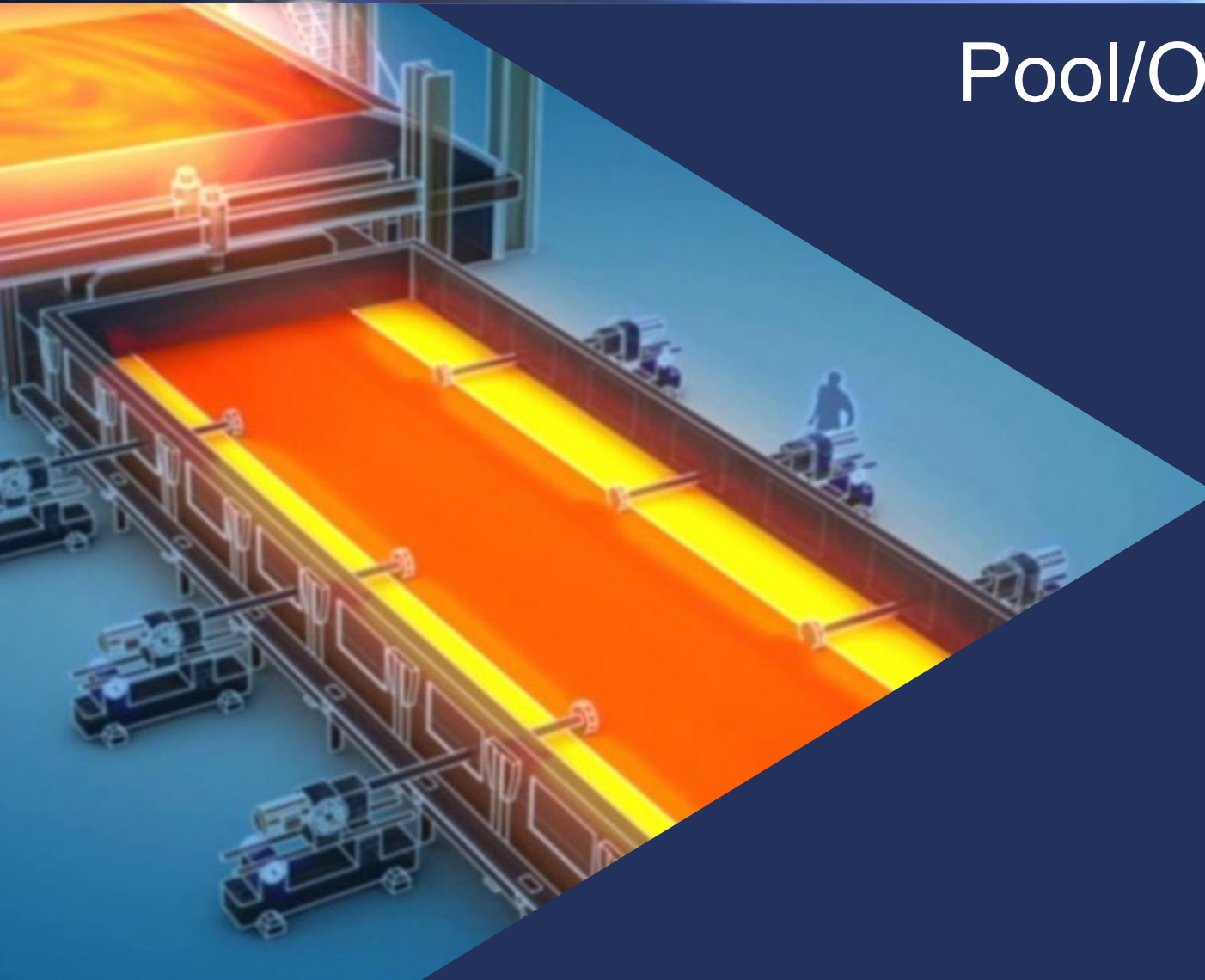
- Custom Reflective Level software.
- Tracks reflected image and outputs real time measurement .
- Alarm setpoints for low and high level alarming as well as temperature alarms for camera.
- Easy one touch zeroing of measurement.
- High resolution camera allows for high measurement accuracy and range.
- Easy to use operators interface.



