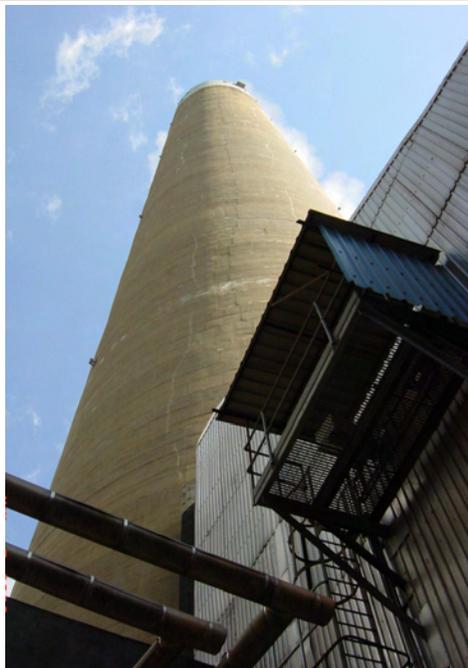


GREENBANK STACKMASTER

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GREENBANK ENERGY SOLUTIONS INC. STACK PARTICLE SIZE MONITOR



Greenbank Energy Solutions Inc, in partnership with our R&D JV company **GAIM Ltd**, have developed the StackMaster technology for on-line, non-intrusive measurement of particulate in stack flue gas.

The technology has been developed from a need to measure the true particulate in a stack by measuring particulate density and size distribution at any desired location in the stack real time.

The objective is a low maintenance technology that is non-intrusive, and external to the stack, which generate real time particulate monitoring that correctly weights for differently sized particles.

Measured parameters are :

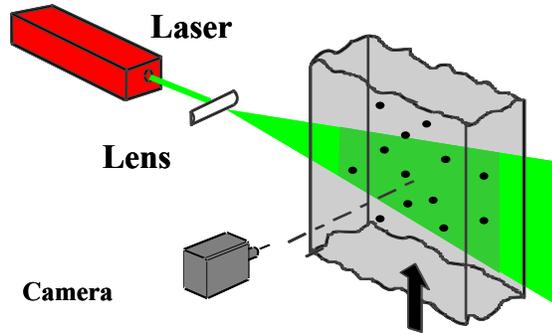
- ◆ Particle size distribution giving % particles in customer required size ranges
- ◆ Particulate density expressed as mg/m^3 , or $\text{lb}/10^6 \text{ Btu}$.



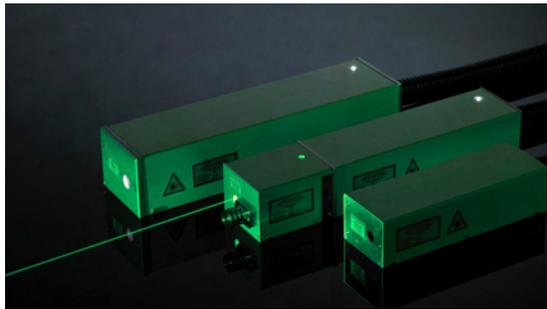
The development was customer driven, with a requirement for an improvement over optical type opacity stack measurements which, work satisfactory for opacity when the particulates remain small and unchanged, however, their sensitivity is impaired when the particle size distribution changes in the flue gas. A simply analogy is comparing water mist to rain, where the opacity reduces but total particulate mass increases - Reflectance of light proportional to $1/\text{diameter}$ of particles.

- Reduction in stack manual sampling costs and frequency
- Real time alarm for poor precipitator performance.
- Identify poor milling / classification by adjusting mill loadings.
- Include in any boiler optimisation strategy
- Allows future identification of particulate matter by size, such as PM10 or PM2.5
- No need for constant recalibration of opacity monitors

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Measurement principal showing laser sheet and CCD rapid imaging.



Laser shown as beam without special laser sheet lens adapter.



Rapid compact vision system integral to the StackMaster with embedded software for rapidly processing images and derivation of particle size and density.



The diagram opposite gives a simple representation of StackMaster which requires to ports in each Chimney / stack

All optical equipment is located physically outside the stack but can measure at almost any point along the diameter desired inside the stack.

A pulsed laser beam is spread through a lens to give a pseudo sheet of laser light in the chimney. This sheet of laser light is pulsed on and off under system control as many times per second as required and projected into the flue gas.

A fast high resolution CCD camera placed at 90 degrees to the laser in the chimney is used to acquire the images of the moving particles. The camera and laser operate under synchronisation a multiple times per second to take freeze frame images.

The parallel laser sheet is effectively 100 mm x 5 mm, with the 5 mm section facing the particulate flow. The camera measures the scintillation from particles passing through and hence is real time and iso-kinetic.

Each frame is a true density measurement of the dust under interrogation – note that the pulsed laser allows crystal clear images to be taken of even the smallest micron dust particles at the center of a stack.

This is because of a phenomenon called MIE scattering that we refer to as the magnification factor, where a micron sized particle will reflect laser light and be magnified on the CCD image to a much larger size.

The focus, magnification and Greenbank developed StackMaster filters allow the technology to interrogate diffused particles at any radius required within the stack.

