



**BUSITEMA
UNIVERSITY**
Pursuing Excellence

**FACULTY OF ENGINEERING
DEPARTMENT OF AGRICULTURAL MECHANIZATION AND
IRRIGATION ENGINEERING**

**DESIGN AND CONSTRUCTION OF A SIMPLE HAND
OPERATED SUGARCANE CRUSHER**

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ABSTRACT

Uganda's economy primarily depends on agriculture with about 80-90% of the population employed in farming accounting to 22% of the Gross Domestic Product (GDP). Sugarcane is one of the major commercial crops grown and processed in Uganda for both local consumption and export. Processing sugarcane is beneficial to the society and the country at large due to its many products which include sugar, alcohol, residues called bagasse is used as an animal feed a raw material for paper industries, as agricultural mulch among others.

There are large numbers of low income sugar cane farmers in Uganda who grow small acreages of sugar cane for subsistence use and for sale to earn family income but find it challenging to use electrical equipment which is expensive to purchase and maintain and thus not practical for the scale of production. These farmers try to utilize machines that use diesel engines which in turn prove to be expensive due to the cost of diesel. Further the existing manual crushers are relatively expensive, require a lot of energy to operate, and produce relatively poor quality juice. The low income sugarcane farmers of Uganda therefore need a low cost and affordable manual sugarcane crusher that can produce high quality juice without need for electricity and skills so as to improve incomes of the farmers and enhance livelihood of the farmers' families. The objective of this project is therefore to design, fabricate and test for the efficiency of hand operated sugarcane crusher

The design of various components took place through careful analysis of the forces acting on the them as this enabled in proper selection of the force resistant materials. plain carbon and mild steel materials plus Aluminium were the major ones used in the fabrication of the prototype due to their suitability for the project and availability. Engineering drawings produced were used in the fabrication of the different components of the machine after which assembly was carried out through welding and use of bolts and nuts.

The prototype was tested for its efficiency and capacity and the results indicated an overall efficiency of 65% and a capacity of 73kg/hr. The costing of the machine was 593,000 Uganda shillings.

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In addition, i would like to thank the management of AEATREC –Namalere mostly the workshop chief technician Mr.Ssasa Richard for accepting me to use their machines in the production of the prototype, may the almighty reward you so much.

Last but not least, more appreciation goes to NARO techicians and class mates that rendered support to me ,encouraged me and so much cared to see that i finish my project.

DEDICATION

With great honor i would like to dedicate this report to my dear parents Mr. Barigye John and Mrs. Natukunda Sikola for their financial and moral support.

DECLARATION

I **Muhumuza Jimmy** solemnly declare that the information contained in this report is mine and has not been presented to any University or higher institution of learning for any academic award.

Signature..........

Date.....08/06/13.....

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APPROVAL

This research project report has been submitted for examination with approval from the following supervisors.

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LIST OF ACRONYMS

GDP – Gross Domestic Product

UBOS – Uganda Bureau of statistics

SCOUL – Sugar Cooperation of Uganda

NARO – National Agriculture Research Organization

FAO – Food and Agriculture Organization

AEATREC – Agricultural Engineering and Appropriate Technology Research Centre

USCTA- Uganda Sugarcane Technologists' Association

Kg –kilogram

hr- Hour

g – Acceleration due to gravity

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Agriculture is the backbone of Uganda's economy with about 80-90% of the population employed in farming accounting to 22% of the Gross Domestic Product (GDP). (*Uganda Bureau of Statistics (UBOS), statistical abstract 2012*). Sugarcane (*Saccharum Officinarum*) is one of the major commercial crops grown and processed in Uganda for both local consumption and export. Sugarcane is a tropical, perennial grass that belongs to the family of grass called *Poaceae* and genus *Saccharum*. The sugar cane plant forms lateral shoots at the base to produce multiple stems, typically three to four meters high and about 5 cm in diameter. Sugarcane has long been grown in Uganda in very small quantities, but commercial production dates from 1921 when planting began at Lugazi (*The Geography of tea and sugar production in Uganda; O'Connor A.M*). Sugar cane is mostly grown in Eastern Uganda in the districts of Iganga, Jinja, Kamuli and also in Hoima and Masindi districts in Western Uganda. Sugarcane consumption in Uganda is estimated to be 9kg per head per annum with a predicted sugarcane consumption per annum expected to increase by 1% over the next 15 years (*USCTA Annual Report 2009*). There are existing large scale sugar cane processing industries in Uganda, namely Kakira sugar works, Kinyara sugar works, Mayuge Sugar Works and Sugar Cooperation of Uganda Ltd (SCOUL).