Canty Reflective Level software performing glass level measurement



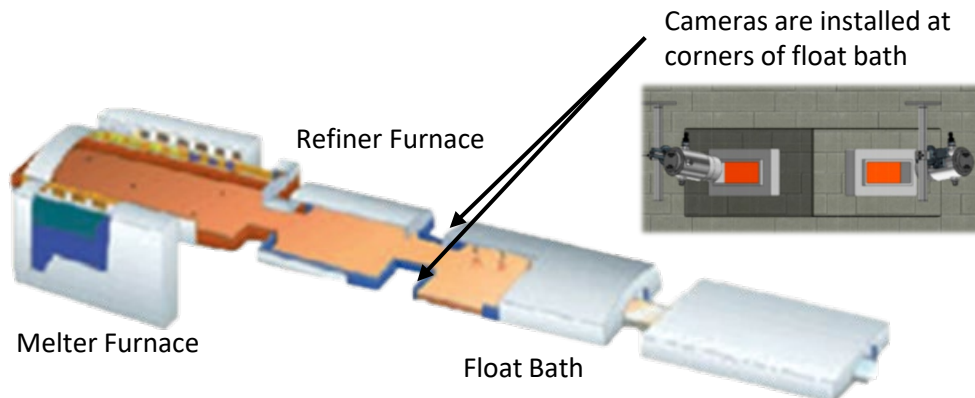
Pool/Onion Edge



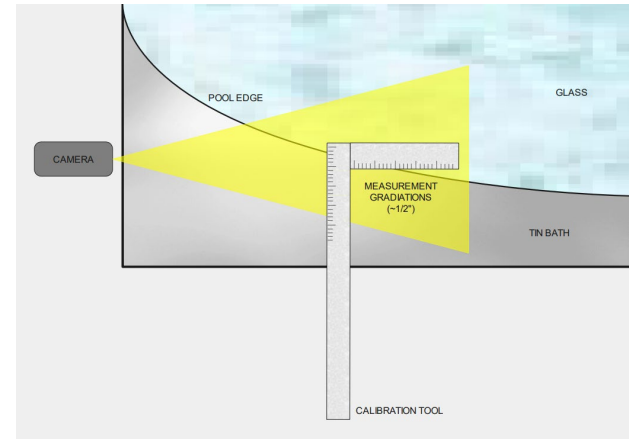
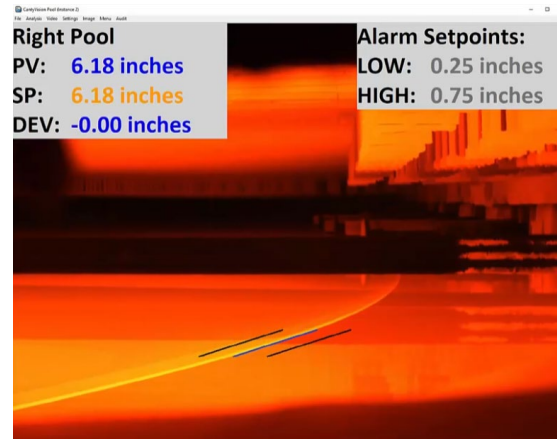
- High temperature camera (water or air cooled, ambient $<200^{\circ}\text{F}$ – surveillance style, $<3000^{\circ}\text{F}$ – insertion style)
- Measures pool/onion edge position as glass enters the float bath.
- Camera is calibrated using real world references.
- Provides continuous high accuracy measurement allowing for consistent operations and automation.
- Software is compatible with all camera models including surveillance and insertion styles.



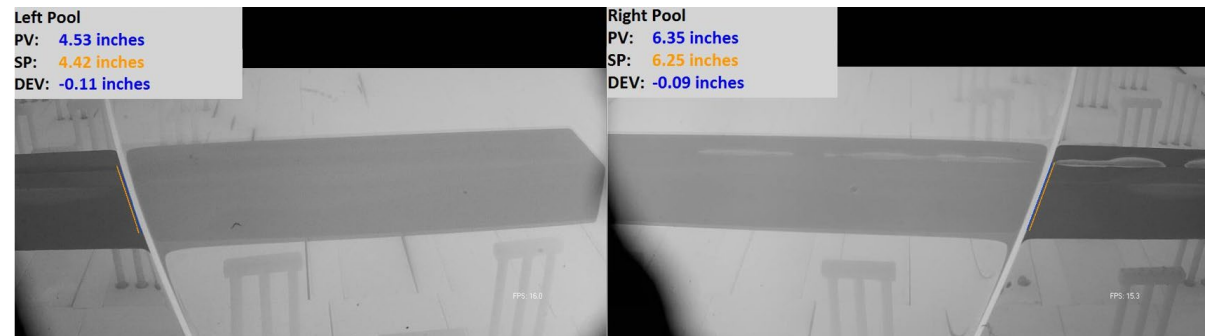
Camera installation at float bath corner view windows



- Custom Pool/Onion software package
- Software tracks the glass edge and gives the operator a visual edge overlay and setpoint.
- System measures setpoint deviation and can alarm at low and high level setpoints.
- Edge measurement and setpoint deviation allow operator/automation to keep glass edge at a constant position.



Camera installed at float bath corner window, camera calibration example

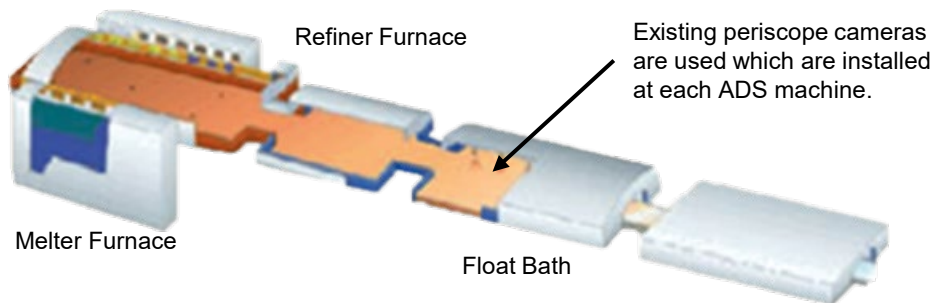
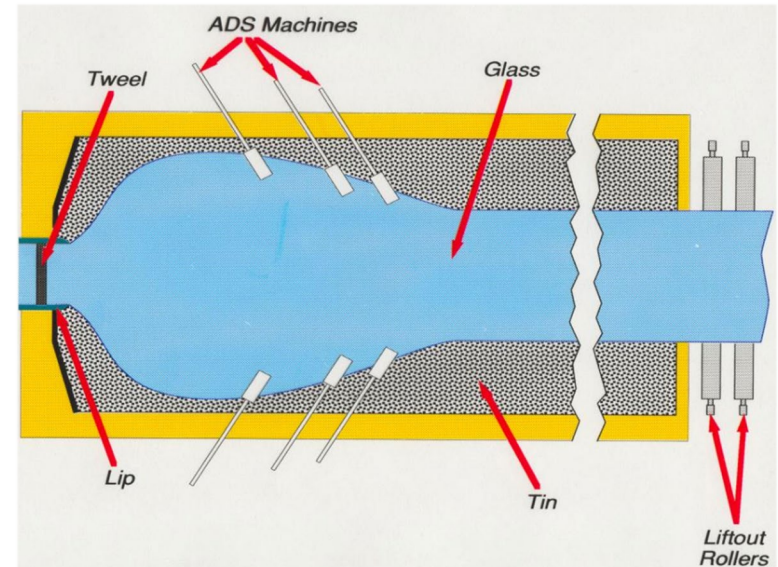


