FACULTY OF ENGINEERING

DEPARTMENT OF CHEMICAL AND PROCESS ENGINEERING

DESIGN AND SIMULATION OF AN AUTOMATED BATCH VACUUM PAN CONTROL SYSTEM FOR SUGAR CRYSTALLISATION

BY

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ABSTRACT

In Uganda sugar is manufactured from sugar cane and about 60% of sugar produced worldwide is from sugarcanes which is a perennial grass containing sucrose. This project deals with control system for a batch vacuum pan during sugar crystallisation by controlling the temperatures and feeding of materials automatically and monitors supersaturation and crystal content online. Sugar crystallisation has been for quite long time when it manual and its associated with a lot of problems such as labour intensive, wastes energy, time consuming, variation in quality that is size and colour of sugar. The research of the study was conducted at GM Sugar Ltd located in Buikwe District, Nakibizi by carrying out extensive literature review, observation, consultation and laboratory test by use of refractometers, Polari meter to know the purity and brix of materials so as to exactly know about the problem so as to generate a solution for it during production of A sugar for commercialisation. From research the major parameters were supersaturation, crystal content, temperature and feeding of materials, therefore the control system was designed by modelling different equations for each parameter and their relationship was determined. The code was developed by use of Arduino software with the help of language C, and the simulation diagram was designed in the simulation environment in Proteus software to enable the code to be loaded on the circuit to run the system and results were displayed on the LCD. The control system contains four sensors which measure and send signals to the micro-controller for it to make decisions and tell acuactuator valves, alarms and led light on what to be done. The temperature ranges of crystallisation was between 65-70°C, average initial crystal content was 24% and feed level of materials were 40% syrup above the calandria at the start of the process, 30% seed when supersaturation is 100%, 20% syrup when crystal content is at 32% and finally 10% syrup when crystal content is at 42%,therefore the crystallisation ends when crystal content is above 48% and showed that it requires 2.5 hours for crystallisation to end since parameters were controlled properly and in 6.5 minutes the crystal content would have increased by 1%. On the simulation circuit the parameters were varied on the sensors to test its validity, results were displayed on the LCD and relation was observed. The economic evaluation of the project was carried out by use of NPV method and it showed that the project is viable once it's being implemented since estimated initial investment was 28,000000 UGX and in five years the estimated NPV was 1,280,900,000. The control system increased the quality of sugar and production, cost of production and down time was reduced and energy was saved therefore much has been done but further work is needed on control of crystal size distribution and circulation of massecuite plus the control of parameters during production of B sugar and C sugar.

DECLARATION

I **KESI DOUGLAS** pursuing a Bachelor of Science in Agro-Processing Engineering at Busitema University hereby declare that the information in this project report is out my effort and it has never been presented for a degree course in any institution or university.

Signature.......................................

Date...20/05/2016...........

APPROVAL

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

Main supervisor

Mr. DDUMBA LWANYAGA JOSEPH

Date.............................

Co. supervisor

Mr. KILAMA GEORGE

Date.............................

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DEDICATION

I dedicate this report to my mother Mrs. Kyomuhendo Komugisha Bonny, my uncle Mr. Kazoora John Bosco, my brother Mulamba Rogers and my sisters Nyamwija Ristella, Arinaitwe Caroline and Kemigisha Immaculate, my father the late Mr. Nkomawo Stanley, to all my family members and friends for their continuous guidance, support, knowledge and wisdom that they have given me all my life and for financing me up to date.

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WBG – World Bank Group

CCS – Commercial Cane Sugar

FAO – Food Agricultural Organisation

GMSL – GM Sugar Limited

CC – Crystal content

CCo –Initial crystal content

CCm – Crystal content of massecuite

SS - Supersaturation

SSm – Supersaturation of massecuite

SSo – Initial Supersaturation

LCD – Liquid Crystal Display

PLC – Programmable Logical controller

CHAPTER ONE: INTRODUCTION OF PROJECT REPORT

1.0 Introduction

This introduces what research of study is about and give a clear view of the problem being solved and the objective and the purpose of the project.

1.1 Background

The sugar industry processes sugar cane and sugar beet to manufacture edible sugar. More than 60% of the world's sugar production is from sugar cane; the balance is from sugar beet. Approximately 10% of the sugar cane can be processed to commercial sugar, using approximately 20 cubic meters of water per metric ton (m3/t) of cane processed. Sugar cane contain70% water; 14% fiber; 13.3% saccharose (about 10 to 15% sucrose), and 2.7% soluble impurities (WBG 2007)

Sugar is initially extracted from the raw cane at sugarcane mills distributed throughout the growing region.(Regulator 2008). Sugar was first manufactured from sugar cane in India, and its manufacture has spread from there throughout the world. Chemically, sugar is the substance sucrose, which can be hydrolysed in acidic solution (i.e. below pH 7) to form the monosaccharaides glucose and fructose as follows.(Alberto et al. 2003)

Sucrose + H_2O → glucose + fructose

During sugar processing there is crystallisation process which uses either a continuous or batch vacuum pan for boiling syrup to form sugar crystals. Sugar crystallization occurs through the mechanisms of nucleation, growth and agglomeration. In the course of production, the crystallization phenomenon is driven by two mechanisms (Jancic & Grootscholten, 1984) that is mass transfer from dissolved sucrose to crystal surface and heat transfer in the calandria.(Alberto et al. 2003). Sugar crystallization is, and since the start of mass production more than 150 years ago remains a key part and plays a very important role in sugar manufacturing. For quite a long time the undisputed masters of the operations were the artisan sugar boilers or human operators who kept the process under control relying on their experience acquired during long years spent on the pan floor. The first instruments to assist the pan men appeared around the middle of the last century, but the real control of crystallization remained for a long time the same when it's manual (Rozsa 2011)

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