Designing of portable Bagasse Powered Steam Generator for Preheating of Seed Cane Hot-water Treatment Plant

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1.Introduction

Sugarcane, which is globally an important source of commercial sugar, plays a major role in economy of sugarcane growing regions. According to International Sugar Organization (2018), over 80 % of the world sugar production is from sugarcane. In 2018, the world sugarcane production was 187.6 million tonnes (Bedford et al. 2018). And, CBSL (2018) report indicates that average sugarcane yield of Sri Lanka is 61 t/ha, which is much lower than the global average value. Further, annual sugar requirement of Sri Lanka is around 553,500 t and annual per capita sugar consumption is around 26 kg. But only 55,552 t of sugar is produced locally and the rest is imported by expending 0.2 billion USD (1 USD = 174.690 LKR) per annum (CBSL 2018). Therefore, improving sugarcane production would strengthen the economy of the country by saving more foreign expenditure. Non-availability of disease-free, healthy planting material is one of the major constraints in improving the sugarcane productivity in Sri Lanka. Rutherford et al. (2003) have estimated that, when 100 % of stalks are infected, the crop loss is around 40 % for ratoon stunting disease and mosaic, while 75 % crop loss is recorded for smut when 100 % of stools are infected in susceptible varieties. To control these systemic diseases of sugarcane, hot water treatment of sugarcane setts is practiced (Croft and Cox. 2013). In Sri Lanka also, the cane cuttings are treated before they are used for field planting. According to the evaluation results of existing seed cane treatment plants in "*Uda walawe*", Sri Lanka, for the treatment of one tone of seed cane, it is required to operate 54 kW electric heaters for three hours, just to bring the system into initial heat. This is not an economical process as it is very costly and time-consuming. As sugarcane cultivation is distributed over rural areas in Sri Lanka, having portable device to accomplish this task is very much beneficial for the farmers. Therefore, this research is focused on introducing a portable bagasse powered steam generator (Hereafter call as preheating device) and turning of the total system into a hybrid hot water treatment plant with the purpose of saving electricity and time in a considerable amount.

2. DESIGN AND FABRICATION

2.1 Development of the concept - Pre-heating device was designed by combining the concepts of shell boiler and water tube boiler. By considering thermal properties and availability, sugarcane bagasse was selected as the biomass energy source for heat generation inside the pre-heating device. steam was selected as the heat transferring media. Direct steam injection system was identified as the best fit for heating, as it can be used for precise and instantaneous temperature control (Hydro-Thermal Corporation 2018) of the water inflow of hot water treatment plant. By calculating the steam energy requirement of pre-heating process, device specifications for feed water, steam, fuel energy and blow down were defined. Automated feed control system, burner control system and steam convey and Injection system were designed to maintain calculated specification of the device (Figure 1).

2.2 Modeling the detailed design - The system components were designed according to properly defined dimensions by using parametric 3D modeling software. Then, the developed parts were

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assembled using the same (Figure 2). The simulation process was conducted by using Finite Element Analysis (FEA) for air flow simulation and temperature variation inside the assembly (Figure 3). Based on observations, modifications were made.

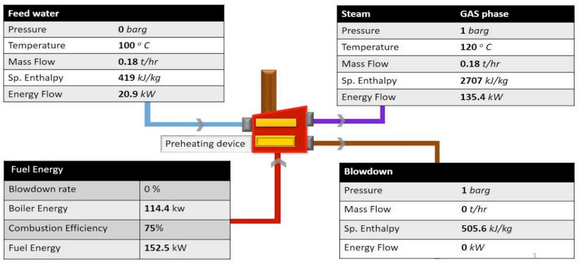

Figure 1 Specifications for the preheating device

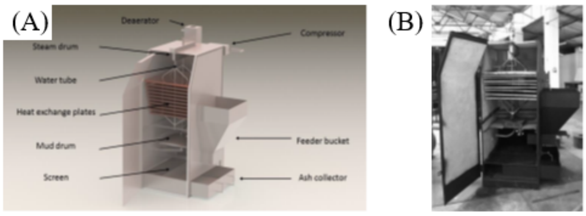

Figure 2 Parametric 3D design (A) and fabricated device (B)

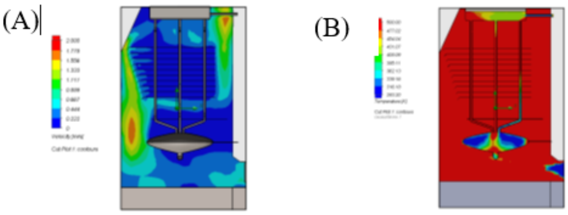

Figure 3 Air flow simulation (A) and temperature variation (B)

2.3 Fabrication of the preheating device - Main heat exchange unit (Steam & Mud drum - Zinc coated Mild steel plates, Water tube - Copper tube, Heat exchanging plates - Zn coated mild steel) was fabricated and successfully tested up to 5 barg pressure. Casing of the device was fabricated by using mild steel angle iron and AISI 1020 Mild Steel plates. High Alumina Castable (HAC) 52 was used as the internal insulation material of the casing. The bagasse feeder bucket was designed as a movable part, by considering the repose angle of bagasse (82^{o} from field Experiment) and architecture of the design. The main burner assembly was made from black iron pipe fittings to initiate bagasse burning inside the device. Safety valve (1' maximum- 7barg), Pressure reducing valve (1/2',1 -10 barg), Gauge glass & fittings, Pressure gauge (maximum- 7 barg), Air vents & vacuum breakers and Modulated steam injector were used according to the designed control systems.

3. Results and Discussion

Fabricated pre-heating device was tested and evaluated by providing feed water and bagasse. Results obtained from the evaluation; Steam production rate - 194 kg/hr, Average steam temperature - 122.75 ^{o}C, Working pressure - 1 barg, Tested pressure - 5 barg, Time required to bring the system into working pressure - 16 min, Amount of air dried bagasse required to bring the system into working pressure - 4.7 kg, Total bagasse requirement for one tone of seed cane treatment - 65 kg, indicated that newly designed device fulfills the defined specifications. Further, Device efficiency, Reduction of electric energy consumption, Reduction of time consumption and Production cost recovery period were evaluated as 80.17%, 99.17%, 37% and 1 year respectively.

4. Conclusion

The preheating device was successfully designed as a solution to high energy and time consumption of the Seed cane hot water treatment plant at initial heating process. Newly designed preheating system reduced the time and electric energy consumption at the initial stage by 37% and 99.17% respectively. According to the evaluation results, efficiency of the preheating device was 80.17%.

5. References

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