**David J. Krygsveld**, Entropy Associates Inc.
**Thursday, November 20, 2008: 8:30 AM-11:00 AM**
**Room 204-A (Pennsylvania Convention Center)**

# Forest and Plant Bioproducts Division (17)

#623 - Topics in Energy from Forest Bioproducts: Economics, Life Cycle Analysis, and Improved Thermal Processes (17004)

Overview: A variety of forest bioproducts topics will be considered, including the engineering and economics of biomass energy systems, lifecycle analysis of forest bioproducts and biofuels, and improvements in processes that utilize energy from biomass for power generation and process heat.

Chair: Kenneth Nichols
CoChair: Bandaru V. Ramarao

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| 8:30 AM | 623a | Renewable Fuels Combustion Technologies<br>**Robert S. Morrow**, Amy Malko, Tom Giaier |
| 9:00 AM | 623b | Biomass Gasification in a Stoker Gasifier<br>**Kevin Whitty**, Eric G. Eddings, Robert S. Morrow |
| 9:30 AM | 623c | Biorefinopttm. A Practical Tool for Process Design and Economic Analysis of Integrated Biorefineries<br>**W. J. Frederick**, Steven Lien |
| *10:00 AM | 623d | Experience with Ash Modifiers to Control Pluggage of Biomass Furnaces and Heat Transfer Surfaces<br>**David J. Krygsveld** |
| 10:30 AM | 623e | Economic Analysis of Optimal Biomass Utilization in An Integrated Biorefinery<br>**Norman E. Sammons Jr.**, Wei Yuan, Susilpa Bommareddy, Mario R. Eden, Burak Aksoy, Harry T. Cullinan |

## *10:00 AM
## 623d

## Experience with Ash Modifiers to Control Pluggage of Biomass Furnaces and Heat Transfer Surfaces

**David J. Krygsveld**, Entropy Associates Inc., 266 Millar Avenue, Miramichi, NB E1V 3B6, Canada

Title
Experience with ash modifiers to control pluggage of biomass furnaces and heat transfer surfaces
Review of stages of combustion.
Types of ash.
Source of problem ash.
Correcting problem.

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# Experience with ash modifiers to control pluggage of biomass furnaces and heat transfer surfaces

**David J. Krygsveld**, Entropy Associates Inc.

## Introduction

As a field engineer, I interface with operations personnel of varying background who, of course, have direct experience with their furnaces and are experiencing plugging due to ash build-up in the furnace and downstream heat exchange surfaces.

In order to ensure that these people understand the process from the same point of view, I explain as follows.

# Review of stages of combustion.

By definition, all biomass units burn carbon.

Naturally each furnace operator will claim that his fuel is unique in some way and so his problem is different. This is not relevant to understanding ash formation.

Biomass is a carbohydrate with moisture and soil contaminants either mixed or bonded in its structure.

In order to burn, the material is introduced to the furnace, where it begins to heat up to 212° F, the vaporizing temperature of water. In this heating process, any contaminants with a lower vaporizing temperature, such as alcohol and turpentine, will evaporate at their boiling point and join the fume from the bed, perhaps combusting.

The fuel remains at the boiling temperature of water until all the moisture is gone before the temperature increases again, this time rising through the volatile temperatures of entrained salts.

When the ignition temperature of carbon is achieved at about 600 ° F, the carbohydrates will decompose and the carbon will burn to carbon monoxide, provided that the air supply is restricted. The carbon monoxide will rise from the initial drying/burning zone until it is supplied with a secondary supply of air to burn carbon monoxide to carbon dioxide at about 1100 ° F.

The carbon monoxide to carbon dioxide flame is relatively unaffected by water and salts the way the drying/burning zone is. Although the average flame temperature in this zone is measured as less than 1900 °F, the fact that glass is melted in this zone suggests that a temperature of over 2500 °F is actually achieved in some area. This is likely due to combustion of hydrogen and other high flame temperature materials.

## Types of ash.

Ash in biomass is of three main types; cold, hot and melted. Cold ash that remains cold usually falls to the grate and is removed by equipment designed for this and so is not a problem. Hot ash, that is ash that is not melted, carries with the main flow of flue gas and is removed from the downstream zones by ash removal equipment and poses no problem because it is not sticky.

Melted ash, usually a very small fraction, will flow with the flue gas and stick to the first surface that cools it to below its fusion point and here lies the problem.

## Source of problem ash.

Melted ash, or ash which has changed state due to high temperature, is the source of problem pluggage.

Because most biomass entrains some sand in its cells, it is impossible to avoid ash formation in most furnaces, due to the areas where the flame temperature is over the melting point of glass.

## Correcting problem.

The strategy concentrates on removal of ash only.

There are two principal strategies to cope with ash formation; design of the furnace and removal of the ash.

Since each user has an already built unit, re-design is not usually an option.

Since the ash is glassy, it is very hard, although brittle and cannot be removed by anything short of mechanical impact such as jackhammering.

Chemistry can be applied to change the crystal strength of the ash, making it friable and easier to remove.

This chemistry is best applied in the carbon monoxide flame where the glass is melted and the chosen ingredient can melt with it.

Several companies supply materials of this type that can often be used to financial advantage.

In my experience, operators often ask for guarantees. The chemical additive is guaranteed to alter ash characteristics and it is at this point that the operator needs to take advantage of this alteration to improve performance.

Question period.

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