**1. BACKGROUND**

Biomass to Biochar Ltd. have a pyrolysis reactor for the conversion of organic materials into

charcoal or for use as a, "biochar". There are some technical and operational issue with the unit that require investigation and resolution.

Biomass to Biochar Ltd. have requested that Conversion And Resource Evaluation Ltd.

[C.A.R.E. Ltd.] provide services of primary importance:

 Review the pyrolysis unit.

 Suggest short, medium and long term actions

 Propose a second stage of more detailed changes subject to further discussions and

agreement on a scope of works.

**2. SITE ASSESSMENT**

A visual inspection of the equipment was made and the following report is based on the assessment and subsequent comments.

**2.1 MPU Construction**

The pyrolysis unit is a mobile unit, designed, built and supplied by PGE, sister company OMC

Engineering, who are involved in the Enviroparks projects in Hirwaun, SW Wales. They have

been active in pyrolysis for over 10 years and built large rotary kiln based systems.

Formal documentation for the safe operation of the equipment was not available on the day. None of the visible equipment was ATEX compliant and there were a range of H&S concerns, which are dealt with below.

**2.2 Equipment comments**

1. Visual inspection of the screw would suggest that the flights are too thin, have too high a

pitch and this probably needs to be reduced by 25-50%. The angle of the walls of the feed hopper would suggest that bridging could occur with a low-density feedstock, such as rushes, straws and/or grasses.

2. Partially combusted gas flow within the kiln means poor heating of the solids, tars

deposition on the walls at cold spots and the potential to burn the feedstock and not pyrolyse it. It’s clear that this counter current flow of gas over the top of the feedstock will lead to limited pyrolysis through the particles at the bottom of the trough.

3. O2 measurement should be provided in the combustion chamber as there is no indication as to the determining factor in the temperature of the burnt gases, nor the air flow. Necessary to be able to set combustion conditions to ensure tar burnout or excess O2 returning to the kiln to prevent risk of fire or detonation of the syngas if O2 > 1 vol%.

4. Allowance should be made for thermal expansion and/or contraction of the

tube, to prevent axial stress on the tube. Any metal subject to a temperature change of >

300°C needs provision for movement of > 3 mm to avoid mechanical stresses, both laterally and axially.

5. All flange seals not visible. Check if a suitable high T material like laminated graphite

[Supagraf™ for example] is present which is O2 resistant at high T.

6. N2 purging from feed end to prevent air ingress is recommended to stop internal

combustion and ensure pyrolysis.

7. Kiln length should be significantly enlarged to obtain a significant material throughput. L/D ratio should be ~10-12 – current one is less than 5 or 6.

8. Seals on char bin should be reviewed. Air ingress into char screw highly possible and evidence of heat damage to the discharge screw clearly visible – severely annealed pipework which leads to mechanical weakness.

9. Temperature measurement on combustion chamber should be provided and on the pyrolysis kiln. Several duplexed type K thermocouples should be fitted.

**2.3 General Recommendations**

1. To reduce feed bridging issues, it is recommended that the hopper is split into 2 with a

vertical dividing plate to allow feedstock to be constrained in only one direction and not in

2. Plate can be coated mild steel and suspended off the lid to within 25mm of the top of the

screw flight. Screw design to be changed to have a screw with a smaller pitch initially of ~150-200mm maximum and opening up to 200-250mm in the kiln.

3. Remove the shroud ducting syngas and combusted gases back to the combustion chamber at the feed end – there is clearly severe heat damage where an internal fire has led to significant distortion of the stainless steel. This will lead to weld weakening and separation of the metals in the alloys, leading to corrosion.

4. Fit a spool piece where the syngas shroud was to increase the operational length of the pyrolysis kiln.

5. Replace the LPG burner with a proper sealed Nuway SG100 [https://www.nuway.

co.uk/product/product-53/] or Fives NA LPG burner with high T ceramic nozzle.

Comply with local gas safety regulations. Check on the gas flow regulator on capacity as

limited to 4 kg/h.

6. Approach Turmec for assistance in rectifying the range of mechanical issues.

7. Cabling should be in amoured metal holders to prevent damage and stop them being

stepped or damaged. Cable failure could lead to shutdown or non-ATEX issues.

8. Check if ATEX assessment carried out to determine extent of the hazardous area and its boundaries.

9. Overhaul heating of the kiln to switch from heating internally [which no other pyrolysis process does using hot gases, only electrical heating of the augur as per the Biogreen, France,

process] to heating the kiln tube externally, i.e., by the use of electrical heaters [Sandvik

Kanthal Fibrothal electrical heating elements], gas heating [burners underneath the kiln],

or by use of the combusted syngas through an annulus constructed around the kiln tube and

properly sealed and ceramic fibre board lined.

10. Remove the gas valve at the end of the kiln and duct the syngas back over the kiln to the

combustor inlet.

11. Compliance with Irish Health and Safety legislation.

**2.4 Safety recommendations**

1. Safety mesh should be provided to prevent items being dropped into the feed screw and prevent personnel injury.
2. Temperature measurement should be provided in the feed hopper in case of fire.
3. Guard rails should be provide to prevent users of the equipment from falling off the trailer. Mounts should be fitted to allow rails and guards to be added to prevent persons climbing onto the unit. Access to unit should be restricted to avoid entering the hazardous area [ATEX Zone 2/22].
4. CE marking or certificate to confirm statutory or regulatory compliance to be provided.
5. ATEX compliance, certificates and defined hazardous area for classification into Zone 2/22 should be provided.
6. 5. Buy an N2 regulator, N2 bottle, flowmeter with integral needle valve and a pressure gauge.
7. Flow to the feed hopper to allow inerting to prevent fires and improve safety.
8. Control cabinet should be ATEX compliant and ask for certification.
9. Provision of CO2 fire extinguishers in the event of a fire and all plant users trained in their use [avoidance of frost injuries from nozzle, etc.]
10. Passive CO monitoring in the ATEX zone.