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Video versus thermal imaging in boilers

The video camera is typical smaller and significantly cheaper than a thermal camera, i.e. most customers goes for an inspection system with a video camera unless features of the thermal camera is needed. Neverthe less, the image quality is mostly superior of the thermal camera in boilers due to scattering of light by fine particles and light from soot particles.

Light	Wavelength	Passive detection	Boiler applications
Visible (VIS)	0.4 – 0.7 µm	> 600°C	Detect ignition (soot), inspection in regions with flame light
Near infrared (NIR)	0.7 – 1.1 µm	> 300°C	Operate at lower light levels
Infrared short wavelength	1.1 – 5.6 µm	All temperatures	See surfaces through hot flue gas at 3.9 µm and better image quality than VIS
Infrared long wavelength	8 – 14 µm	Best at low temperatures	Hot flue gas (H_2O and CO_2) emit light and mostly not used in boilers

The color video camera is mostly used in situations where visible light is emitted (flame light from soot) or light from a bright source is reflected or absorbed by surfaces or particles. The video camera can be used in most situations in boilers if features can be seen by the human eye.

Surfaces hotter than approx. 600°C emit visible light and surfaces can be seen as dark red, 800°C as orange, 1000°C as yellow and over 1300°C yellow-white. The temperature of soot particles in flame of a candle light is typical around 1300°C.

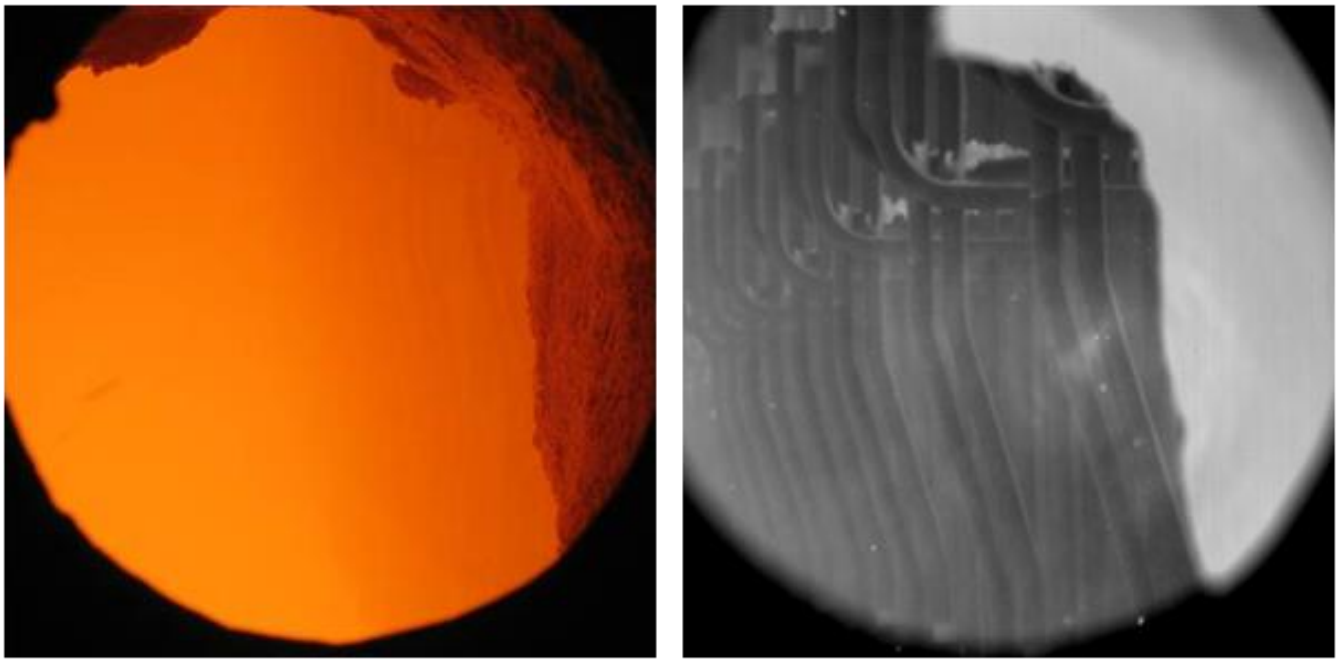

Figure 1 Left: Hard to see details in picture of SH from color video camera . Rule of thumb boilers with soot/small ash particles: 10 times better view in IR than VIS. Left picture: look at super heater in full scale coal fired boiler with video camera, right picture: SH tubes can be seen with IR-endoscope with IR camera that was invisible with the video camera.

