UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF PROTOTYPE SUGAR CANE JUICE EXTRACTION MACHINE (MECHANICAL)

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics and Automation) with Honours.

By

MUHAMMAD AFIQ BIN YUSOF

900529-01-6277

B050910083

FACULTY OF MANUFACTURING ENGINEERING

2012

DECLARATION

I hereby, declared this report entitled “Development of Prototype Sugar cane juice extraction machine (mechanical)” is the results of my own research except as cited in references

Signature	:	
Author’s Name	:	MUHAMMAD AFIQ BIN YUSOF
Date	:	3 JUNE 2013

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering in Robotics & Automation (Hons.). The member of the supervisory is as follow:

…….

(Project Supervisor)

ACKNOWLEDGEMENT

First of all, praises to Allah god almighty for His guidance and bless. I would like to express my gratitude upon every individual who helped me in developing this project. I would like to thank my family for their encouragement, Mr Yusof Ahmad my father who gave me all the support and solutions, Mr Mahasan Mat Ali my supervisor for giving support through day and night, all the staff of faculty of manufacturing engineering who helped directly or indirectly, my partner, Amin who sacrificed a lot for accomplishing this, my friends Zaafaran, Farkhan and fellow friends. I would also like to thanks the company that involved in this development, Aname Technologies Sdn Bhd and Spectronic Precisions Sdn Bhd, suppliers and everybody.

ABSTRAK

Tujuan projek ini adalah untuk membangunkan sebuah prototaip mesin perahan jus tebu. Kajian ini adalah untuk mengintegrasikan mesin perahan yang sedia ada di pasaran dengan beberapa ciri-ciri tambahan. Tujuan membangunkan projek ini adalah untuk merevolusikan industri jus tebu tempatan. Dengan kewujudan mesin yang boleh beroperasi dalam keadaan bilik tertutup, ia membantu dalam menaik taraf jus tebu industri ke satu tahap yang lain. Beberapa ciri-ciri tambahan yang ditambah kepada mesin perahan jus tebu adalah sistem pembersihan dan penghancuran hampas tebu. Tebu batang mula-mula dihancurkan untuk mendapatkan jus; serat sisa (hampas tebu) kemudiannya dipotong menjadi lebih kecil dan disimpan di dalam tong. Mekanisme penghancur akan dibersihkan secara automatik menggunakan sistem pembersihan.

ABSTRACT

The purpose of this project is to develop a prototype of sugar cane juice extraction machine. This study is to integrate the existing extraction machine with few additional features. The reason of developing this project is to revolutionise the local sugar cane juice industry. With the existence of machine that can operate in closed room condition, it helps in upgrading sugar cane juice industry to another level. Few additional features added to the juice extraction machine are cleaning system and bagasse crushing and collecting. Sugar cane stalk is first crushed to extract the juice; the left over fibre (bagasse) is then cut into smaller pieces and stored in a bin. The crusher mechanism will be cleaned automatically using cleaning system.

TABLE OF CONTENT

ABSTRACT ii

TABLE OF CONTENT iii

LIST OF TABLES vii

LIST OF FIGURES viii

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE xi

CHAPTER 1 : INTRODUCTION

1.1 Problem Statement 1
1.2 Project Aim 2
1.3 Objectives 2
1.4 Scope 2

CHAPTER 2 : LITERATURE REVIEW

2.1 Sugar cane juice extraction machine 3
2.1.1 Conventional sugar cane juice extraction machine 4
2.1.2 Modern sugar cane juice extraction machine 5

2.2 Working principle of sugar cane juice extraction machine 6
2.2.1 Sugar cane juice extraction method 7

2.3 Advantages and disadvantages of extraction machine 8
2.4 Research study on sugar cane juice extraction machine 9
2.4.1 Rolls 9
2.4.2 Crusher rolls 10

2.5 Research study on spray nozzle for cleaning purpose 11
2.5.1 Type of nozzle 11
2.5.1.1 Hydraulic fine spray 12
2.5.1.2 Air atomizing 12
2.5.1.3 Comparison of hydraulic and air atomizing 12
2.5.2 Spray pattern 13
2.5.2.1 Full cone pattern 13
2.5.2.2 Hollow cone pattern 14
2.6 Research study on collector structure for bagasse 15

