Introduction

Growing economic, environmental and social imperatives to utilise renewable energy sources have brought a greater focus on developing and optimising technologies for the effective conversion to energy of an increasing variety of waste materials. Whilst animal waste has long been used as a domestic fuel, traditional methods are being replaced by industrial scale processes which are more efficient, productive and environmentally superior. However, the diversity of animal waste that can be used as a biomass fuel means that the combustion of animal litter is as complex as traditional plant based biomass. The challenge of understanding the different characteristics and properties of such fuels is critical to designing a solution which can provide the most efficient combustion; as well as adapting for specific fouling and slagging propensities.

Chicken litter is a suitable and readily available waste material that has great energy potential, but it has specific properties which must be addressed in the design solution.

## Common Physical Properties For Poultry Litter

<table>
<thead>
<tr>
<th>Physical or Chemical Property</th>
<th>Effect of Combustion</th>
<th>Potential Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rich in calcium, phosphorous and potassium-based alkali metals</td>
<td>High alkali content High chloride content</td>
<td>High levels of slagging, fouling and corrosion of the furnace and boiler. High particulate emissions</td>
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<tr>
<td>K and Na</td>
<td>Forms silica salts which become sticky</td>
<td>Forms slag on hot surfaces of the combustion equipment and boiler.</td>
</tr>
<tr>
<td>High chlorine level</td>
<td>HCl formation</td>
<td>Increased risk of high temperature corrosion to the furnace and boiler.</td>
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<tr>
<td>High Sulphur level</td>
<td>Releases sulphur content that is &gt;10 x higher than that of wood</td>
<td>Increased potential for high SOx emission</td>
</tr>
<tr>
<td>Variable moisture content depending on climate and livestock practices</td>
<td>Dry fuel increases the risk of more explosive and fluctuating combustion. Moist fuels require some drying prior to combustion; and more sophisticated combustion systems to handle higher moisture levels.</td>
<td>Fluctuating combustion levels, lower efficiency. Increased energy requirement for drying fuel.</td>
</tr>
<tr>
<td>Small particle size</td>
<td>Small particles have a tendency to burn in suspension when using a pneumatic spreader or drop chute feeding system.</td>
<td>Increased risk of high temperature corrosion and higher quantities of fly ash. Fly ash disposal is expensive.</td>
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</table>
DP CleanTech has engineered and manufactured over 80 biomass plants worldwide. Our proprietary patented European technology is the basis for the most efficient and robust biomass-fired boiler + water cooled vibrating grate (WCVG) solutions in the world. DP’s engineering knowledge and experience originated in Denmark in 1986 and has been extended and improved to efficiently handle over 60 types of fuel. DP’s particular strength lies in designing boiler solutions for complex and corrosive fuels that contain high levels of alkalis and chlorine. DP has references for over 50 high performing plants using such fuels.

The DP Specialist solution for 100% combustion of chicken litter to produce electricity and/or process heat is based on DP’s longstanding and in depth experience of combusting highly complex, fouling and corrosive biomass fuels in order to address the specific combustion problems associated with chicken litter.

### Key Features

**Fuel Feeding System**
Including feed hopper, chute and hydraulic-driven pusher

**Boiler**
Including water-cooled vibrating grate, furnace and steam boiler pressure and non-pressure parts

**Flue Gas Treatment System**
Including flue gas ducts, absorbent injection reactor, bag filter and chimney stack

**Fly Ash Removal System**
Chain conveyor, bucket elevator, screw conveyor and silo

**Feedwater System**
Including deaerator/feedwater tank, boiler feed pumps, feedwater pipeline to boiler

**Combustion Air & Draft System**
Including air ducts, force draft fan and induced draft fan

**Boiler Bottom Ash/Slag Ash Removal System**
Submerged chain conveyor

**Steel Support Structure, Galleries, Platforms, Stairs and Boiler Roof and Siding**

**Advanced Automatic Boiler Process Control and Dedicated Protection System**
DP’s boiler design is a three-pass vertical arrangement with water-cooled wall membranes and a single uncooled fourth pass (the economiser tower). The boiler is equipped with horizontal bare and fin-tube Superheaters located in the third and fourth pass. The flue gas is reduced to below 800°C before entering the superheater pressure parts in the third pass. This design minimises the risk of high temperature corrosion, a common problem with hanging superheaters located in the first and second pass.

**Designed Performance Parameters**

<table>
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<tr>
<th>Load Capacity (MCR)</th>
<th>Main Steam Flow</th>
<th>Main Steam Pressure</th>
<th>Main Steam Temperature</th>
<th>Power Output (MWe)</th>
<th>Fuel Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>40-150 t/h</td>
<td>60-70 Bar(a)</td>
<td>450-480°C</td>
<td>10-40</td>
<td></td>
</tr>
</tbody>
</table>

**Key Benefits**

**Corrosion Preventative Superheating**

DP’s advanced control system (DPAAC) automatically regulates the furnace and boiler temperatures to maintain stable operation, whilst minimising minimum flue gas temperature fluctuations and reducing the fouling of pressure parts. Excessive fouling of the boiler is removed by water lance blowers.

