BIOFIT Industry Forum on Bioenergy Conversion 2021

Burner Technologies Bioenergy Conversion to Bio-oil

Prerequisites and Driving Forces (and Obstacles)

Items to present

My life experience of bio-oils in 15 minutes

- Why bio-oil?
- Types of bio-oils – Properties and differences - Economy
- Types of burners – Suitability for different bio-oils
- Choice of materials – Pipes, tanks, burners etc.
- Economy
- Environmental impact
- MCP directive (2015/2193/EU)
- Other tips and experiences

Why use bio-oils, or not?

Incentives for using bio-oil

- Unlimited resources
  - Reduce or eliminate the use of non-sustainable resources
- Climate reasons
  - Reduce or eliminate the emission of CO_2 from non-sustainable and fossil fuels
  - Note: Some “bio-oils” may have some minor admixture of fossil additives.
- Economic reasons
  - Earn money due to cheaper fuels (at least in some cases)

Types of bio-oils – Properties and differences

General overview (typical information)

- Light bio-oils
  - No heating for storage, not even outdoors (normally)
  - No pre-heating for combustion
  - Often developed for use on diesel engines
  - Often standardized

    FAME (fatty acid methyl ester) - EN 14214 - Liquid petroleum products - Fatty acid methyl esters (FAME) for use in diesel engines and heating applications

    HVO (hydrogenated vegetable oil) – EN 15940 - Automotive fuels - Paraffinic diesel fuel from synthesis or hydrotreatment
  - Suitable for use in most types of burners, possibly with minor modifications
  - Low viscosity (typical 5 – 10 cSt at 20 °C) (1 cSt = 1 mm^2/s)
  - Light bio-oils can often be delivered as winter / summer quality, with varying viscosity
  - Low corrosion aggressiveness (Acid number TAN, typical 0,5 – 1 mgKOH/g)
  - Low / Medium flash point (varying 60 – 100 °C)
  - Low ash content (typical < 0,001 weight-%) (as or better than LFO, light fuel oil)
  - Low N-content (typical < 0,01 weight-%) (as LFO)

Types of bio-oils – Properties and differences

General overview (typical information)

- Medium heavy bio-oils
  - No heating for storage indoors, but outdoors
  - Pre-heating for combustion, normally needed
  - Often developed for heating / CHP plants
  - No official standards
  - Some de-facto frame standards formulated by oil suppliers; e.g. Bio-10

    The number refers to the solidifying point or crystallization point.
  - Suitable for use in some selected types of burners
  - Medium viscosity (typical 20 – 25 cSt at 20 °C, 10 – 20 cSt at 40 °C) (1 cSt = 1 mm^2/s)
  - Medium corrosion aggressiveness (Acid number TAN, typical 10 - 25 mgKOH/g)
  - Medium flash point (typical 130 – 150 °C)
  - Low ash content (typical < 0,05 weight-%) (as LFO)
  - Low N-content (typical < 0,01 weight-%) (as LFO)

Types of bio-oils – Properties and differences

General overview (typical information)

- Heavy bio-oils
  - Heating for storage, indoors and outdoors
  - Pre-heating for combustion, always needed
  - Often developed for heating / CHP plants
  - No official standards
  - Some de-facto frame standards formulated by oil suppliers; e.g. Bio25

    The number refers to the solidifying point or crystallization point.
  - Suitable for use in some selected types of burners
  - High viscosity (typical 50 – 60 cSt at 20 °C, 30 – 50 cSt at 40 °C, 10 – 20 cSt at 80 °C) (1cSt = 1 mm^2/s)
  - High corrosion aggressiveness (Acid number TAN, typical 50 - 100 mgKOH/g)
  - High flash point (typical > 150 °C)
  - Low ash content (typical < 0,05 weight-%) (as LFO)
  - Medium N-content (typical < 0,01 weight-%) (higher than LFO)
  - Special quality with extra low ash content (< 0,03 weight-%) and N-content (< 0,03 weight-%) may be delivered

Types of burners - Suitability for different bio-oils

General overview (typical information)

- High pressure burners

  Atomizing of oil by spreading of the oil in a nozzle under high pressure

  - Suitable viscosity: 5 – 10 cSt
  - Suitable for most Light bio-oils
  - Not suitable for Medium and Heavy bio-oils
  - Normal capacity range: 1 – 10 MW
  - Sensitive for erosion in the nozzle and high-pressure pump
  - Sensitive for corrosion aggressiveness (Medium and High Acid number)
  - Manufacturers: Elco, Lamborghini, Weishaupt, Bentone etc.