StackMaster requires well diffused particulate flow, which dictates the best location to apply the measurement technology typically well up the stack.

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- ISO-Kinetic.
- No Material Handling.
- Low maintenance with only 2 static optical devices located outside the stack.
- Crystal clear images using pulsed laser technology & StackMaster filters.

StackMaster captures multiple images per second and rapidly determines number of particles and particle size distribution.

Calibration is required for the specific set up location and densities to be used in calculations.

The system rapidly calculates the mg/m^3 from number of particles measured and their size, and the known volume of interrogation from the laser & CCD alignment.

The images show image capture, calculations including StackMaster filters and the display of particle size in range bins.

The particle size outputs as % and mg/m^3 are output as 4-20 mA current loops through Field-point PLC. The system then repeats the process.

A 4-20 mA of MW load is taken from the plant so that the system shuts down when not in use.

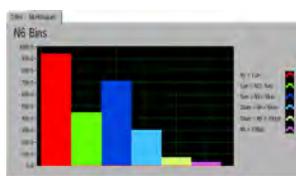
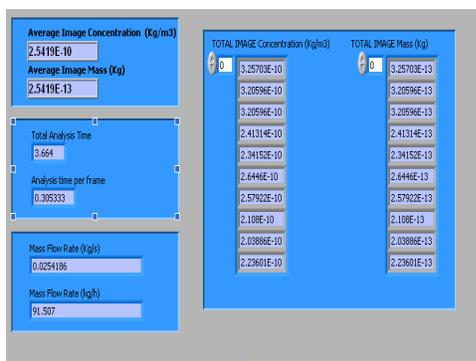
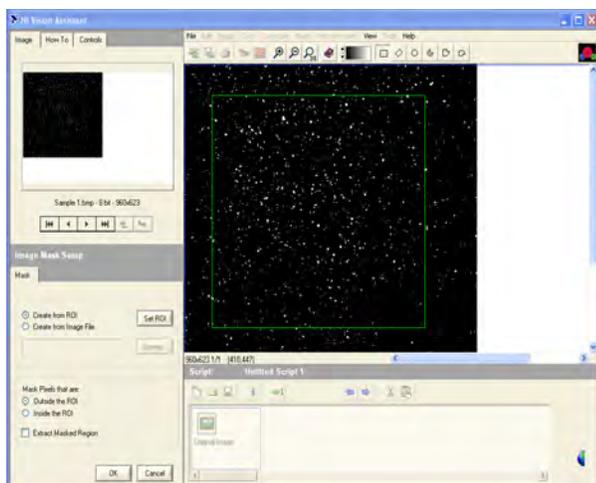
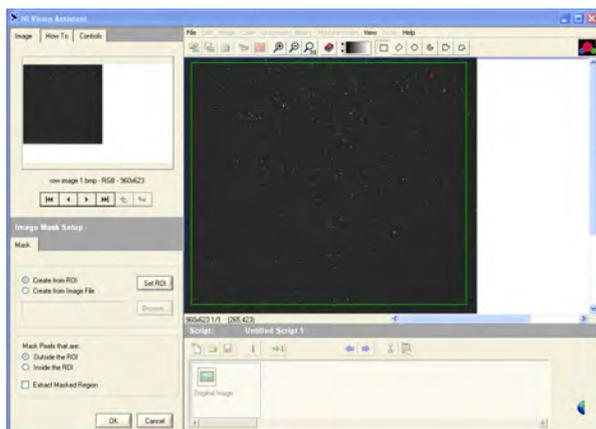
Laser system

The laser system is a parallel beam fully enclosed in the stack, and is designed to comply with BS EN 60825-1 and BS EN 60101-1 .

All covers are interlocked, so that the laser cannot be run if any cover is removed.

An electronic safety shutter with additional verification is standard. The laser comes with a solenoid driven safety shutter.

This shutter automatically closes when the laser turns off.



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Scope of supply

ISO-Kinetic dust concentration and particle size stack analyzer comprising;

Sensors / optical equipment

- Laser with optics fully enclosed for parallel beam laser sheet including mounting
- Laser plate / slit for laser alignment.
- Laser generator / local control in IP65 cabinet
- Electrical interlocks for local ports of entry into the stack.
- Mounting and high resolution rapid CCD camera
- Optional Laser stop at other side of stack
- Optional industrial compressor fan for air cleaning curtain for optical equipment

Industrial Vision system & PLC enclosure housing:

- IP65 cabinet
- Rapid control with trigger for synch with laser
- Compact vision system for rapid analysis
- Field-point with Ethernet and I/O
- Large red / green indicators on cabinet for laser on / off
- Power supplies and control for laser
- StackMaster software
- Industrial VDU

I/O

- 4-20 mA for mg/m³
- 2 x 4-20 mA for particle size analysis in percent
- 4-20 mA input for boiler load MW

Electrical requirements

- 110 VAC for control cabinet / Laser control
- Optional 415 VAC 3 phase for local air compressor

Accuracy

- Better than BS 6069 that applies to variance of dust loading in a chimney stack.

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