**Controlled Fouling**

The pusher fuel feeding system slowly feeds the chicken fuel into the furnace and maintains an optimum layer of fuel on the combustion grate. This minimises the risk of fuel blockages and bridging usually found with drop chute and dosing silo-reclaimer feeding systems.

**Steady Combustion Control**

Slow, steady pushing of the fuel onto the grate, interspersed with short periodic vibrations of the combustion grate and automatically controlled combustion air enables steady combustion with less fluctuation. Pushing fuel rather than using an pneumatic spreader or drop chute minimises the amount of fuel burning in suspension (which can increase the risk of fouling and corrosion in the first and second pass).
Chicken litter has a high ash content of up to 20% when dry. The pusher system ensures that only 20% of this overall ash content becomes fly ash (compared to other feeding systems that produce 50%). Around 80% of the ash is removed from the boiler as bottom ash. This can be sold as fertiliser.

Reduced Fly Ash

DP’s water-cooled vibration grate (WCVG) is less prone to high-temperature corrosion and has fewer moving parts, requiring less maintenance than other grate technologies.

Reduced Maintenance

The fuel handling system is over-sized to handle low quality fuels consisting of up to 25% ash.

High-Volume Fuel Handling System

Emissions Handling Features

DP’s Flue Gas Treatment (FGT) plant provides a proven, simple and effective method of meeting the required emission limits.

- NOx suppression - NOx formation is suppressed by controlling the combustion air by spraying water into the furnace hot spots. This alternative method is tried and tested at all four Chicken Litter-fired power plants under operation in the UK, with NOx levels below 200 mg/Nm3. It is both effective and significantly less expensive than using Selective Non-Catalytic Reduction (SNCR) with Ammonia or Urea injection.

- SOx scrubbing – Dry flue gas cleaning system with Hydrated Lime injection to remove SOx pollutants from the flue gas. Meets emissions limits with a lower O&M cost than semi-dry systems.

- Increased bag filter capacity – to handle higher levels of fly ash in the flue gas. This also reduces bag cleaning frequency and increases bag life.

- Efficient scrubbing - Maximum contact time between the reagent and flue gas in the reactor tower, ensures effective mixing before entering the fabric filter section.
Key Benefits

Guaranteed Emissions Reduction
The FGT has been installed at multiple plants in the UK and Asia, operates successfully and consistently achieves mandatory emission limits.

Reduced Maintenance Costs of FGT
The dry flue gas cleaning system meets emission limits to be met at lower maintenance and operating costs than semi-dry and wet systems.

Quality Standards
DP equipment, materials and systems are designed and manufactured in accordance with the latest prevailing codes and standards.

- TSG - Special Equipment Safety Specification
- GB - China National Standard
- ASME - American Society of Mechanical Engineers
- PED - Pressure Equipment Directive
- EN - European Norm
- BS - British Standard
- JIS - Japanese Industrial Standard

Boiler Design Layout and Overview
The boiler is of similar size and appearance to the Mahachai Green Power 9.9MWe biomass power plant commissioned by DP in 2016. The design is based on the DP MaxMulti solution with proprietary water cooled vibrating grate (WCVG) technology.
Key Features and Processes

- Biomass power plant: 10 to 40 MW gross electric power capacity
- Fuel feeding system (hydraulic pusher): reduced risk of fuel bridging/blockage, stable combustion and reduced fly ash quantities.
- Boiler system: medium pressure, medium temperature boiler for optimal system efficiency and reduced fouling and corrosion of boiler pressure parts.
- Flue gas cleaning system: Advanced system with Hydrated Lime injection SOx scrubbing and higher-volume fly-ash capacity bag filters.
- Control and protection system: 100% automatic, low opex and high reliability.
- Back-up power: 40% load oil burner and diesel genset (for critical systems).
- Turbine Island: high-quality; cost efficient partners (e.g. Siemens, ShinNippon)
  Automatic speed control, voltage regulation, protection and synchronisation.
- Cooling system: water or air-cooled (depending on water availability)

DP Specialist Boiler (Poultry litter)

1. Shredded fuel
2. Walking floor
3. Screw conveyor
4. Weight cell
5. Non-shredded fuel
6. Feeding hopper
7. Belt conveyor
8. Pusher feeder
9. Hydraulic station
10. Vibrating grate
11. Slag conveyor
12. Primary air
13. Secondary air
14. Combustion chamber
15. Steam drum
16. Superheater 1
17. Superheater 2
18. Water lance blowers
19. Boiler feed water
20. Economizer
21. Flue gas cooler
22. Air preheater 1
23. Air preheater 2
24. Steam turbine generator
25. Water-cooled condenser
26. Bag filter
27. Ash handling
28. ID fan
29. FD fan
30. Stack

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About DP CleanTech

- DP CleanTech designs, engineers, manufactures and commissions biomass and waste-to-energy power plants, providing complete solutions for turning waste materials into clean energy.
- DP CleanTech has over 80 biomass power plant references around the world using high pressure, high temperature technology originally developed in Denmark.
- DP CleanTech built the first biomass power plant in China and is responsible for over 30% of the biomass power plants operating in China today.
- DP CleanTech is recognized as a world leader in the biomass clean energy field.