

# The Creation of Community Technology Innovation for Sugarcane Cutting Tractor Accessory by Community Participation of Community Technical and Knowledge

Rataphol Sangkhasuk<sup>a\*</sup>, Prakasit Sokrai<sup>b</sup>, and Jirawat Tungjitsommanas<sup>c</sup>

<sup>a,b,c</sup> Faculty of Industrial Technology, Phranakhon Rajabhat University, 9 Changwattana Road, Bangkok, Bangkok, 10020, Thailand

<sup>a\*</sup>Corresponding author

**Abstract**— This research aims to design and create innovations in sugarcane harvesting technology. In applying the wisdom of farmers in solving the problem of sugarcane harvesting in Chai Badan District, Lopburi found that there is an insufficient labor for harvesting, a lot of farmers burn sugarcane before harvesting, which affects the problem of PM2.5 air pollution, and insufficient sugarcane harvesters. They have to wait in line for a long time, and there is also a limit on the area where sugarcane harvester cannot enter the area. The study population consists of 30 people. Specific population groups were selected to provide 2 people for repairing agricultural machinery and 28 sugarcane farmers. Using participatory action research (PAR) techniques, which coordinate engineering knowledge and the knowledge base of people in the community using engineering design, the tractor accessory's structure is designed with the Solid Word program and has strength analysis by using the Finite Element Method (FEM). The pattern of sugarcane harvesting in the area can be divided into 3 types: 1) burning sugarcane harvesting, fresh sugarcane harvesting, and harvester harvesting. There is design and creation of an innovative prototype for community technology to produce tractor accessory. The prototype of the tractor's accessory has efficiency in sugarcane harvesting with a speed of 9.6 rai per day and a standard deviation of 1.14 rai per day. The average cost of sugarcane harvesting is 60 baht per rai.

**Keywords**— Community Technology; Sugarcane Cutting Tractor Accessory; Community Participation of Community

## I. INTRODUCTION

Sugarcane production in Thailand has developed the technology continuously including production processing technology to increase the value of the produce, production efficiency, and reducing production costs related to the use of agricultural machinery. There are a few studies that show the sugarcane harvesting process has the highest proportion of labor costs. This reflects the need for more machines to replace human labor [1]. Because of the shortage of labor in the agricultural sector, especially for sugar cane harvesting, the country has to import expensive tractor accessories, and sometimes the accessories do not work properly for the area. Studying guidelines on modern agricultural development according to the Thailand 4.0 policy will affect farmers in Thailand who provide innovative technologies to help develop society, the environment, and the economy to be a leader in sustainable modern agriculture. During the year of sugarcane production, the problems of insufficient labor and having higher labor costs caused the production costs to be high, but the price of the produce tends to be low [2]. The output from 2018 to 2019 is only 750 baht per ton. In the case of harvesting after burning, the price will be deducted from the original 30 baht per ton. In the case of harvesting 1 ton of sugarcane, there are labor costs for cutting about 150 baht per ton in the case of sugarcane burning. But if not burned, the cost of sugarcane cutting may increase to 250 baht per ton or account for 33% of the selling price. If using harvester, they must invest more than ten million baht to purchase which generally farmers unable to buy. In case renting a harvester, they have to wait in a queue for a long time due to the limited number of harvesters. Such problems enable us to create community technology innovations like sugarcane cutting tractors' accessories. A tractor is a basic tool that is used in the local agriculture area. Therefore, the concept was created in accordance with the technique and knowledge of the community. It is able to harvest the sugarcane with high efficiency, and the price is not expensive when compared with imported technology. Of such importance, it was able to solve the problem of labor shortages in sugar cane harvesting. It can also solve environmental problems from sugarcane burning before harvesting, which causes air pollution of PM 2.5 as well [3].