CHAPTER 3 : METHODOLOGY

3.1 Flow chart 16
3.2 Background Research 18
3.3 Conceptual design and ideas 18
3.3.1 Conceptual ideas sketch 1 19
3.3.2 Conceptual ideas sketch 2 20
3.4 Detail Design 21
3.5 Fabrication 21
3.5.1 Crushing mechanism 21
3.5.2 Bagasse Collector 22
3.5.3 Cleaning system 22
3.6 Testing and Troubleshooting 22

CHAPTER 4 : RESULT AND ANALYSIS

4.1 Mechanical development 24
4.1.1 Chassis Structure 25
4.1.2 Crusher Mechanism 27
4.1.3 Gearbox 28

4.1.3.1 Helical gear 30
4.1.3.2 Bevel gear 31
4.1.4 Drive system 32
4.1.4.1 Pulley and belting 33
4.1.4.1.1 V-belt 33
4.1.4.1.2 Pulley 34
4.1.4.2 Electric AC Motor 35
4.1.4.3 Chain and Sprocket 36
4.1.5 Bagasse Cutter 38
4.1.5.1 Base plate 39
4.1.5.2 Blade 41
4.1.6 Cleaning System 43
4.1.6.1 Water rail 43
4.1.6.2 Water pump and tank 45
4.1.7 Solenoid valve for juice valve 47
4.1.8 Waste bin 48
4.2 Testing and Analysis 49
4.2.1 Solidworks 2011 Stress test simulation 50
4.2.2 Sugar cane juice analysis 52
4.2.2.1 First stalk medium size 52
4.2.2.2 Second stalk small size 53
4.2.2.3 Third stalk medium size 54
4.2.3 Bagasse analysis 56
4.3 Calculations 57

CHAPTER 5 : CONCLUSION AND FUTURE RECOMMENDATIONS

5.1 Conclusion 60
5.2 Future recommendations 61

REFERENCES 62

APPENDICES

A	Drawing and design concept parts of prototype	63
B	Solidworks simulation test for chassis structure	67
C	Solidworks simulation test for gearbox	71

LIST OF TABLES

1	Comparison table of conventional and modern machine	8
4.1	AC Motor description	36
4.2	Water pump description	46
4.3	Study results for chassis structure	50
4.4	Study results for gearbox	51
4.5	Table of sugar cane juice extracted	55

LIST OF FIGURES

2.1	Conventional sugar cane juice extractor machine	5
2.2	Two types of sugar cane juice extraction machine power source	6
2.3	Flow process of juice extraction machine	6
2.4	Flow process of extracting sugar cane juice	7
2.5	Rolls assembly on juice extraction machine	10
2.6	Example of tooth crusher rolls	11
2.7	Comparison between hydraulic fine spray and air atomizing	13
2.8	Full cone spray pattern and nozzle	14
2.9	Hollow cone spray pattern and nozzle	14
2.10	Side view of bagasse collector	15
3.1	Process flow chart	17
3.2	Concept of extracting sugar cane juice	18
3.3	Conceptual ideas sketch 1	19
3.4	Conceptual ideas sketch 2	20
4.1	Mechanical development tree diagram	25
4.2	Front section of chassis structure	26
4.3	Rear section of chassis structure	27
4.4	Crusher mechanism structure	28
4.5	First part of gearbox on chassis	29
4.6	Second part of gearbox for converting axis of rotation	30
4.7	Helical gear mounted on chassis and pulley for speed reducer	31

4.8	Bevel gear for changing direction of rotation	32
4.9	V-belts used for pulley and belting system	34
4.10	Driver pulley on motor and driven pulley	35
4.11	AC Electric Motor	36
4.12	Sprocket and chain used	37
4.13	Sprocket attached on gearbox	37
4.14	Sprocket attached on gearbox	38
4.15	Bagasse cutter arrangement	39
4.16	Base plate design using Solidworks 2011	40
4.17	Base plate attached on chassis before chroming process	40
4.18	First design of primary blade	41
4.19	Second design of primary blade	42
4.20	Secondary blade	42
4.21	Water rail for cleaning system	44
4.22	Water rail installed on hopper	44
4.23	Drawing for water tank	45
4.24	Acrylic water tank	46
4.25	Submersible and adjustable water pump	47
4.26	Solenoid valve	48
4.27	Design of waste bin for bagasse	49
4.28	Testing and Analysis diagram	49
4.29	Chassis stress test simulation	50

