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Research Paper :

Performance and evaluation of heat exchanger for hot water generation

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ABSTRACT

A wood based batch type heat exchanger based on natural draft gasifier system has been developed at College of Technology and Engineering (CTAE), Udaipur (Rajasthan). The system was designed to produce 180 litre of hot water per batch for thermal application. The average efficiency of the heat exchanger system worked out to around 25.65 per cent for single trial in a day and 35.56 per cent for four batches in a day. The performance of the system was evaluated in terms of heat exchanger efficiency, benefit cost ratio and pay back period.

Key words : Heat exchanger, Hot water generation, Benefit cost ratio, Pay back period.

Rapid industrialization in India has resulted in an ever-increasing demand for process heat and steam. Most of these industries are in the metallurgical and food processing sectors and have to use petro-fuels like furnace oil, light diesel oil (LDO) or diesel to meet their energy demands. However, due to uncertain supplies and high cost of these fuels, there is an urgent need for other sources of energy.

Biomass gasification is the process in which solid biomass materials are converted by a series of thermo chemical reactions, to a combustible gas called producer gas, liquids (tar and oils) and solid (char and ash). The reactions are carried out in the reactor called as gasifier.

Biomass based natural draft gasifier system can be used for various purposes *viz.*, institutional cooking, hot water generation, steam generation for process in a variety of traditional industries in the developing country and other thermal applications such as par-boiling, pottery making etc.

A heat exchanger is a device that is used to transfer heat between two or more fluids that are at different temperatures. Heat exchanger is essential element in a wide range of system. The most commonly used type of heat exchanger is the shell and tube type heat exchanger applicable for a wide range of operating temperatures and pressures.

The system design consists of a natural draft gasifier, shell and tube type flue gas water heat exchanger as major components.

The study was attempted with the following objectives to design and develop producer gas operated heat exchanger, to test and evaluate the performance of the developed system and to assess techno-economical feasibility of the developed system.

METHODOLOGY

The system was designed to generate hot water with following design consideration:

Design data

- Operating pressure (P) = 1 bar
- Temperature gradient (Δt) = 70 ^{0}C
- Specific heat of water (C_p) = 1 kcal kg^{-1} ^{0}C^{-1}
- Heat exchanger efficiency = 40 %
- Capacity of water = 180 litre per batch

Gasifier data:

- Heat produced by gasifier (Rated) = 20000 kcal h^{-1}
- Specific gasification rate = 150 kg h^{-1}-m^{-2}
- Calorific value of producer gas = 1100 kcal m^{-3} or 4.6 MJ m^{-3}
- Gas output from wood chip = 2.2 m^3 kg^{-1}

Calculated data

- Gasifier efficiency = 70.36 per cent

The gasifier is available to supply the heat 20000 kcal h^{-1}, but by calculating gasifier efficiency actual heat available is (Q_h)= 20000 x 0.70 = 14000 kcal h^{-1}

The 14000 kcal h^{-1} heat is available, therefore the quantity of hot water generated with temperature gradient 70 ^{0}C.

$Q = m \times C_p \times \Delta t$

14000 = m x 1 x (97-27) m= 200 lit.

Dimensions of heat exchanger for hot water generation:

The inner diameter of the shell was kept twice of