Development of sugarcane harvesting by using technology instead of human labor based on related research consist of the disadvantages analysis of traditional sugarcane cutting machinery that has the following disadvantages: high center of gravity, easy obstruction and high waste disposal rates, etc. [4]

The analysis and experiment of flow patterns in sugar cane cutting machinery and get the leaves out to improve the efficiency by keeping the distance between the rotary blade and the fixed blade which Sugarcane leaves will be cut off more easily [5]. Optimization and simulation of cutting process, there are three factors studied; a rotational speed of the grinding drum (RS), the overlap length of the upper and lower blades (OL), and the angle of inclination (BA) and Box-Behnken design [6]. Analysis and

simulation experiments of the peeling process of harvester. Optimal operating parameters can effectively improve the peeling quality. The sugarcane peeling process was simulated to analyze the change in pressure and force of sugar cane leaf cutting [7]. Articulation cutting is designed within the basic system of the machine in order to prevent damage to sugar cane buds and to cut cane joints automatically in breeding sugarcane. It can meet the needs of agriculture and the bud damage rate is zero [8]. A design of sugar cane leaves peeling by applying slider-crank mechanism [9]. In addition, analysis of sugar cane chopper blades at steel grades and heat treatment processes [10]. Thailand has solved a problem of sugar cane harvesting human labor and Reduce burning sugarcane harvesting, but in order to use the sugarcane harvester to be worth it, must harvest sugarcane in large quantities. Characteristics of sugarcane plot must be long and optimized. Developed a fresh sugarcane harvesting which consists of a 70horsepower tractor and a 180-horsepower diesel engine that serves as the power for various parts of the sugar cane harvester, such as the chopper blade, leave peeling roller set, sugarcane conveyor rollers set, which still use large machines to harvest the sugarcane [11]. This is the idea of creation a sugar cane cutting tractor accessory with 21-27 horsepower in order for farmers in the community can access more agricultural technology in Thailand. Another important process in sugarcane harvesting is sugarcane leaves peeling that can increase the efficiency of sugarcane harvester [12]. And in the development of Sugarcane Cutting Tractor Accessory, we also look at the factors of sugarcane since planting. This affects the design of the Sugarcane Cutting Tractor Accessory to design for 2-row harvesting which has cost less than the traditional method [13]. Factors affecting decision on sugarcane planting in terms of physical, social, promotion, and services [14] farm size, planting experience, sugarcane prices, household assets. and sugar cane price guarantee [15]. The creation of Sugarcane Cutting Tractor Accessory, it is necessary to know the practices guideline related to the sugarcane purchase process of the sugarcane industry according to local conditions [16].

## II. MATERIAL AND METHOD

This research aims to reduce sugar cane harvesting costs for farmers. By developing community innovation through the participation of people in the community, the Sugarcane Cutting Tractor Accessory was designed and created from the actual experience of sugarcane production in the area, with limitations in various aspects of the area, such as the distance of sugarcane trenches, soil hardness, area size of sugarcane plots, etc. In addition, sugarcane harvesters sold in the market are expensive and farmers cannot afford them, as it is a large machine that affects the accumulated soil. The operating procedures are as follows:

### A. Data collection sugarcane harvesting processes

As Focus Group Interview with a farmer and agricultural machinery repair shops in Chai Badan District Lopburi. There are 3 types of sugarcane harvesting processes as follows:

1. Fresh sugarcane harvesting is a type of physical work done by manual labor using a sugarcane knife for cutting. Started by bringing a knife to remove the leaves that enable to enter the sugarcane haulm's base. Gathering in bundles for 8-15 sugarcane trees depending on size, then cut the cane base.
2. Burning sugarcane harvesting, it is the most popular method in Chaibadan district, Lopburi.
3. Harvester tractor harvesting

### B. Data collection sugarcane harvesting cost

It has a harvesting cost that varies depending on the type of harvesting. There will be a charge of labor cost for each sugarcane bundle, which will have 8-15 cane trees in the form of burning and fresh cane. The data collection of selling price which purchased from the sugar mill and sold by local famers run from 2020 to 2021 as follow in table 1

TABLE I  
THE COMPARISON OF SUGARCANE HARVESTING COST

No.	Harvesting type	Harvesting cost (Baht per rai(	Selling price (Baht per ton(
1	Burning sugarcane	150	970
2	Fresh sugarcane	250	1,050
3	Harvester	200	1,050

From Table 1, it was found that the harvesting cost of burning sugarcane is 150 baht per rai, but will be deducted another 30 baht for contaminants from burning, affecting the selling price to 970 baht per ton. Fresh sugarcane harvesting costs are 250 baht per rai, and there is an additional incentive for no burning at 50 baht, causing the selling price per ton to increase to 1,050 baht. For harvesters, the harvesting cost is 200 baht per rai, and there is an additional incentive for no burning at 50 baht each, causing the selling price per ton to increase to 1,050 baht.