4.30 Gearbox stress test simulation 51

4.31 Sugar cane with 71 cm long 53

4.32 Sugar cane with 90 cm long 54

4.33 Sugar cane with 50 cm long 55

4.34 Bagasse collected 56

4.35 Gear positioning for speed reduction 57

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
AC	-	Alternating Current
PSM	-	Projek Sarjana Muda
CNC	-	Computer Numerical Control
NC	-	Numerical Control
RPM	-	Revolution per minute

CHAPTER 1

INTRODUCTION

Sugar cane is commonly known as the source for making granulated sugar for daily consumption. Sugar cane also quiet tough to crush to extract the juice. This plant is made up of strong fibre. It is also known for its toughness and shape which is long straight plant like bamboo. Besides being the main ingredient for making sugar, it also extracts a healthy juice. Sugar cane juice is popular on Asia and India subcontinent as it is a path for migration thousands of year back. The juice can be drink directly after crushing the sugar cane. In order to crush this hard sugar cane, it needs a very strong roller and force to crush it, hence squeeze the juice out of the plant. Crushing sugar cane and extracting the juice has been done since the early days manually.

As for now, people become less interest drinking this juice because it is difficult to find a clean and proper process in producing the juice. Mostly, sugar cane juices were sell on the side of the road, which is not very clean due to blowing of dust and germs with wind. Sugar cane juice is best drink fresh and chilled. A clean processing mechanism and proper disposing of its fibre is seen as an interesting option to upgrade the crusher machine in the market. The fibre of sugar plant after extraction is called bagasse.

1.1 Problem Statement

Most sugar cane juices were sold on a small business with a conventional extraction machine. Usually sugar cane farmer will supply directly to the small businesses. It is the conventional method. A new transition of sugar cane juice industry could change the chain cycle of farmer and sugar cane juice seller. Sugar cane from farm will go to the warehouse where cleaning, peeling, cutting and packaging takes place. From warehouse, the packed sugar cane will go to the sugar cane juice seller. A sugar cane juice extractor machine with a proper disposal of bagasse is needed to operate on a closed room environment such as shopping complex. The bagasse from the extractor machine will then be made as decomposed fertilizers and will be used by sugar cane farmer.

1.2 Project Aim

Develop an extractor machine for sugar cane with a proper disposal of bagasse and can be operated on a closed room environment.

1.3 Objective

The objective is to develop a prototype of sugar cane juice extractor machine with a bagasse collector.

1.4 Scope

The scope of this project consists of:

1. Develop the juice extraction mechanisms for sugar cane juice extraction.
2. Develop a cleaning system.
3. Set up a bagasse cutter and collector.
4. Set up filter for sugar cane juice.

CHAPTER 2

LITERATURE REVIEW

Under this chapter of literature review, it relates and focuses on the studies that related to the project. It aims to review the critical points of current knowledge in a particular topic. This chapter relates the objective of this project based on the studies. For this chapter it starts with explanation and information on sugar cane juice extractor machine. Two types of extractor machines which is conventional and modern extractor machine is explained and compared. The comparison takes place in terms of advantages and disadvantages of both machines. The major part of this project which is the requirement of the company is highlighted for designing purposes. In this chapter, it also explains how sugar cane juice extractor machine works. The information, ideas and knowledge were gained from books, journal article and research. Related information and graphics also was shown to provide guidelines for this project.

2.1 Sugar cane juice extraction machine

Sugar cane juice extractor machine is a machine used to extract the juice from sugar cane. Sugar cane juice extractor machine were built since 1800 years back and it's been evolving since. These juice extractor machines were built to help human extract the juice from sugar cane through crushing and rolling process. Sugar canes are

popular on country such as India, Thailand, Brazil, China and India subcontinent. The development of this machine has been started hundreds years back on many countries. Crushing a sugar cane requires strong force due to its strong and hard characteristics. Juice extractor machines were built mostly focused on the mechanical of the machine. The efficiency of machine depends on the mechanical system that has been designed on the machine. Mechanical power is the most essential needs in these identified areas (Olaoye, 2011). There are two types of sugar cane juice extractor machine that can be categorised under this topic which is the conventional juice extractor and modern juice extractor.