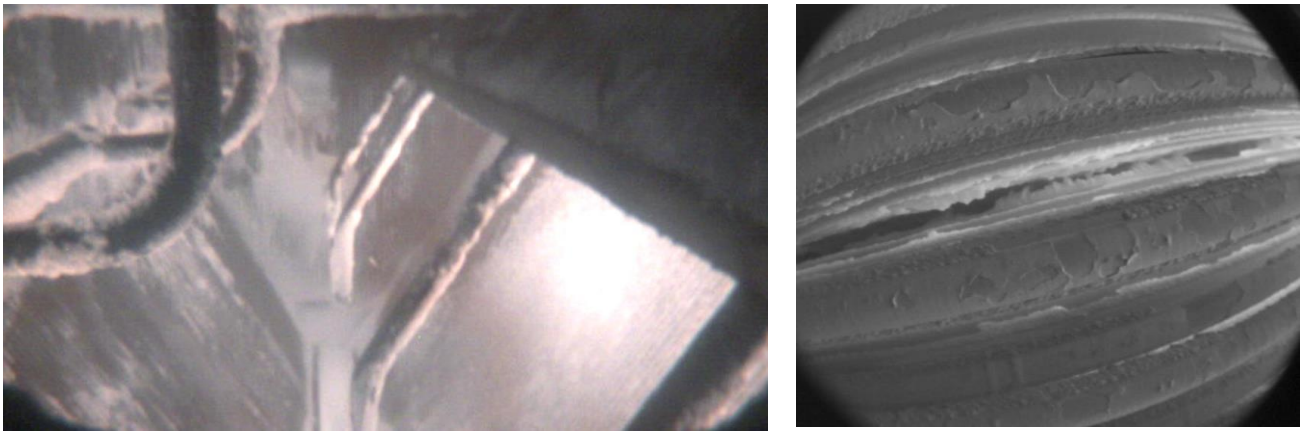

Figure 2 left: Image of deposits in waste incinerator with low-cost analog NIR video camera. Image quality is affected by light scattering from ash particles. Right: Image quality is significantly improved using a modern digital NIR video camera. Example from super heater inspection during operation of incinerator.

Flames and burners

The best solution for burner and flame optimisation is an inspection system combinening both video and thermal imaging

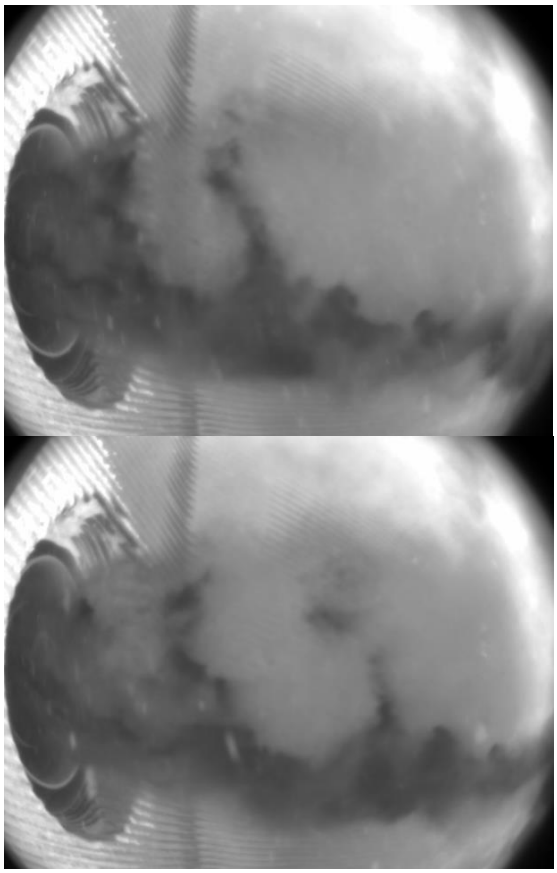

Figure 3 Two thermal images of 40 Mth wood dust flame taken with IR camera with endoscope optics and time separation of 20 ms. Fuel particles are still cold and appear dark in picture, whereas deposits at boiler wall are bright. Movement of turbulent flow structures in flame can tracked using 100 Hz frame rate and 700 µs exposure time. Thermal image taken with IR-endoscope from Pyrooptic and FLIR SC7600 camera.

