BUSITEMA UNIVERSITY
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FACULTY OF ENGINEERING

DEPARTMENT OF CHEMICAL AND PROCESS ENGINEERING

DESIGN AND SIMULATION OF AN AUTOMATED STEAM PRESSURE CONTROL SYSTEM FOR A BAGASSE FIRED BOILER

By

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ABSTRACT

The sugar industry has been able to adapt cogeneration as a self-reliable opportunity in manufacturing with bagasse as its fuel. The bagasse fired boilers convert chemical energy in bagasse to thermal energy and this process is characterized by high pressures and temperatures. Currently, the steam pressure control in many sugar industries including SCOUL (case study area) is manual which does not offer many benefits to boiler operations such as energy saving, reduction in downtime, increase in boiler efficiency and reduction in hazards among others.

This study has focused on designing and simulating an automated steam pressure control system using the bagasse feeders and forced draught fans as actuators in the control of feeding rates of bagasse and air respectively. Pressure is controlled automatically using the programmable logical controller (PLC) and is measured using a pressure sensor. The system was modeled using Matlab Simulink tool, Arduino for coding and Proteus for simulation. The design consist of a microcontroller to receive input signals from the pressure sensor, processes the data acquired and sends the output signal to the LCD to be displayed.

The results of the study show that the designed system was able to maintain the steam pressure within the safe operational range of a medium pressure (1.5 – 2.0 MPa or 225 – 300 psi) bagasse fired boiler and there was a direct proportionality between the steam pressure and temperature at the super heater. The simulation validated the expected behavior of system hardware and technically economical when implemented.

Sugar industries should adopt the designed system to better steam pressure control in bagasse fired boilers and reduce hazards. Further work is required to improve the steam pressure control of a bagasse fired boiler with recommendations such as inclusion of a bagasse drier, considering boiler loads and a dumping grate type of furnace design among others.

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DEDICATION

This work is dedicated to my dear parents; Mr. Girawal Emmanuel and Mrs. Grace Iyobot Girawal, lovely family members and all friends for the love and support. May the good Lord Almighty continue to bless you abundantly!

DECLARATION

I **Kinene James** declare to the best of my knowledge that the work presented in this final year project report is my own and has never been presented to any University or higher institute of learning for any academic award.

Signature.....

Date.....23rd/MAY/2016.....

APPROVAL

This final year project report has been submitted to the Department of Agro-Processing Engineering for examination with approval from the following supervisors:

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(MAIN SUPERVISOR)

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Eng. Godfrey Ssajja Ssali

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Date.....

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LIST OF ACRONYMS

B.F	-	Bagasse Feeder
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
F.D.	-	Forced Draught Fan
GCV	-	Gross Calorific Value
H_2O	-	Water
I.D.	-	Induced Draught Fan
MPa	-	Mega Pascal
MW	-	Mega Watts
MWh	-	Mega Watts hour
NCV	-	Net Calorific Value
O_2	-	Oxygen
pH	-	Potential Hydrogen
PSI	-	Per Square Inches
SCOUL	-	Sugar Corporation of Uganda Limited
TPD	-	Tonnes Per Day
TPH	-	Tonnes Per Hour
VFD	-	Variable Frequency Drive

CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter contains the background of the study, problem statement, objectives, purpose, justification and the scope including the limitation to the study.

1.1 Background

Sugar cane is a major commercially grown agricultural crop in the vast majority of countries in Africa. It is one of the plants having the highest bioconversion efficiency of capture of sunlight through photosynthesis and is able to fix around 55 tonnes of dry matter per hectare of land under this crop on annually renewable basis, (Isabirye *et al.*, 2013). In Uganda, the sugar industry is one of the oldest industries in the country, with its history dating back to early 1920. By the 1960's, the sector's annual production was about 140,000 tonnes of which 120,000 tonnes was for domestic consumption and 20,000 tonnes for export. It is estimated that Uganda's domestic demand shall be close to 500,000 metric tonnes by the end of 2015. In addition, the factories will be encouraged to produce close to 100 megawatts of "green" electricity from burning bagasse, mainly for their own use and the surplus will be offloaded for sale to the national grid. This will help ease the power shortfall that Uganda is currently facing, (Edwards, 2013).

The sugar cane processing industry has played an important role in many developing countries like Uganda, where agricultural activities provide the best potential for labour- absorption in rural areas (Real, 2014). In the traditional sugar cane factories, the existence of high energy consumption and pollution into the environment are largely due to the low-efficiency technology they have. Most cane sugar factories have been designed to be energy self-sufficient, with sugar as the primary product. A bagasse fired cogeneration system, made up of medium pressure boilers (1.5 – 2.0 MPa or 225 – 300 psi) plus small steam driven turbo alternators, provides all the steam and electricity needed to run the mill and factory, leaving little surplus bagasse. Low efficacy boilers are typically used in the sugar industry to generate power by direct combustion of bagasse with a maximum efficiency of 26%. Pyrolysis and gasification can achieve higher energy conversion than combustion (Garcia-Perez *et al.*, 2002).

Bagasse fired boilers constitute vital energy sources for the sugar cane processing industry because they guarantee energy production in a relatively economic way through the use of bagasse as fuel, which represents waste coming from the industry itself. These boilers are characterized by a

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