2.1.1 Conventional sugar cane juice extraction machine

Conventional sugar cane juice extractor machine were used for a long time because it is cheap and last longer. Conventional machine is a simple machine consists of several gears, rollers and lever attached on a cast iron chassis body. Most conventional machines are made up from cast iron material which is strong and durable. These machines were made by simple mechanism of rolling and crushing (Kulkarni, 2005). Human force is required to extract the juice using this machine. A lever is attached on a set of gear, when the lever is spin manually by hand, both rollers will spin to crush sugar cane. This process required lots of energy because sugar cane is hard to crush and sugar cane needed to be crush repeatedly. Most conventional machine consist only a set of roller.

Conventional machine operates on exposed extraction mechanism which is not hygienic for food and beverages standards. Besides that, rust on the surface of the roller also may affect the quality of the juice and contaminate the juice.

Figure 2.1: Conventional sugar cane juice extractor machine

2.1.2 Modern sugar cane juice extraction machine

In this modern day, sugar cane juice seller uses modern extractor machine because it does not require force to extract the juice. Modern sugar cane juice extractor machine uses motor in solution of replacing the human force. There are two types of power source, petrol engine and electric motor. Petrol engine were introduced to sugar cane juice extractor machine before electric motor. Belting is used to transfer the force from the engine to sets of gear. Petrol engine produce loud noise during operation and emit harmful gas such as Carbon Monoxide.

Electric motor is introduced for sugar cane juice extractor machine as a solution for petrol engine generator. Electric motor does not produce loud noise and emit harmful gas unlike petrol engine. However, the bigger the torque of motor, the more current it consumes to operate. Most electric motor powered extractor machine uses spur gear for force transmitting and load reduction. The forces from motor are rotating on the same rotation axis of the roller. The currently available sugarcane juice extractors require high energy and sophisticated mills, driven mechanically (Olaoye, 2011).

(a) (b)

Figure 2.2: Two types of sugar cane juice extraction machine power source (a) Petrol engine (b) Electric motor

Source: http://thiruvananthapuram.olx.in, www.asia.ru

2.2 Working principle of sugar cane juice extraction

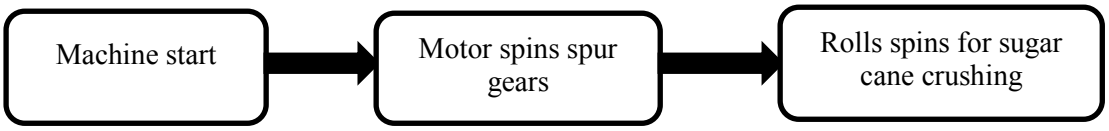

Figure 2.3: Flow process of juice extraction machine

The development of a small scale sugarcane juice extractor was therefore to meet the needs of the small scale farmers who cannot afford the high capacity and complex cane crushers. This successfully project designed and constructed a simple mechanical device for extraction of sugarcane juice (Olaoye, 2011). The concept of sugar cane juice extraction machine is simple crushing mechanism consists of sets of

gears and rolls. The gears and rolls are powered by the AC (Alternating Current) electric motor.

When machine is turned on, voltage is supplied to generate the electric motor. Spur gears are attached to the motor. Voltage supplied causing the motor to spin; the motion is then transferred to the rolls through sets of spur gears. Sugar cane will be fed between the rolls with grooved surface. Compression occurs due to smaller area between rolls than diameter of sugar cane. The compression occurs through the whole stalk causing the juice to be extracted. The load of compressing the sugar cane is reduced by spur gears. The load is distributed and reduced for less power consumption.