Types of burners - Suitability for different bio-oils

General overview (typical information)

- Pressurized air burners

  Atomizing of oil by means of low-pressure supply air

  - Suitable viscosity: 10 – 20 cSt
  - Suitable for Light bio-oils; Medium bio-oils with pre-heating
  - Works for Heavy bio-oils with pre-heating
  - Normal capacity range: 2 – 20 MW
  - Relatively unsensitive for erosion
  - Relatively unsensitive for corrosion aggressiveness (Medium and High Acid number)
  - Manufacturers: Turboflame, PetroBio etc.

Types of burners - Suitability for different bio-oils

General overview (typical information)

- Rotary cup burners

  Atomizing of oil by high-speed rotation of a spreader cup

  - Suitable viscosity: up to 40 cSt
  - Suitable for Light bio-oils; Medium and Heavy bio-oils with pre-heating
  - Works for Medium bio-oils without pre-heating
  - Possible to ignite Medium and Heavy bio-oils without pre-heating
  - Normal capacity range: 5 – 50 MW
  - Very unsensitive for erosion
  - Very unsensitive for corrosion aggressiveness (Medium and High Acid number)
  - Manufacturers: Saacke, PetroBio, Ray Egelhof etc.

Choice of materials – Pipes, tanks, burners etc.

Special considerations as regards choice of materiel in contact with bio-oil

- Pipes with armatures
  - Light bio-oils
    - Suitable pipes: Pressure Vessel Steel or Stainless Steel
    - Unsuitable pipes: Copper pipes
  - Medium heavy bio-oils
    - Suitable pipes: Stainless Steel
    - Could work: Pressure Vessel Steel (at conversion of existing plant)
  - Heavy bio-oils
    - Suitable pipes: Stainless Steel
    - Unsuitable pipes: Pressure Vessel Steel

Choice of materials – Pipes, tanks, burners etc.

Special considerations as regards choice of materiel in contact with bio-oil

- Tanks with armatures and components
  - Light bio-oils
    - Suitable pipes: Pressure Vessel Steel or Stainless Steel
    - Could work: Plastic (if not heated tanks)
  - Medium heavy bio-oils
    - Suitable pipes: Stainless Steel
    - Could work: Pressure Vessel Steel (at conversion of existing plant)
  - Heavy bio-oils
    - Suitable pipes: Stainless Steel
    - Could work: Pressure Vessel Steel (at conversion of existing plant)
      - Erosion corrosion may occur in at badly welded joints.

Choice of materials – Pipes, tanks, burners etc.

Special considerations as regards choice of materiel in contact with bio-oil

- Burners
  - Light bio-oils
    - All sealings must withstand the selected bio-oil.
  - Medium heavy bio-oils
    - All sealings must withstand the selected bio-oil.
    - Suitable materials: Stainless Steel
    - Could work: Pressure Vessel Steel (at conversion of existing plant)
  - Heavy bio-oils
    - Suitable materials: Stainless Steel
    - Special considerations must be taken regarding the risk for erosion corrosion.

Choice of materials – Pipes, tanks, burners etc.

Special considerations as regards choice of materiel in contact with bio-oil

- Oil Pumps
  - Light bio-oils
    - No special considerations in comparison with mineral oil.
  - Medium heavy bio-oils
    - Suitable materials: Cast Iron, Pressure Vessel Steel or Stainless Steel
  - Heavy bio-oils
    - Suitable materials: Stainless Steel

Choice of materials – Pipes, tanks, burners etc.

Special considerations as regards choice of materiel in contact with bio-oil

- General
  - All sealings must withstand the selected bio-oil, e.g. to FKM (Viton) or PTFE (Teflon).
  - Bio-oil with an Acid Number exceeding 90 - 100 mgKOH/g may result in corrosion, even at Stainless Steel.