### C. Encounter problems in the community

By collecting data from 30 participants in the project using focus group, the problems found in the sugarcane harvesting can be summarized as follows:

1. There is high labor cost of sugar cane harvesting.
2. Lack of human labor in sugar cane harvesting especially in fresh sugarcane.
3. Affecting PM 2.5 pollution problem from burning sugarcane leaves before harvesting.
4. Sugarcane harvesters must be imported from abroad and are expensive.
5. Takes a long time for harvesting.
6. Insufficient of harvester and wait in line for long queue.
7. harvester cannot be used in Chaibadan district due to the distance of the planting trench in the area is in the range of 1.2-1.4 meters.
8. Limitation of unsuitable areas for sugarcane harvesting by harvesters.
9. Subsoil problems from using heavy sugarcane harvesters in the area

### D. Community needs survey

1. Need equipment to reduce human labor for harvesting.
2. Able to produce by themselves in the community without using the imported materials.
3. There is a mechanism that can be maintained by itself in the community.
4. Can be applied to use with local tools in the community
5. fast harvesting.
6. There is not much increasing in fuel costs.

### E. Comparison sugarcane harvesting type

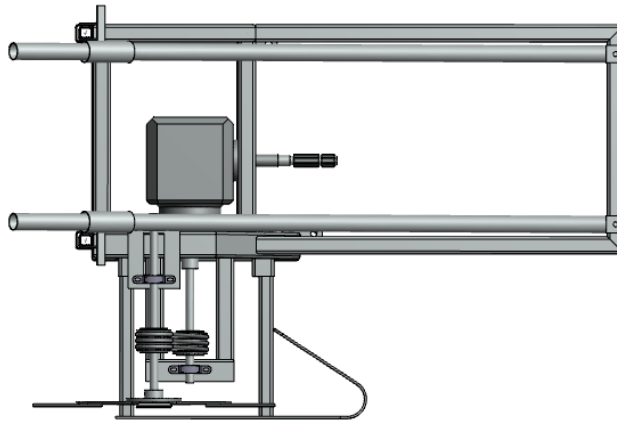
Comparison of advantages and disadvantages of each sugarcane harvesting type as shown in Table 2.

TABLE III  
COMPARISON OF EACH SUGARCANE HARVESTING TYPE

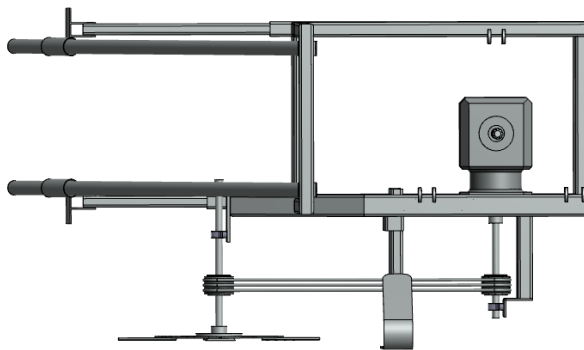
No.	Harvesting type	Advantages	Disadvantages
1	Burning Sugarcane	- Easily to harvest - Low harvesting cost	- Affecting problem of air pollution from burning - To be deducted for contaminants cost
2	Fresh sugarcane	- Got clean sugarcane - There is support money from factory for fresh harvesting	- Lack of labors for fresh sugarcane harvesting - high harvesting cost
3	Harvester	- To reduce the human labor  - Fast harvesting	- Lose weight of sugarcane from logs cutting - Waiting in long line for using harvester and must be a large farm. - Subsoil problems from using heavy sugarcane - The distance of sugarcane planting trenches must be more than 1.5 meters.

