

Combustion of pyrolysis oil in a 9 MW_{th} water tube boiler

Test set-up

The combustion of pyrolysis oil made from pine wood was compared to a reference case of heavy fuel oil (HFO) in an industrial, 9 MW_{th} boiler (figure 1). The water tube steam boiler generates steam at a pressure of 40 bar(g).



Figure 1 Stork Technical Services test boiler

The combustion tests were executed with a Stork Low NO_x Double Register gas- and oil burner (figure 2).

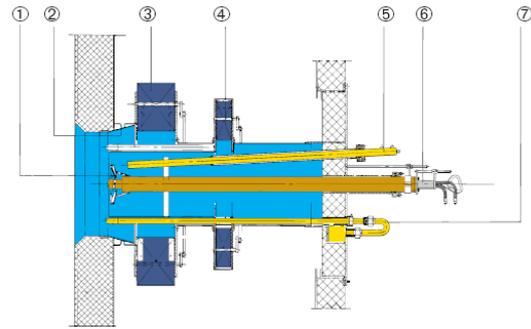
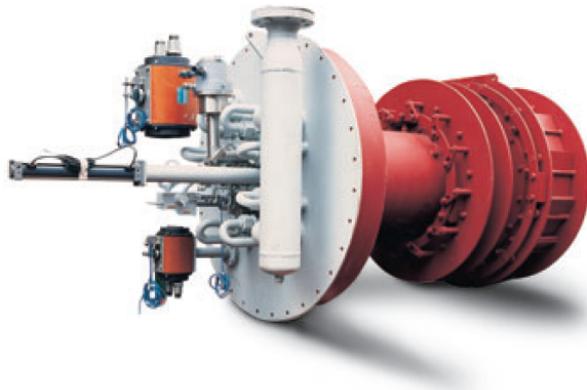
For atomization of the liquid fuels, an optimized Y-jet steam-assisted atomizer was used. The pyrolysis oil was preheated to a temperature of 60 °C in order to lower the viscosity and thereby enhance the atomization. The heavy fuel oil was preheated for the same reason to a temperature of 100 °C.

Flue gas emissions were performed with the in house flue gas analyzers of Stork Technical Services. Dust emission measurements were performed by ECN (Dutch Energy Research Centre), specially certified to perform these demanding measurements.

The main characteristics of the fuels used are show in table 1.

Table 1 Oil properties

Property	HFO	Pyrolysis Oil
Density [kg/m ³]	1050	1150
LHV [MJ/kg]	40.36	16
Nitrogen content [wt.%]	0.42	0.1
Water content [wt.%]	0.7	22



- ① STABILIZER
- ② BURNER THROAT
- ③ SEC. AIR REGISTER
- ④ PRIM. AIR REGISTER
- ⑤ IGNITION BURNER
- ⑥ OIL BURNER
- ⑦ GAS SPUD

Figure 2: Double Register Burner

Test results

Pine pyrolysis oil was successfully fired at 2.6 MW_{th} while HFO was fired at a capacity of 4.7 MW_{th}. The reason for the lower capacity on pyrolysis oil, was the limited amount of available pyrolysis oil in combination with the minimum time required for reliable dust emission measurements.

The flame of the pyrolysis oil stabilized at a larger distance from the impeller than the HFO flame (figure 3, impeller is dark spot on the left, flame going to the right side). This is most likely due to the water content of the pyrolysis oil in combination with the lower heating value. It was found that a small natural gas pilot flame of 0.6 MW is required for flame stabilization when firing pyrolysis oil.

It is believed that this pilot flame can be reduced or even omitted when preheating the combustion air. Besides natural gas, a liquid fuel may also be used for the pilot flame.

The combustion of the pine oil was homogeneous and no abnormalities were visible. The combustion of the pine oil gave a significant lower NO_x emission when comparing it to the HFO emission, which is due to the reduced flame temperature and low fuel nitrogen content. The flame temperature is reduced due to the high moisture content and the low LHV.

The measured emission levels for the combustion of pyrolysis oil and heavy fuel oil are shown in table 2.

Table 2 Measured emissions

Oil	Heat total [MW]	Heat oil [%]	Oil flow [kg/h]	O ₂ [vol% dry]	CO [ppmvd]	NO _x [mg/m ₀ ³ @3 %O ₂]	Dust [mg/m ₀ ³ @ 3%O ₂]
HFO	4.7	100	411	4.0	< 5	550	30
Pine oil	2.6	76	606	3.0	< 50	133	13 - 20



Figure 3: Flame of pyrolysis oil combustion

Conclusions

Based on the test results and the experience gained, Stork Technical Services is capable of designing, producing and installing burners suitable for the combustion of pyrolysis oil on a commercial basis in the typical range of 5 - 100 MW_{th}. Also, existing burner systems can be retrofitted to make them suitable for pyrolysis oil (co-)firing.

About Stork Technical Services

Stork Technical Services has 14,700 employees and is an international player in the field of knowledge-based Asset Integrity Management for the chemical, oil & gas and power industries.

From concept through to execution, Stork Technical Services helps its customers to reduce risk, assure safety and improve environmental performance. Stork Technical Services provides innovative solutions and integrates thinking and doing in the areas of Asset Integrity, consultancy, maintenance concepts, repair, renovation, new construction, relocations, services and other related complex projects.

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