FLIR SC7600 BROADBAND INSB CAMERA IS USED FOR BIOMASS POWER PLANTS INSPECTION AND OPTIMIZATION

Located by Denmark's Roskilde Fjord, Risø DTU is the National Laboratory for Sustainable Energy at the Technical University of Denmark (DTU). Risø DTU's research fields are closely related with energy supply, energy consumption and health-related technology.

The research at Risø DTU is performed within several research divisions (biosystems, fuel cells, materials, radiation, systems analysis, wind energy, plasma physics and solar energy).

Among the on-going research themes, biomass combustion is making large use of infrared imaging technology for about eleven years.

BIOMASS COMBUSTION PLANTS

Biomass is a renewable energy source, referring to plant matter grown to generate electricity. Biomass is – generally – solid matter that has absorbed solar energy through the photosynthesis. The goal is therefore to make use of the solar energy that has been stored in the most natural way, biomass being considered CO_2 neutral when compared to fossil fuels. The main motivation for biomass combustion based plants is linked to CO_2 emission reductions as pledged by the Danish government in the 1990's. But unlike its Scandinavian neighbours, Denmark's landscape doesn't have such natural forestry abundance. Another biomass source was therefore chosen: straw.

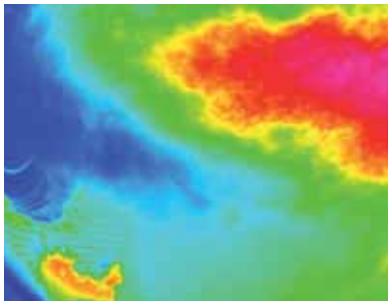
Raw straw (processed as chips or stacks depending on the plant's configuration) is generally fed into the furnace by means of screw feeders, onto a tilted grate, where most of the energy content is released by pyrolysis and gasification.

This combustion process is at the heart of Risø DTU's application.

"The process can be split up into three zones: a first zone where the straw is heated up, dried and some gas released, a second zone – ignition – with strong combustion and intense flames (pyrolysis) and a third and last zone (burn-out zone), with less intense combustion – reaction between carbon and oxygen – and a large fraction of ash on the grate" says Sonnik Clausen (Senior Scientist, Risø DTU).

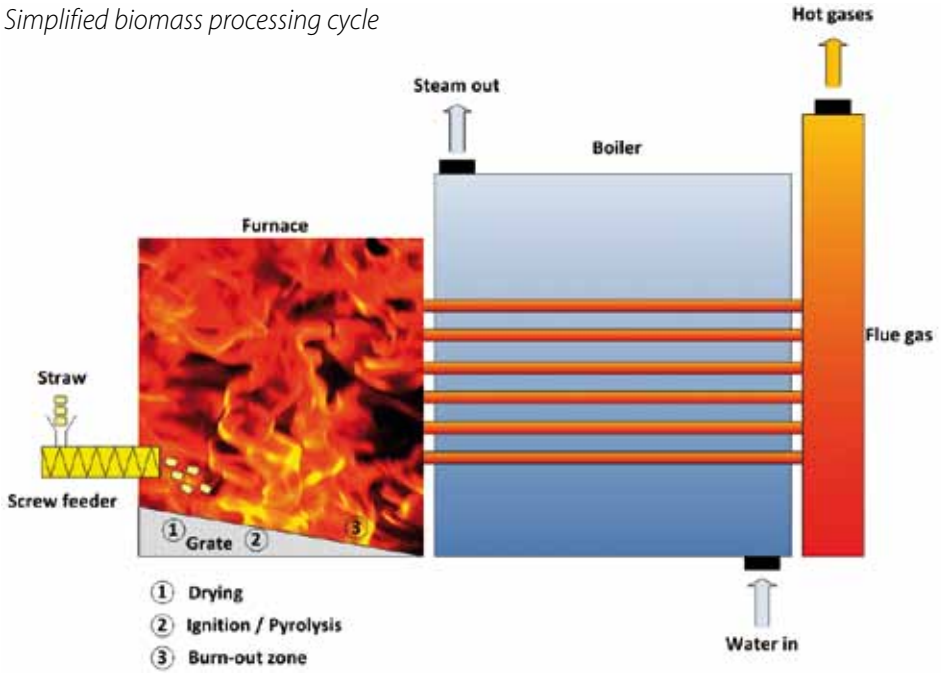
There are two major topics regarding the straw combustion process:

- Firstly, its chemical composition is the source of slag deposition on the inner surface of the boiler, altering the boiler's efficiency by reducing heat transfer. Deposits and gas emissions also contribute to corrosion of metallic components. These issues might lead to a temporary plant shutdown, a risk that should be avoided. Therefore, Risø DTU



Flame inspection on a 40 MW pulverized wood flame.

Simplified biomass processing cycle



is making use of a FLIR SC7600 infrared camera for preventive monitoring of slag deposits and clear understanding of the slag deposition process.

• On the other hand, optimization of the combustion process, i.e. increasing the plant's efficiency, requires a theoretical model to refer to – computational fluid dynamics model – and on-site metrology for further data correlation. This metrology process is mostly undertaken with the SC7600 infrared camera, but spectroscopy by means of FTIR measurements can also be used along with the boiler control system indicators (steam production, CO emission, fuel load…).

THERMOGRAPHY AND INFRARED VISION: FOR A "GREENER" WORLD...

The SC7600 camera sports a broadband (1.5 to 5.1 µm) InSb 640x512 pixels detector with a pitch size of 15 µm. Advantages of infrared imaging are temperature measurement, hot/cold regions discriminations and matter discrimination using temperature or emissivity variations. Accordingly to Sonnik Clausen: "A video camera cannot be used to monitor the straw surface and temperature in zones with intense combustion in large power plants due to strong disturbances from flame light".

Observation within the combustion zone is done through several available ports, allowing access to different zones of the boiler. For this purpose, Risø DTU has developed and manufactured an infrared endoscope that is mounted onto their FLIR SC7600 camera housing. "The burning straw on the grate can be observed, for example how the straw/fuel moves on the grate, tilt of the straw stacks that cause problems with CO emission, zones with intense combustion as well as cold zones", continues Sonnik Clausen.

The broad spectral sensitivity of the camera is particularly useful in this case, as well as the capability to mount standard off-the-shelf or custom-made filters on a fully integrated filter wheel. As an example, filtering at 3.99 µm allows seeing through the flame, while filtering at 4.76 µm makes CO detection possible. Typical combustion temperatures range from 1300 to 1500 °C with boiler walls from 600 to 700°C. Unlike microbolometer based cameras, the SC7600 camera can be set with a very low integration time (snapshot mode), thus enabling the capture of fleeting events like burning biomass particles.

As production from wind mills varies through time, flexible load operation of power plants might be requested. "We see problems with ignition and stability of flames at low loads, the power plant being designed for full load operation. Flame symmetry can affect formation of pollutants (thermal NO) and we've observed CO corrosion of boiler walls due to the lack of symmetry" says Sonnik Clausen.

Considering all the previous aspects (broadband spectral sensitivity, integrated filter wheel, versatile mechanical interfaces, high spatial resolution and snapshot mode), the SC7600 FLIR camera is a perfect choice for this application.

Working in collaboration with energy consultants, Risø DTU strives in finding proper solutions on how to make biomass power plants more efficient, increase their flexibility and minimize risks of downtime. "We expect growth in consultancy on inspection of boilers, flames and furnaces with infrared cameras. There is also a need in inspection systems for flame symmetry and behaviour, leak detections, temperature uniformity on tubes and boiler surfaces to be used by staff, and permanent installations for monitoring of deposits, active control and regulation of combustion process and temperatures. In the future, we will work on surface temperature's measurements inside diesel engines and very fast temporal measurements of gas composition and pollutants using an infrared camera" ends Sonnik Clausen.

Temperature measurement through a port

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All photos from Sonnik Clausen - Risø DTU.

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