### F. Design and creation of technology innovations

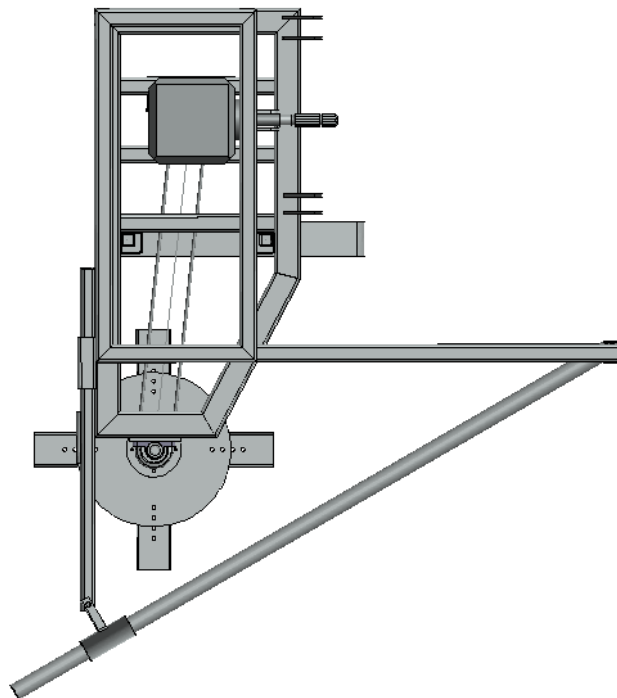
1. Structure design of sugar cane tractor accessory; the structure can be designed as shown in Fig 1, Fig 2, and Fig 3.



**Fig. 1** Design of sugarcane cutting tractor accessory (Beside)



**Fig. 2** Design of sugarcane cutting tractor accessory (Front)



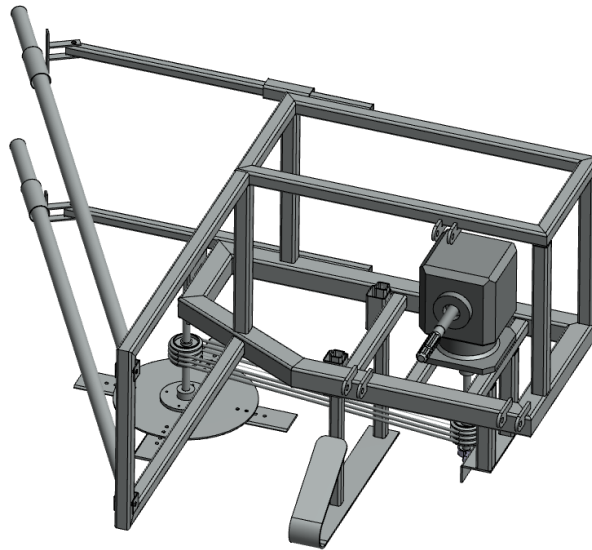
**Fig.3** Design of sugarcane cutting tractor accessory (Top)

*G. Structural strength analysis*

It uses Finite Element Analysis (FEA) function under Solid work software to analyses which can be divided into 3 main steps:

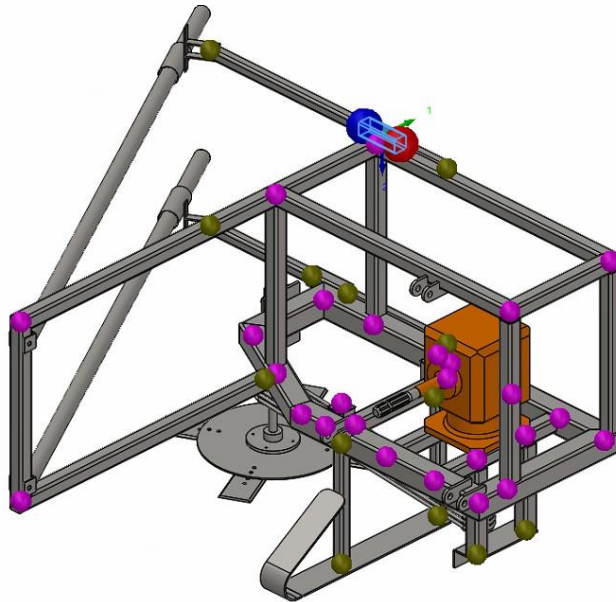
1. *Pre-Processing*; it is the process of design and creation a piece of work before Finite Element Analysis.