The first step in sugarcane processing involves juice extraction through crushing of the sugar cane. The large scale sugar processing industries are engaged in processing of sugarcane using sophisticated modern equipment which utilizes electrical power for juice extraction and further processing of the extracted juice. There are also large numbers of low income sugar cane farmers in Uganda who grow small acreages of sugar cane for subsistence use and for sale to earn family income. The modern sugar cane processing equipment is expensive and not practical for the scale of production of the local small scale sugar processors. Thus these small scale sugar cane farmers face a big challenge to process their sugarcanes at their level of production. The prevailing sugarcane crushing methods used by the small scale sugarcane farmers include use of machines that utilize diesel engines that are expensive to local farmers in terms of purchase and

REFERENCES

- Abamaster Incorporated (2010), counter top Sugarcane Juice Extractor.
- Anon, [http:// www.macalester.edu/geography/agr/journals/196](http://www.macalester.edu/geography/agr/journals/196), accessed on 11th-10-12
- Anon, <http://www.jstor.org/stable/621700>, accessed 5th/10/12
- Anon., Sugar production from cane sugar, www.appropedia.org, Accessed 2nd/10/12
- Bhandari V.B., (2007), Design of Machine Elements, Second Edition, ISBN 0-07-061141-6, 978-0-07-061141-2, Published by McGraw-Hill Companies
- Bhandari V.B., (2007), Introduction to machine design, 8th edition, published by Tata Mc Graw Hill publishing company limited, ISBN-13:978-0-07-043449-3.
- Budynas-Nisbett, (2006), Shigley's Mechanical Engineering Design, Eighth Edition, ISBN: 0-390-76487-6, published by McGraw – Hill
- [com/products/Sugar-Cane-Juicer-Machines-Presser-Counter-Top-model%2C-1- HP.html](http://www.products/Sugar-Cane-Juicer-Machines-Presser-Counter-Top-model%2C-1-HP.html)
- DEP agro Machineries Private Limited, [http://www.dep agro machines.com](http://www.dep_agro_machines.com)
- Hanna L. W. (1970), Climatic Influence on Yields of Sugar-Cane in Uganda
- http://www.alibaba.com/productgs/575769020/2012_Best_Selling_Manual_Sugarcane_Juicing/howimage.html
- <http://zzditai.en.alibaba.com>
- Kaul R.N. and Egbo C.O, (1985), Introduction to Agricultural Mechanization, Macmillan, London, England, UK
- Khurmi R.S and Gupta J.K., (2005), Text book of machine design, Fourth Edition
- Methods of crushing sugarcane <http://www.ehow.com> › Business, accessed on 15th-10-12
- O'Connor A.M., (1965), East Africa Geography; The geography of tea and sugar production in Uganda, Revision number 3, page 3
- Rika Susan (2010), Article: A Household Sugarcane Juicer Only a Sweet Dream?
- Spotts M.F, (1985), Design of Machine Elements, 6th edition, Prentice Hall, Englewood Cliffs, NJ, USA
- Spotts M.F, Shoup T.E and Hornberger L.E., (2003), Design of Machine Elements, 8th Edition, ISBN 0-13-048989-1, published by Pearson Education, Inc.

Uganda Bureau of Statistics, (2012), Statistical *abstract*, UBOS, Kampala, Uganda
<http://www.ubos.org/2012%20Census%20Final%20Reportdoc.pdf>.

Wikipedia, (2010), Sugarcane, <http://en.wikipedia.org/wiki/Sugarcane>

www.abamaster.com/productSpecWeb.php?modelId=2000

www.ezinearticles.com/?expert=Rika_Susan.

Zama Enterprise (2010), Sugarcane Juicer Machine Presser, www.zamaenterprise.com.