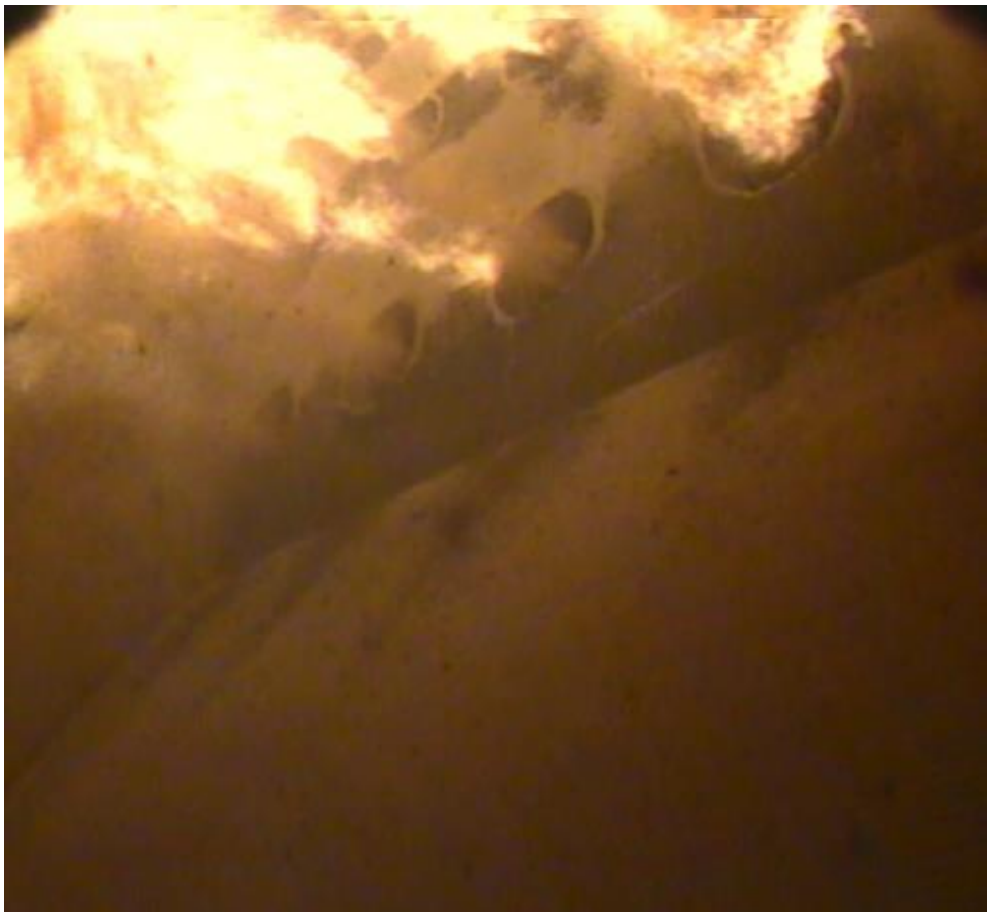

Figure 4 Video image from lower row of 4 pulverised 30 MWth wood flames. The 4 flames look very different due to problems with ignition. Image recorded with water-cooled video probe from Pyrooptic.