Periscope camera installation

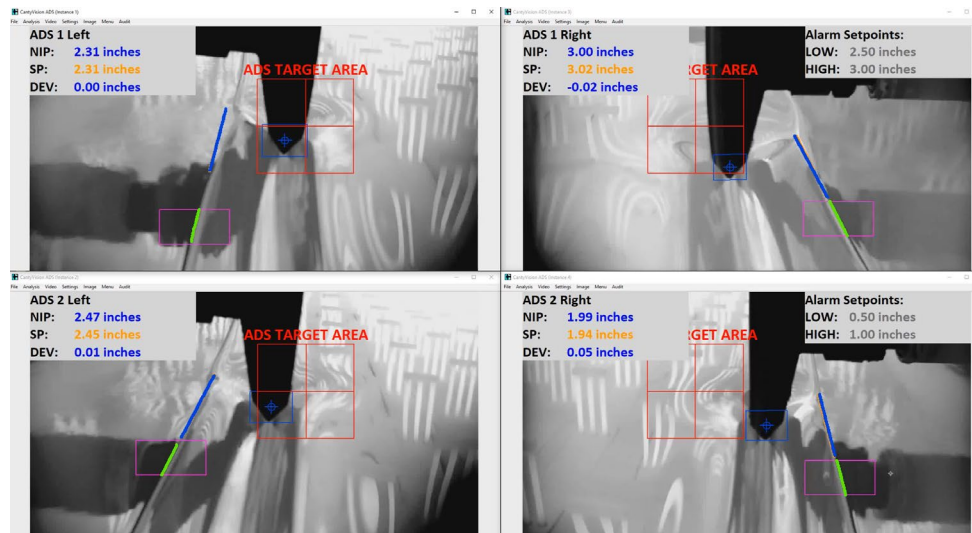
ADS



- ADS measurement utilizes existing periscope cameras.
- Cameras are installed on each ADS machine.
- Measurement of NIP (edge to knurl) and setpoint deviation allows for precise control during changeover or constant operation.
- Software can help keep ADS operations consistent, allowing for automation and preventing ADS from moving off of the glass while reducing waste.



- Custom ADS software package.
- Software tracks ADS head and glass edge position using machine learning algorithm.
- Each camera is calibrated using a known reference on the ADS machine.
- NIP measurement is output for each camera.
- NIP measurement is output for each camera.
- Setpoint deviation measurement allows operator to input a setpoint then control to that position.
- Software algorithms automatically turn off on unused machines.
- Remote software inputs and outputs allow for complete control of software from customer PLC.
- Multiple software instances can be run on a single machine
- Alarms can be triggered when ADS head gets too close to the glass edge.

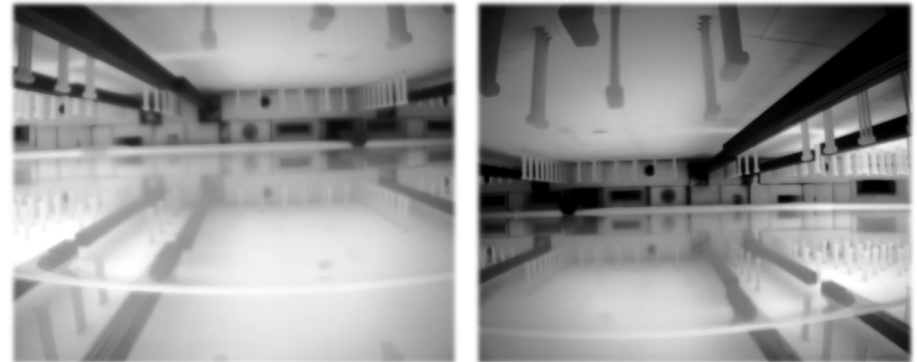


Multiple instances of ADS software can be run on a single machine, all overlays are optional.

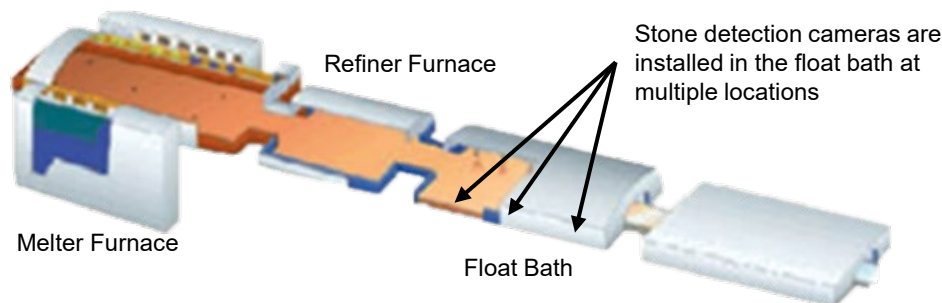
Stone Detection



- Stone detection cameras can withstand process temperatures up to 3000°F.
- Are typically installed at multiple locations in the float bath on both sides looking for stones or other contaminants on the glass surface.
- High resolution 3.1 megapixel cameras allow for unrivaled view inside the float bath.
- Alarm are triggered when detecting contaminates (stones from refractory insulation etc.) on the glass surface, this allows operations to pull up coating equipment and prevent damage.