1.1 Create a 3D model of the analyzed workpiece as shown in the Fig. 4



**Fig. 4** Model of sugarcane cutting tractor accessory

1.2 Enter the information of the analyzed workpiece. It must be the same properties as the real product. It uses steel material as shown in the Fig. 5



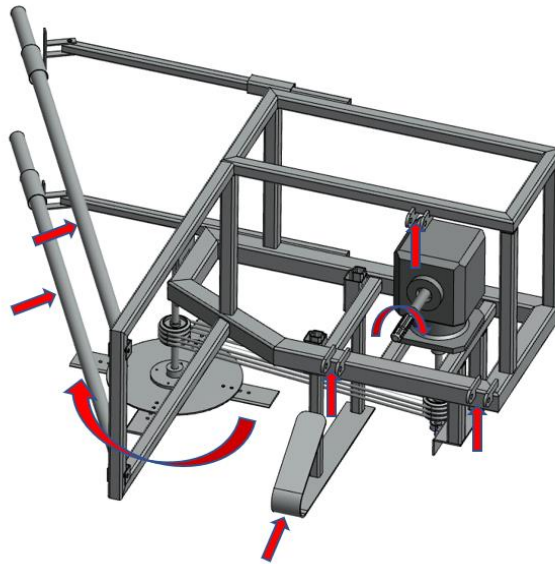
**Fig. 5** Analyzed workpiece

1.3 Determine the deformation behavior of materials as shown in the Fig. 6

Property	Value	Units
Tensile Strength	399826000	N/m <sup>2</sup>
Compressive Strength		N/m <sup>2</sup>
Yield Strength	220594000	N/m <sup>2</sup>
Thermal Expansion Coefficient	1.3e-005	/K
Thermal Conductivity	43	W/(m·K)
Specific Heat	440	J/(kg·K)
Material Damping Ratio		N/A

**Fig. 6** Deformation behavior of materials

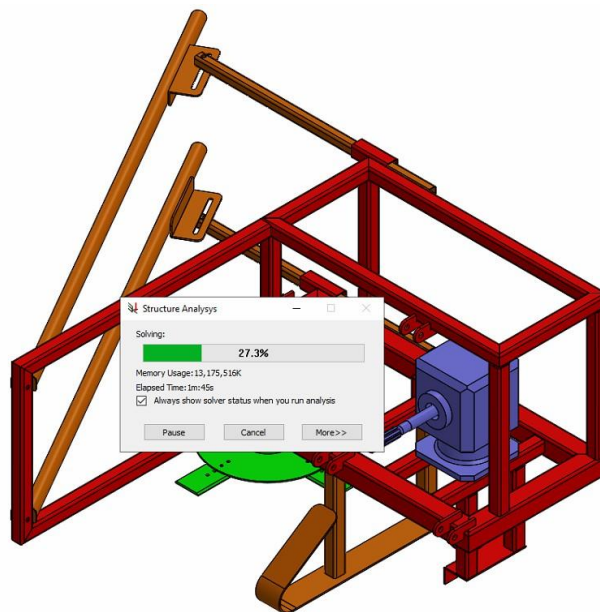
1.4 Determination of the force on the sugarcane cutting tractor accessory with two main parts: Self weight force (Weigh of sugarcane cutting tractor accessory is 150 kg.) and external force (By analysis the PTO shaft force, re-action force from the sugar cane and the ground) as shown in the Fig. 7.



**Fig. 7** Direction of the action force

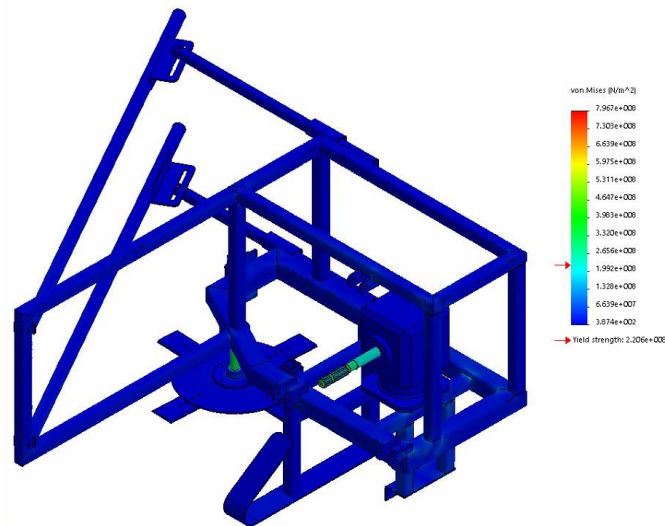
## 2. Evaluation and calculation process

