30kW TLUD gasifier based pasteurization system: Working Report

Abstract

In an effort to develop an inexpensive, environmentally friendly and appropriate method of milk pasteurization using locally available materials, Paramount Dairies Limited (PDL) built a working 30kW thermal heat system (Prototype I) based on TLUD gasifier technology.

To test the feasibility and impact of said system in the working environment particularly in the areas of fuel supply and cost, system usability (human factor) as well as maintenance and durability it was installed in the PDL cheezery by early October of 2009 and has been running to date. This report contains the learning generated since installation.

Introduction

Milk pasteurization for cheese making at PDL has historically been done using the double vat (Bain Marie) method with a direct heating source for the milk specifically, charcoal stoves. Although more reliable than electric power the charcoal has a number of disadvantages including: the great inefficiency of the stoves (10%); the accelerating deforestation in the region and therefore the spiking prices of charcoal; the unhygienic environment for cheese making created by the ash and debris from the fire; and the high temperatures around the cheese vats creating an unfriendly working area for production staff.

In contrast the 30kW TLUD gasifier based pasteurization system, using papyrus reed as a fuel is not only up to 30% efficient but also allows for a removed heat source, resulting in a better cheese making environment both hygienically and as well as having a comfortable production area for staff. It is also carbon negative since the end result of the gasification process is charcoal which once implemented on a larger scale would significantly benefit the environment.

Figure 1: Charcoal produced after burning of the papyrus

Fuel supply and cost

Fuel:

The main fuel source used is papyrus reed of which approximately 2000 square kilometres are available in Uganda. With a crop cycle of about 300 days papyrus reed makes a very attractive fuel alternative to wood.

Figure 2: Weighing dry papyrus reeds

Figure 3: Papyrus reeds

The reeds are cut to the length of the fuel cylinder and then stacked vertically inside the fuel chamber at a ratio of about 0.075 kg of fuel to fuel chamber volume in litres. Since installation two truckloads (each of two ton capacity) have been consumed. The 30kW system is being used to pasteurize 500L batches of milk on an average of 3 days a week. Each batch requires 20kg of papyrus fuel raising the milk temperatures from 28-65˚C within one hour, the average weekly consumption of papyrus being around 60kg.

Cost:

In comparison to charcoal the papyrus reed is quite cheap. It is cut in the swamp and left lying flat to dry out before being transported to the cheezery.

Daily milk production capacity [L]	Fuel	Mass of fuel [kg]	Cost/kg [shillings/kg]	Daily cost [shillings]
2500L	Papyrus	~ 100 (10 kg/stove)	250	25000
2500L	Charcoal	~ 480 (30kg/bag)	533.33	96000

System usability (human factor)

The system has been readily adopted by the staff; they easily assemble the milk vats, piping and the pumps as well as prepare and pack the fuel. As a result of using the system regularly a few changes have been adopted by the staff.

One such change was made on the system component that delivers the hot water into the water jacket. The component was used to deliver the hot water more smoothly through multiple orifices that reduced the impact of the piped water from the main. Removal of this component increased the rate of pasteurization.

Figure 4: Showing the system component that delivers hot water into the water jacket.

Regular use of the TLUD stoves has revealed that three components in particular wear more easily due to the high temperatures experienced during combustion ranging from 584-850˚C. The inner cylinder fuel chamber as expected, the primary air inlet spout as well as the grate:

However, the TLUD`s continued to function effectively without the primary air inlet and it was also discovered that they could do so without the grate. Once the reeds were packed into the inner fuel cylinder it was placed into the outer cylinder without the grate; the stays on its outer surface held it in place at a height above the base of the outer cylinder maintaining the primary air gap that facilitates fuel combustion.

Maintenance and durability

The inner fuel chambers that wear out are easily and cheaply replaced.

Appendix

Installation

System Components

Heat exchanger:

The heat exchanger consists of two concentric steel pipes welded together at the ends with two connection points for plumbing. The hot gases are channelled through the inner pipe which acts as a flue whereas the water is pumped through the jacket between the two pipes facilitating heat transfer between the two fluids. The flow configuration can be either parallel or counter flow.

TLUD Gasifier (Combustion device):

The combustion device is a Top Lift Updraft (TLUD) gasifier. Based on micro gasification technology but scaled up to industrial capacity, the gasification process relies on a natural draft up the heat exchanger's inner pipe (flue) to maintain the airflow necessary for effective and smoke free combustion. Once combustion of the fuel is complete; the gasifier can continue to burn the charcoal created by the gasification process or else can be removed and put to use in other applications such as fertilizer or charcoal – a carbon negative process. The fuel chamber volumes of the industrial TLUD's range from 145-163L and the gasifiers weigh from 22-24kg, each with a fuel capacity of about 12.5kg of dry papyrus reed.

Figure 5: The TLUD gasifiers filled with dry papyrus reeds

Figure 6: Burning the dry papyrus reeds

Pumps and piping:

Two pumps each approximately 0.5 hp are used to circulate the water in the system consisting of PP-R piping at a flow rate of 0.81 kg/s. A compressor fan is mounted behind each pump to reduce the heat stress on the pumps.

Figure 7: The two pumps connected to the vat.

Figure 8: The pump and compressor fan

Milk vats:

Two concentric aluminium milk vats facilitate heat transfer from the water to the milk contained in the inner vat. The volume of the water jacket between the two vats is up to 125L and milk vat has a capacity of 500L.

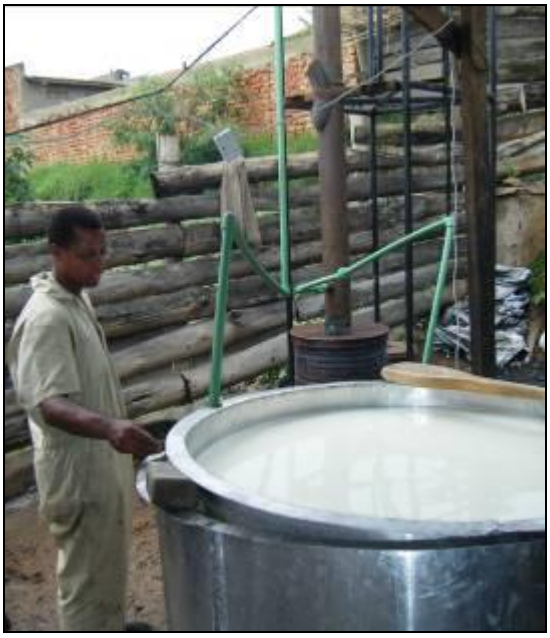

Figure 9: The two concentric aluminium vats

Figure 10: Monitoring temperatures of the milk.