2.2.1 Sugar cane juice extraction method

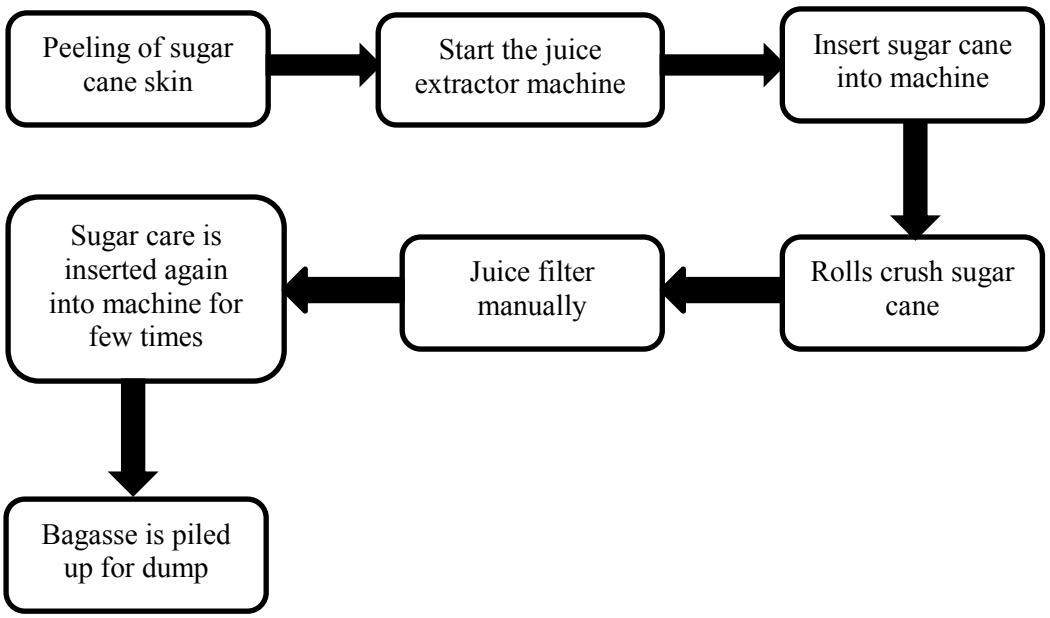

Figure 2.4: Flow process of extracting sugar cane juice

Extracting sugar cane juice is quite messy using existing sugar cane juice extraction machine. First, the skin of sugar cane is peeled using knives or machine. Mostly sugar cane juice seller uses knife due to high cost of stripping machine. After the

outer skin is peeled, it is fed into the operating extraction machine. The crushed sugar cane will be strained and came out from behind of the machine. It is then inserted again into the machine to extract more juice. The juice is collected from the tip of the machine. The juice extracted is then filtered from its fibre. The small fibre is filtered because it may cause discomfort to throat when consuming. After juice extraction occurred, the bagasse is piled up for dumping.

2.3 Advantages and Disadvantages of Extraction machine

Table 1: Comparison table of conventional and modern machine

Type of machine	Description	Advantages	Disadvantages
• Conventional juice extractor	• Mostly made from cast iron • Opened machine • Normally consists of 2 rolls	• Simple mechanism • No electricity needed	• Easy to rust • Manually powered by human • Sugar cane needs to be crushed for few times (repeating)
• Modern juice extractor	• Mostly are made from stainless steel and aluminium • Consists more than 2 rolls	• Easy to operate • Efficient rolls •	• Sugar cane needs to be crushed for few times (repeating) • No proper disposal of bagasse

From Table 1, it states the characteristics of the machines. User who uses conventional machine needs much effort in extracting the juice. Although the structure of the machine is simple, it needs repetition in crushing sugar cane because

it made up of only 2 rolls. The material used for the machines are the factor of rust occurring.

Modern machine uses electric motor to extract the juice. The rolls made for modern machine are more efficient than conventional because the surface of the rolls. Both conventional and modern needs repetition in crushing sugar cane and does not have a proper disposal of by product, bagasse.

2.4 Research study on juice extraction machine

It is mentioned by Olaoye (2011), the development of a small scale sugarcane juice extractor was therefore to meet the needs of the small scale farmers who cannot afford the high capacity and complex cane crushers. In this project, the study focuses on rolls for extracting the juice and crusher for bagasse. Sugar cane juice extraction machine that exist in the market today does not have a crusher for bagasse.

2.4.1 Rolls

As mentioned by Fernando (2007), the sugar cane juice extraction process (crushing) is made by compressing the shredded sugar cane between groove rolls. Groove on the rolls plays an important role for juice extraction. The groove on the surface of rolls is designed based on efficiency of extraction and for gripping sugar cane.