Typical camera view inside of float bath; JM Canty Extreme Temp Camera



Stone detection camera installation

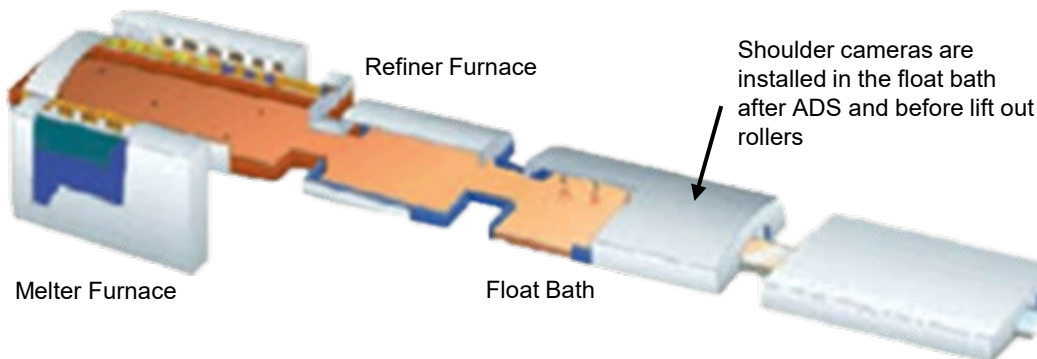
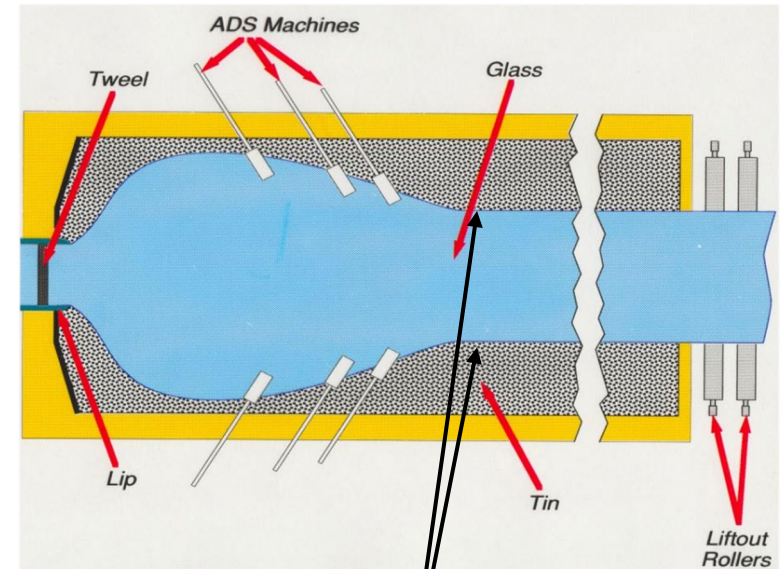
- Custom Stone Detection Software package.
- Software performs advanced analysis only tracking moving objects in the image. This prevents issues with false detections.
- Small stones that are very hard to see can therefore be tracked due to the advanced image processing algorithms that subtract the differences in the image.
- Custom alarms can be set for varying size contaminants.



Shoulder Fence

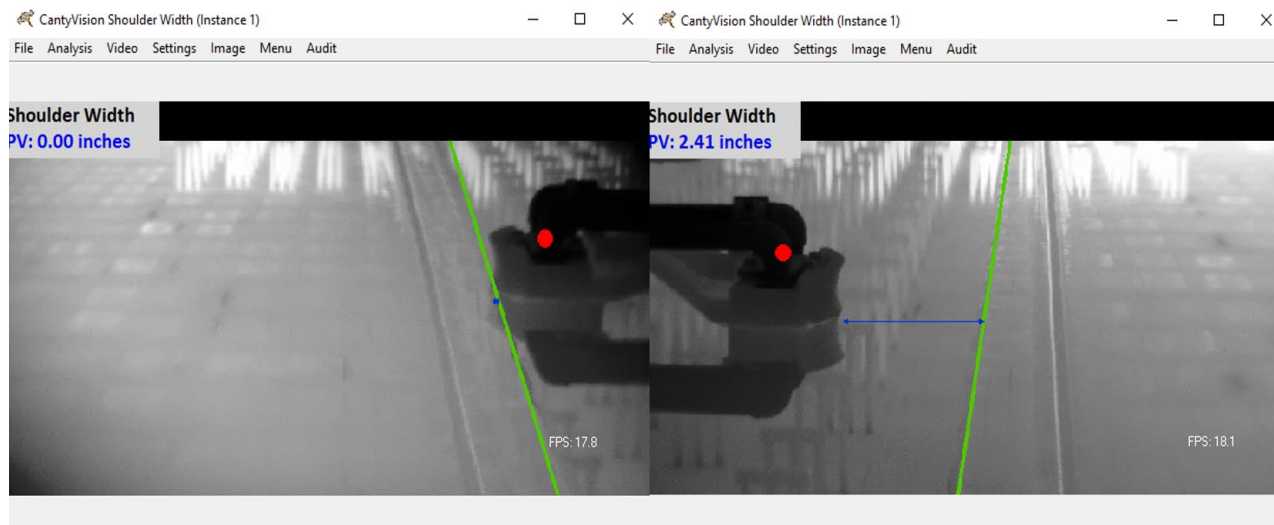


- Shoulder/fence measurement utilizes existing periscope camera installation.
- Software allows operations to get an accurate distance measurement from the fence to the edge of the glass.
- Calibration can be preformed using an existing visible known reference within the field of vision of the camera.