Economy

General overview (typical information)

- Price of energy costs – Prices are indicative and may vary due to national regulations, taxes, subsidies etc.
  - Light bio-oils (vegetable origin): Higher (20 – 30 %) than for LFO
  - Light bio-oils (based on residual products): Normally somewhat lower than for LFO
  - Medium heavy bio-oils: Normally lower (15 – 25 %) than for LFO
  - Heavy bio-oils: Normally much lower (30 – 40 %) than for LFO
- Maintenance and operation costs
  - Light bio-oils: Approx. equal to for LFO
  - Medium heavy bio-oils: Somewhat higher than for LFO
  - Heavy bio-oils: Higher than for LFO
- Investment costs (for new plants) - Subsidies may occur
  - Light bio-oils: Approx. equal to for LFO
  - Medium heavy bio-oils: Somewhat higher than for LFO
  - Heavy bio-oils: Higher than for LFO

Environmental impact

What environmental impacts are to be anticipated by an extended use of bio-oils?

- Overall comparison with LFO
  - All figures are approximate and is strongly dependent of the actual plant.
- CO_2 emission – Very low, but not necessarily zero
  - Emissions due to the content in the oil and fuel for transportation may occur
- Dust emission – Higher than for LFO
  - Typically, 70 mg/(n)m^3 dg at 3 % O_2 as PM10 for Heavy Bio-oil (LFO 50 mg/(n)m3)
- NOx emission - Higher than for LFO
  - Typically, 400 mg/(n)m^3 dg at 3 % O_2 as NO_2 for Heavy Bio-oil (LFO 200 mg/(n)m^3)
- SOx emissions – Approx. equal to LFO
  - Typically, 35 mg/(n)m^3 dg at 3 % O2 for Heavy Bio-oil (LFO 35 mg/(n)m3)

MCP directive (2015/2193/EU)

The consequences of the implementation of the Directive of on the limitation of emissions of certain pollutants into the air from Medium Combustion Plants (1 – 50 MW) - (the Swedish implementation as SFS 2018:471 as *green italic*)

- Allowed emissions - Dust
  - 50 mg/(n)m^3 dg at 3 % O_2 - for all boilers ≤ 5 MW
  - 30 mg/(n)m^3 dg at 3 % O_2 - for existing boilers (in operation before 2018-12-20) > 5 MW
  - 20 mg/(n)m^3 dg at 3 % O_2 - for other boilers > 5 MW
    - Normally dust filter required
- Allowed emissions - NOx
  - 650 *(450)* mg/(n)m^3 dg at 3 % O_2 - for existing boilers (in operation before 2018-12-20)
    - Normally no special means required in EU/EES, *Probably possible without any special means in Sweden*
  - 300 mg/(n)m^3 dg at 3 % O_2 - for other boilers
    - Probably not possible for bio-oils
- Allowed emissions - SOx
  - 350 mg/(n)m^3 dg at 3 % O_2 - Normally no special means required
- Reserve boilers exception
  - Boilers with an annual operation period of 500 h (1 000 h/a in emergence situations), estimated as an average over a rolling 5-year period - for existing boilers (in operation before 2018-12-20)
  - Boilers with an annual operation period of 500 h, estimated as an average over a rolling 3-year period - for other boilers

Other tips and experiences

In some of the cases achieved by own experiences.

- Boilers – Operation and maintenance
  - Normal brick work in boilers may be less resistant against bio-oils, independent of type of oil.
  - Combustion of bio-oils is likely to result more deposition of soot and ashes in the boiler, especially for Medium Heavy and Heavy bio-oils.
  - A considerable proportion, 30 – 50 %, of the ashes is likely to be deposited in the boiler.
  - A larger specific combustion chamber volume is needed. Likely due to a higher generation of prompt NOx at the combustion. This may result in a reduced boiler capacity at conversion of existing boiler plants.
  - Plan for alternative bio-oils (for better price competition) and LFO (for emergency situations)

Other tips and experiences

In some of the cases achieved by own experiences.

- Bio-oil - Long time durability
  - The Long Time Storage Durability ("best before date") for bio-oils may be limited compared to light mineral oil, due to biological degradation processes of the oil.
- Reserve Boilers Exception
  - To utilize the exception in the MCP Directive – Divide the boiler capacity into several boilers
- Prepare for increased costs, for operation and maintenances
  - Bio-oils may be unpredictable regarding quality and properties, may cause unexpected costs; e.g. soot sweeping, removal of ashes, cleaning of filters etc.

The End

This was my life-time bio-oil experience transmitted to you in 15 minutes.

At least it was a scratch on the surface.

If you have any questions, please let me know!

Stefan Roslund

Semix Consult AB

stefan.roslund@semix.se