This step is called Solver procedure in order to solve mathematical equations within the program. Many times using the external Solver program to calculate specifically as shown in the Fig. 8



**Fig. 8** Structure analysis

3. Analysis of the results of the calculations, it will be calculated as shown in Fig. 9



**Fig. 9** Analysis of the results

From Fig. 9, it is found that the yield strength of the structure of the material must not exceed the acceptable value of the material, which is  $2.206 \times 10^8$ . From the picture, it can be seen that there is no part of the structure with the yield strength exceeding the specified. Therefore, it is appropriate for such a structure.

#### H. Material preparation

List of materials used in the production of semi-automatic agricultural welding machines. There are details as follows:

1. Bill of Material (BOM): the production of Sugarcane Cutting Tractor Accessory for agricultural machinery as shown in Table 3.

TABLE III  
MATERIAL LIST

No.	Spare part name	Material	Size	Amount
1	Middle Support base	Channels Steel	50x25x4x6	2
2	Side Support base	Channels Steel	50x25x4x6	2
3	Left PTO. support Column	Steel Tube	50x50x3.2	2
4	Right PTO. support Column	Steel Tube	50x50x3.2	2
5	PTO power shaft bracket	Steel Tube	50x50x3.2	2
6	Shaft support bearing	Housing bearing	UCP 205-16x1"	2
7	Power shaft	shaft	Dimeter 1"	1
8	Direction control arm	Steel Tube	50x50x3.2	2
9	Top control arm	Steel Tube	50x50x3.2	3
10	Bottom control arm	Steel Tube	50x50x3.2	4
11	Vertical control arm	Steel Tube	50x50x3.2	5
12	Upper support base	Steel Tube	50x50x3.2	6
13	Lower support base	Steel Tube	50x50x3.2	7
14	Upper support steel	Steel Tube	50x50x3.2	8
15	lower support steel	Steel Tube	50x50x3.2	9
16	Belt	Belt	-	3

No.	Spare part name	Material	Size	Amount
17	Pulley	Pulley	5"	2
18	Cane cutter gear	Gear 1:1.3	27 HP	1
19	Blade fixing kit	Blade fixing kit	-	1
20	Sugar cane cutter	Sugar cane cutter	-	4
21	Blade guard	Steel Plate	8 mm	1
22	Belt card	Steel Plate	3 mm	1
23	PTO shaft head	PTO	-	1

### *I. Assembly of sugarcane cutting tractor accessory*

There are operation steps as follows.

1. Assembling starts at the base of the machine.
2. Install the powertrain
3. Install the control part and then install the powertrain

Sugarcane cutting tractor accessory as shown in Fig. 10, Fig. 11, Fig. 12, and Fig. 13.



**Fig. 10** Sugarcane cutting tractor accessory (Beside)



**Fig. 11** Sugarcane cutting tractor accessory (Front)





**Fig. 12** Sugarcane cutting tractor accessory (Top)



**Fig. 13** Sugarcane cutting tractor accessory with tractor

### III. RESULT

#### A. Time for sugarcane harvesting

Time for sugarcane harvesting by collecting 5 times and find the average and standard deviation. as shown in Table 4

TABLE IVV  
HARVESTING TIME

No.	Type of harvesting	Harvesting time (Rai/day)					Time average (Rai/day)	Standard deviation (Rai/day)
		1	2	3	4	5		
1	Burning sugarcane	0.5	0.6	0.5	0.5	0.5	0.52	0.04
2	Fresh sugarcane	0.2	0.25	0.25	0.25	0.3	0.25	0.04
3	Harvester	27	23	20	25	25	24	2.65
4	Sugarcane cutting tractor accessory	10	9	10	11	8	9.6	1.14