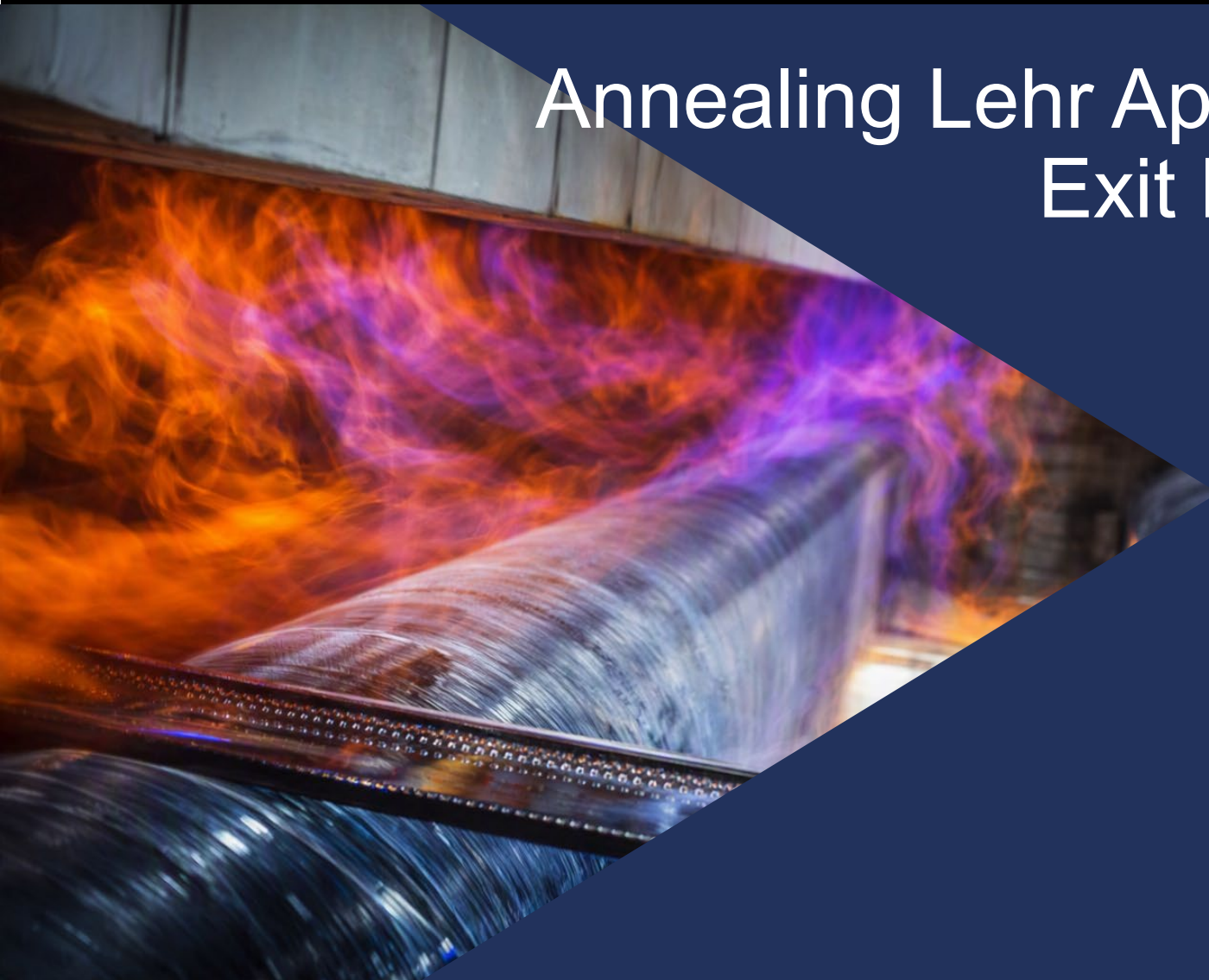
Approximate shoulder/fence position, existing periscope cameras are used

- Custom Shoulder Width Software package.
- Software uses machine learning algorithm to find fence position then to find the glass edge position.
- The distance from the fence to the glass edge is then calculated and output.
- Multiple overlays can be displayed to indicate the edge position, fence position and distance measurement.
- Multiple instances of the software can be run to preform measurement on both left and right sides.

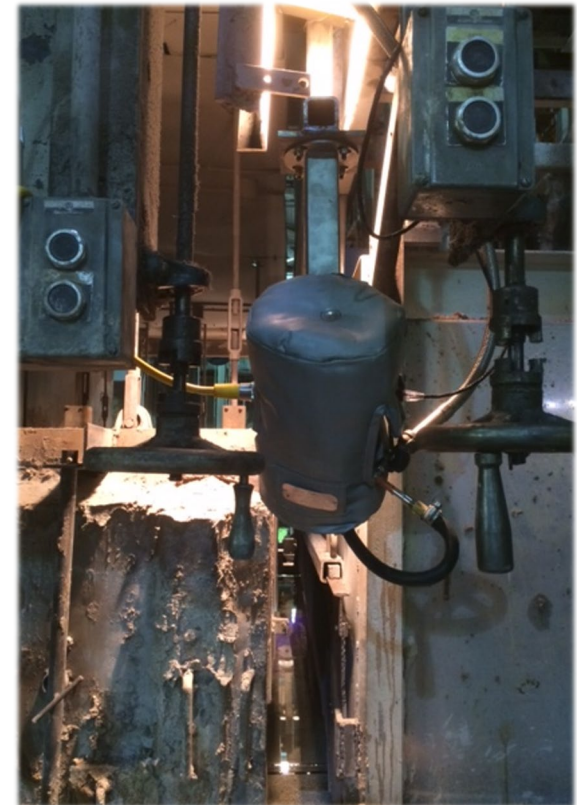
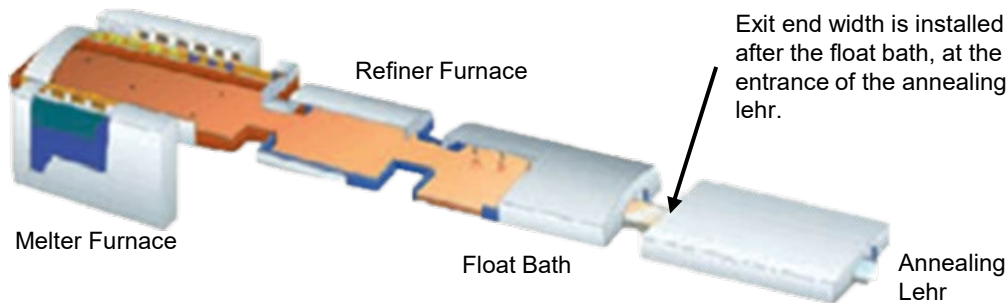


Shoulder measurement left and right, green overlay is glass edge, blue arrow is distance from fence to glass edge, red dot indicates fence position.