Grate fired boiler

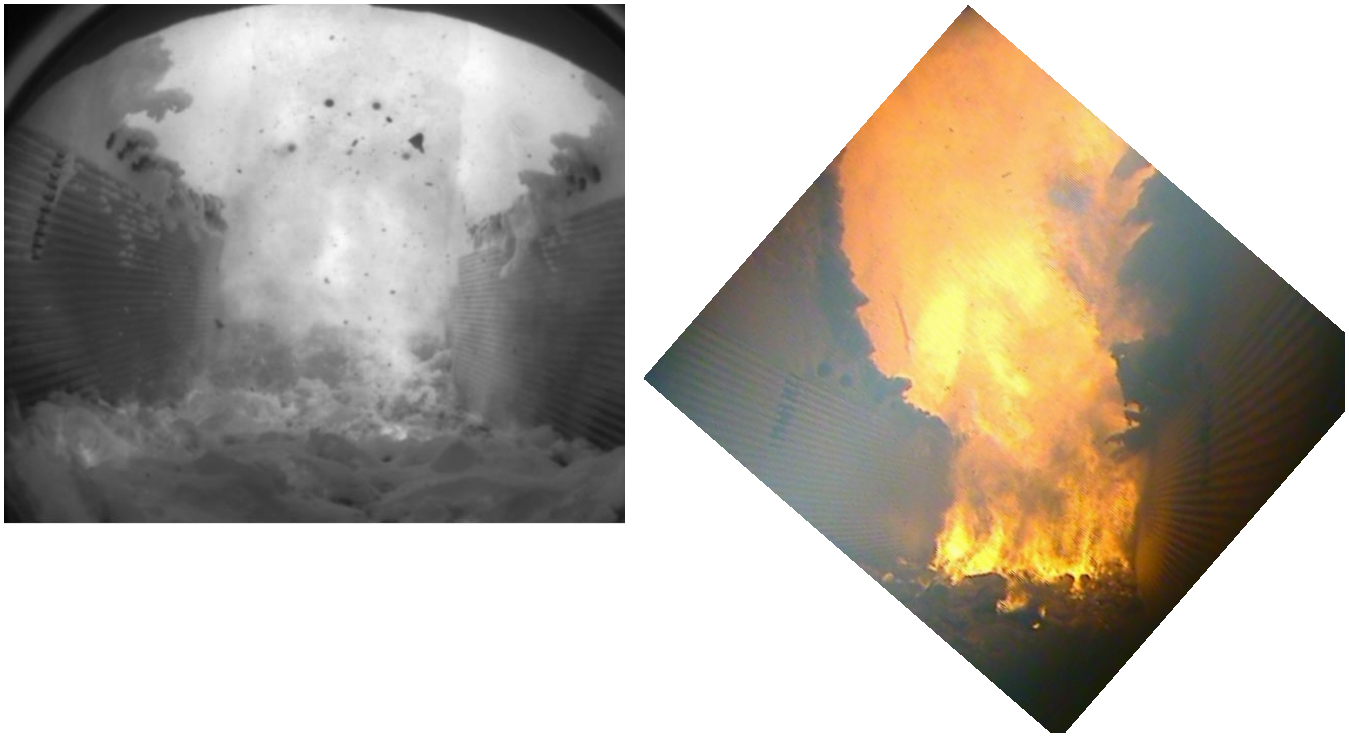

Figure 5 Thermal image (left) from IR camera with endoscope optics from rear end of grate in waste incinerator. The region with intense combustion is seen clearly at the midle of the grate and front wall (inlet grate) can be seen. Right: Video image recorded from same position as IR image. Thermal image taken with FLIR SC7600 camera mounted with endoscope.

IR industrial endoscope

Pyrooptic is a manufacturer of high quality industrial rigid endoscopes for looking inside high temperature processes, e.g. instrument used to examine the interior of boilers, burners and flames during operation. Technology has advanced to a level that permits high speed visual and thermal videos to be obtained simultaneously using the same endoscope optics, e.g. snap-shot infrared images of the turbulent mixing of gas and fuel in small and large power plant flames can be recorded together with visual image showing ignition details.

Robust and proven design, i.e. sapphire front lens and operation at high temperature designed for extreme conditions and can be inserted into flame or hot flue gas flow with IR endoscope mounted in a water-cooled stainless steel (SS 316) probe.

Large field of view, optional bended view and clear images by computer optimized modular endoscope optics.