Annealing Lehr Applications: Exit End Width

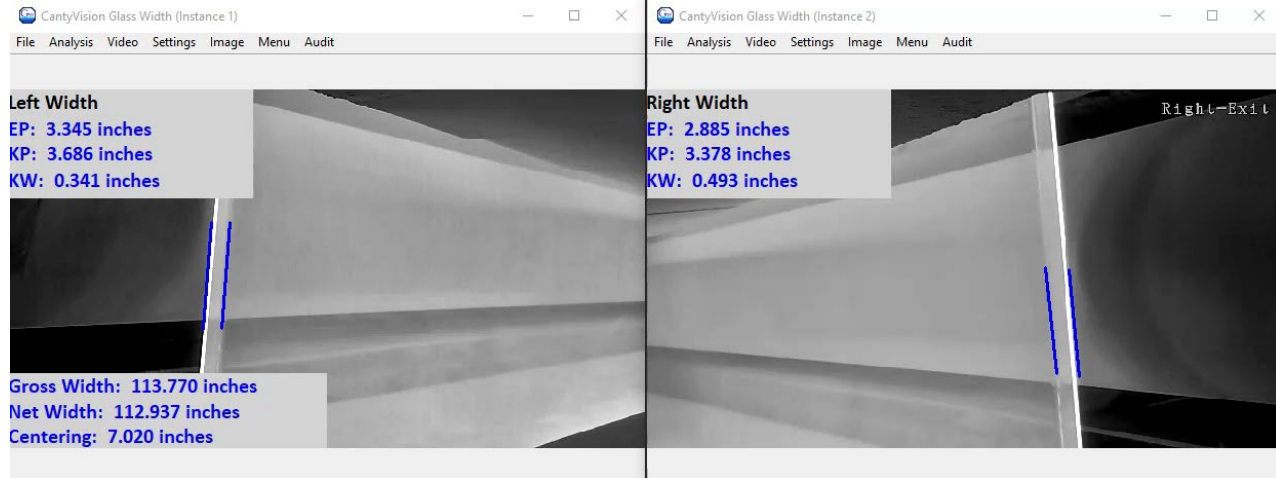


- High temperature camera (water or air cooled, ambient <220°F).
- Measures the gross and net width as glass enters the annealing lehr.
- Measures centering of glass within the annealing lehr.
- Does not use any external lighting.
- Maximize production and minimize waste while having a constant eye on production to prevent major issues in the process.



Installation on one side, exit end width consists of 2 cameras one on each side of the glass

- Custom Exit End Glass Width software package.
- Software instances communicate with each other to calculate gross width, net width and centering position of the glass within the Lehr.
- Camera height and camera angle are input into software during setup to create an initial calibration.
- Calibration offset table allows operator to mark a point in time then make calibration adjustments to real world cold end measurements.



Calibration Offset

Calibration Offset ☒ ON

Calibration Offset Table

Date	Time	Gross	Net	Measured Gross
10/12/2023	12:53 PM	156.79	149.14	NaN
10/12/2023	10:47 AM	156.41	148.94	NaN
10/12/2023	9:35 AM	156.99	149.04	NaN
10/12/2023	9:09 AM	155.97	147.96	NaN
10/11/2023	11:17 AM	155.34	149.92	NaN
10/2/2023	11:48 AM	138.72	136.22	NaN
9/27/2023	4:26 PM	149.25	146.80	NaN
9/24/2023	8:28 PM	140.69	137.43	138.74
9/17/2023	10:55 PM	151.58	147.79	153.46
9/6/2023	9:49 AM	154.87	149.24	158.10
9/6/2023	9:48 AM	154.87	149.18	NaN
9/5/2023	2:43 PM	144.38	138.39	NaN
9/5/2023	2:15 PM	144.32	138.81	144.25
9/4/2023	1:48 PM	151.10	147.69	NaN
8/30/2023	6:57 AM	145.15	142.17	NaN
8/30/2023	6:44 AM	145.54	143.54	NaN

Save Cancel

- Alarm at the loss or gain of width.
- Alarm on centering of glass.
- Output NIP width
- Reliable edge and knurl tracking



Direct Electronics Cooling (DCE)