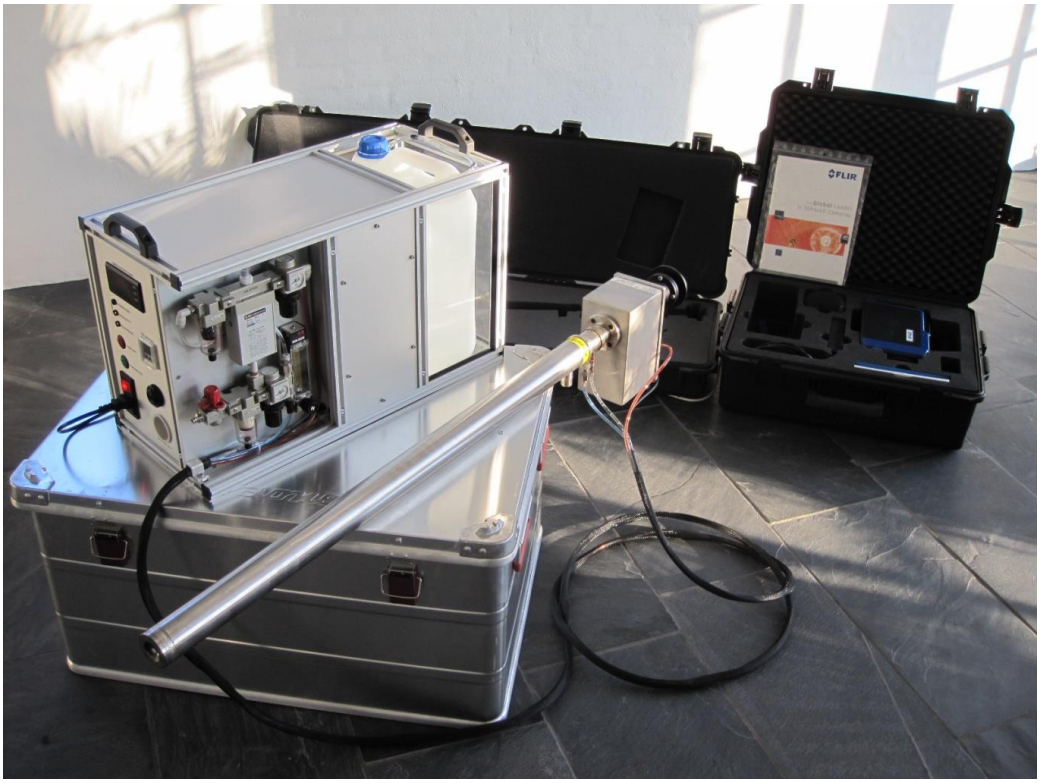

Figure 6 Complete mobile endoscope system (3 units), combined VIS and IR endoscope connected to water-injection control unit and IR-camera (not mounted, laying in transport case). Many options or customized solutions are offered.