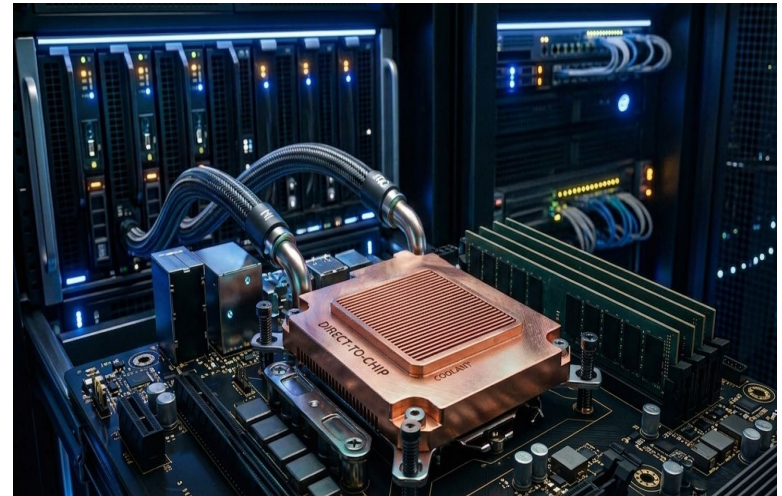
Immersion

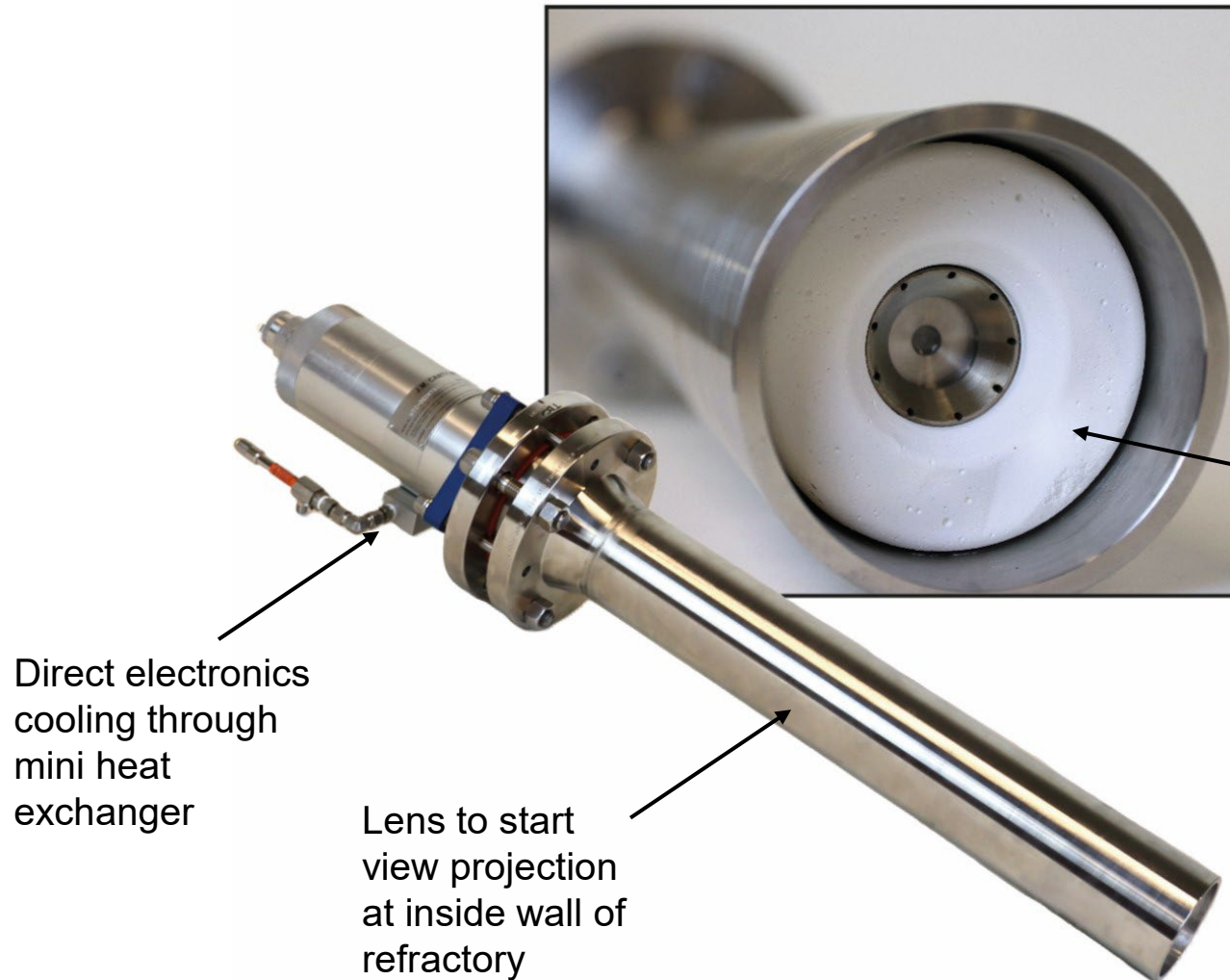
- Entire sensor is submerged in coolant
- In one case study, cooling usage per camera was 20 SCFM.



Direct to Sensor

- Coolant flows directly to imaging sensor resulting in effective cooling
- In on case study, cooling usage per camera was 2 SCFM.





Direct electronics
cooling through
mini heat
exchanger

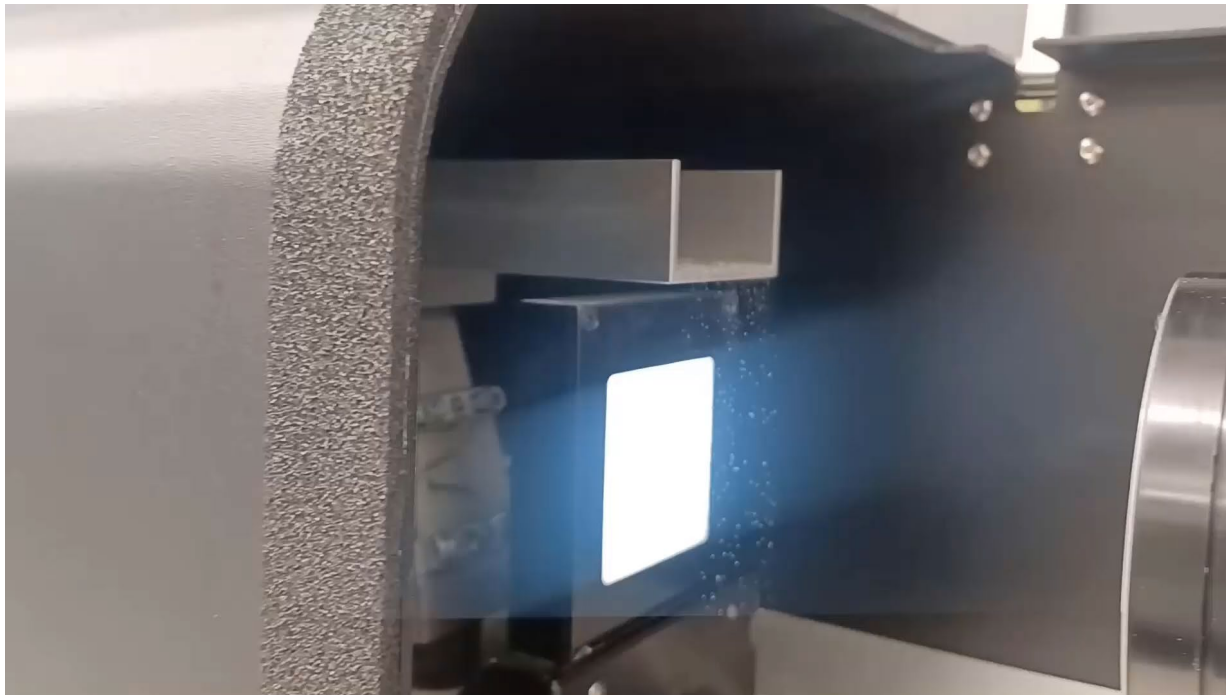
Lens to start
view projection
at inside wall of
refractory

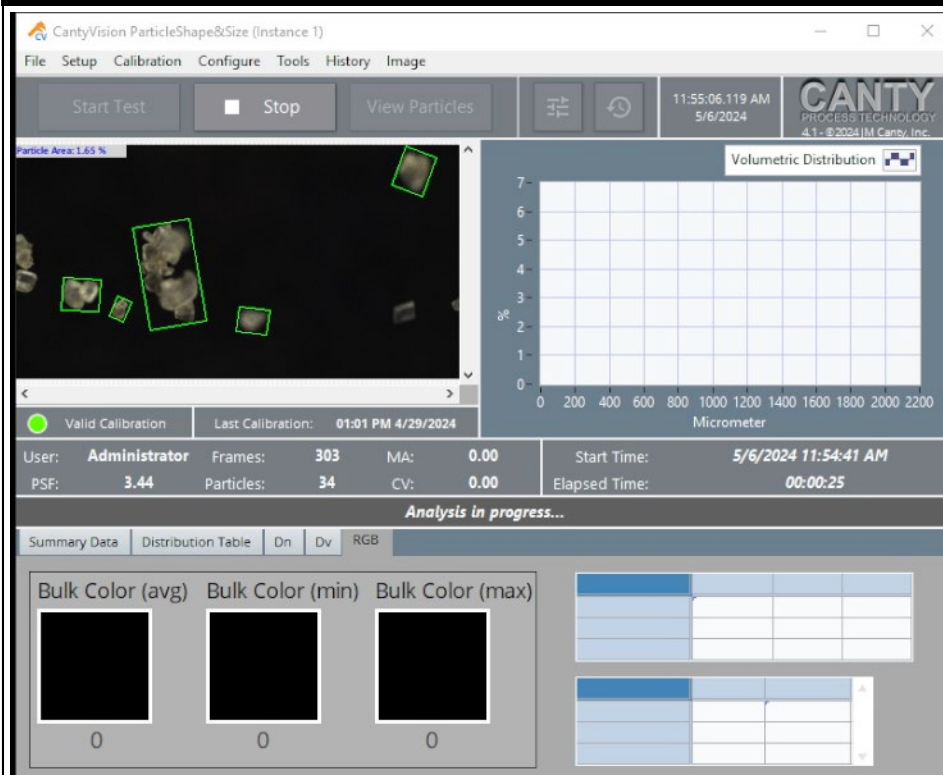
Enabled by DCE
air connected to
spray tube can
either exhaust
into the furnace
or simply
circulate through
and back to
surrounding
environment

Cullet Size, Shape and Color

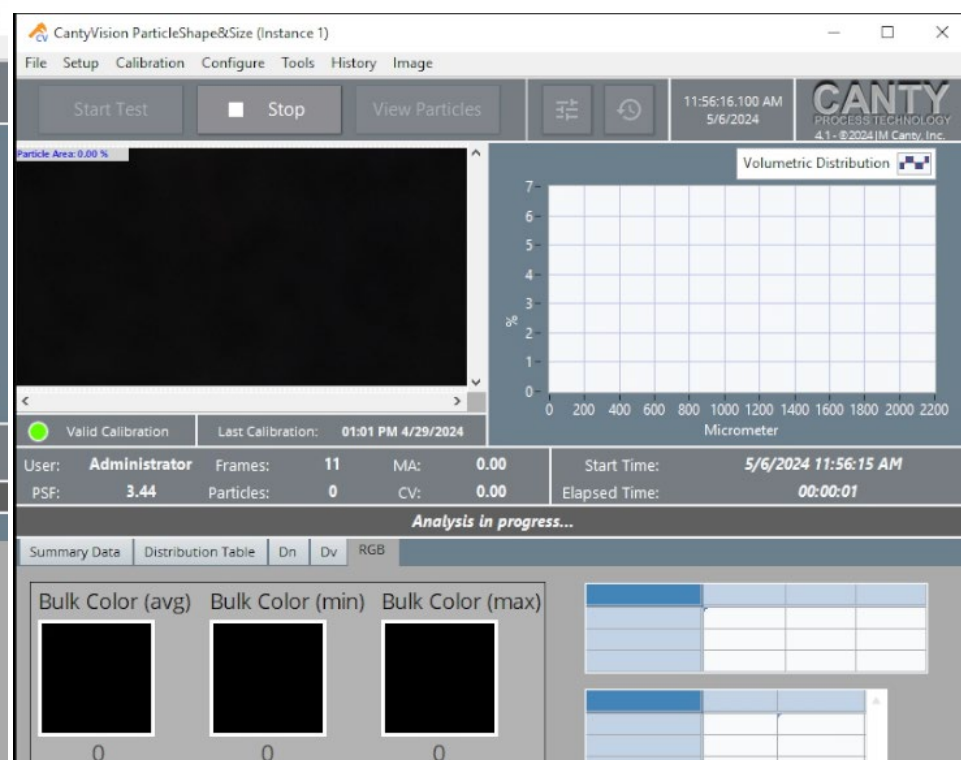


- Historically need two setups one to measure the size of the cullet and the other to measure the shape of the cullet.
- Recent advanced in hardware have allowed for image acquisition of size, shape, and color at the same time.

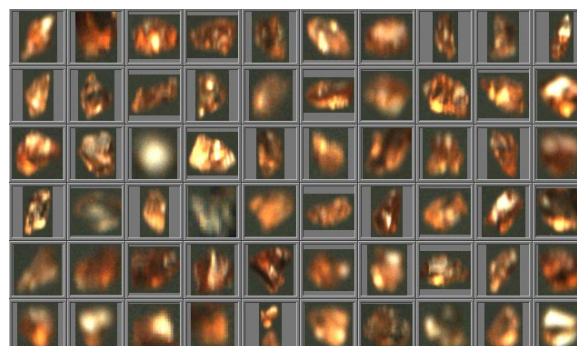




Brown Particle



White Particle



Red Particle

This concludes the presentation –
Thank You!

Questions?