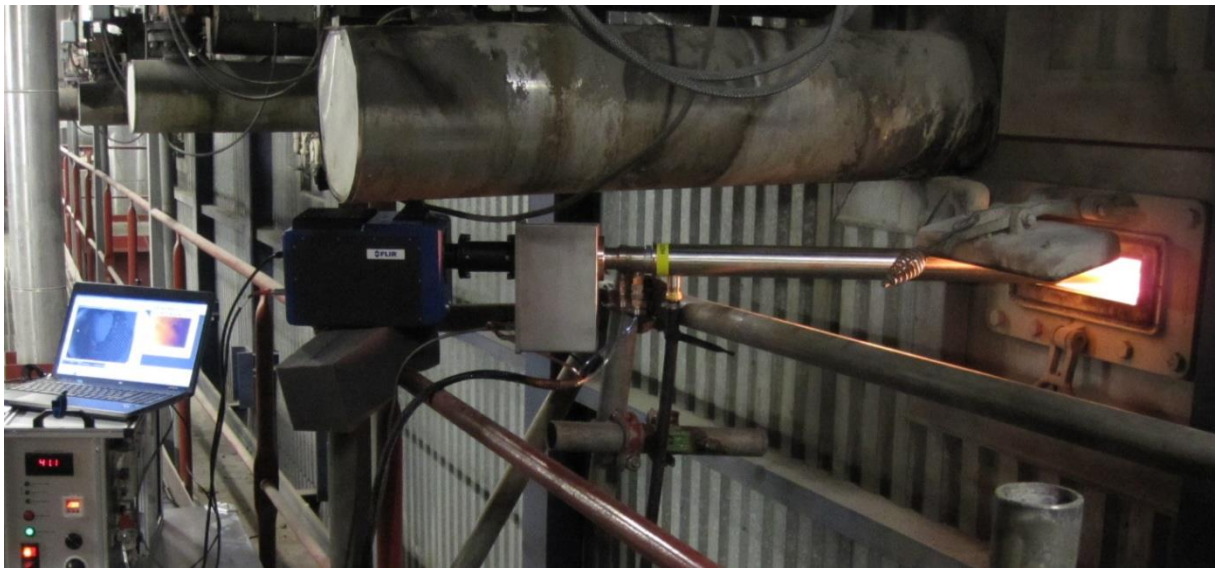

Figure 7 Inspection of flame during adjustment of burner settings (swirl) with combined VIS and IR endoscope system inserted into boiler. Pyrooptic offer mobile and permanent installed systems.

Permanent installed monitoring systems

Figure 8 IR camera system with two thermal cameras built into a water-cooled probe. Installation from straw and wood fired grate fired boiler at Fjernvarme Fyn A/S, Denmark. The system is controlled from the control room and images of the burning biomass displayed in Milestone.

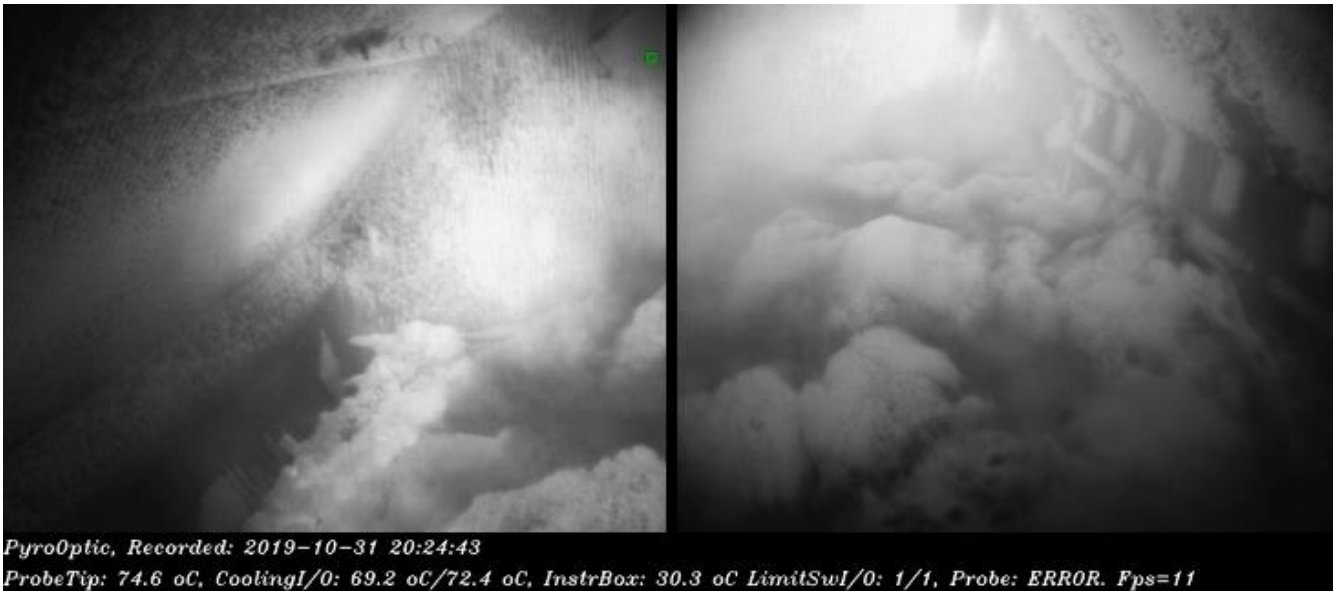

Figure 8 Thermal images of burning straw on a 10 m wide grate with dual view IR camera system. Straw enters grate (right) from 4 fuel feeding systems and the straw is burned out at the end of the grate (left). Dark zones in images are regions with low temperature and very high CO concentration.

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April 1, 2020