As Table 4, it was found that the harvesting time of burning sugarcane was 0.5, 0.6, 0.5, 0.5 and 0.5 rai per day, the average time was 0.52 rai per day and the standard deviation was 0.04 rai per day. The harvesting time for fresh sugarcane was 0.2, 0.25, 0.25, 0.25 and 0.3 rai per day, the average time was 0.25 rai per day, and the standard deviation was 0.04 rai per day. The harvesting time of sugarcane harvester was 27, 23, 20, 25 and 25 rai per day, the average time was 24 rai per day and the standard deviation was 2.65 rai per day. The harvesting time of sugarcane cutting tractor accessory was 10, 9, 10, 11 and 8 rai per day, the average time was 9.6 rai per day and the standard deviation was 1.14 rai per day.

The comparison of time efficiency between Sugarcane cutting tractor accessory and 3 types original harvesting as shown in Table 5

TABLE V  
HARVESTING TIME PERFORMANCE

No	Type of harvesting	Average of harvesting time (Rai/day)	Improve harvesting time (Rai/day)	Improved performance from the original	Improve average
1	Burning sugarcane	0.52	9.08	1,746.15%	
2	Fresh sugarcane	0.25	9.35	3,740.00%	1,808.7%
3	harvester	24	-14.4	-60.00%	
4	Sugarcane cutting tractor accessory	9.6	-	-	-

In Table 5, it was found that the average time of burning sugarcane harvesting was 0.52 rai per day. By using the sugarcane cutting tractor accessory, it was harvested faster at 9.08 rai per day, increasing efficiency by 1,746.15%. The average time of fresh sugarcane harvesting was 0.25 rai per day, and by using the sugarcane cutting tractor accessory, it was harvested faster at 9.35 rai per day, increasing efficiency by 3,740%. The average time of harvester harvesting was 24 rai per day, and by using the sugarcane cutting tractor accessory, it was harvested at a slower 14.4 rai per day, decreasing efficiency by 60%. The average efficiency is greater than three types of original harvesting, which was 1,808.72 percent or has average efficiency of using labor is better than 3 types of original harvesting method and using sugarcane cutting tractor accessory at 18.08 times.

#### B. Harvesting cost

The data was collected by a focus group to find the average cost of sugarcane harvesting per ton. From 2020 to 2021, sugarcane can be sold at 1,000 baht per ton, from which 30 baht per ton will be deducted for burning sugarcane and addition more 50 baht per ton for fresh sugarcane. For sugarcane harvesters, farmers have to invest more than ten million baht. The sugarcane product in the Chai Badan district is about 7 tons per rai as shown in Table 6.

TABLE VI  
HARVESTING COST

No.	Harvesting type	Selling price (Baht per ton)	Harvesting cost (Baht per rai)	Percentage of the cost of harvesting
1	Burning sugarcane	970	150	15.46
2	Fresh sugarcane	1,050	250	23.81
3	Harvester	1,050	250	23.81
4	Sugarcane cutting tractor accessory	1,050	60	5.71

As Table 5, it was found that burning sugarcane has selling price at 970 baht per ton, harvesting cost at 150 baht per rai or 15.46 % of selling price. For fresh sugarcane and harvester have selling price at 1,050 baht per ton, the harvest cost at 250 baht per rai or harvesting cost at 15.46% of selling price, as for sugarcane cutting tractor accessory has the selling price at 1,050 baht per ton, the harvesting cost at 60 baht per rai or has the harvesting cost at 5.71% of selling price.

The efficiency harvesting cost comparison of 3 types original harvesting method and using sugarcane cutting tractor accessory as shown in Table 7.

TABLE VII  
HARVESTING COST

No.	Type of harvesting	Harvesting cost (Baht/rai)	Improve harvesting cost	Improved performance from the original	Improve average
1	Burning sugarcane	150	90	60%	
2	Fresh sugarcane	250	190	76%	70.67%
3	harvester	250	190	76%	
4	Sugarcane cutting tractor accessory	60	-	-	-

In Table 7, it was found that the average harvesting cost of burning sugarcane was 150 baht per rai. By using the sugarcane cutting tractor accessory, it was reducing the harvesting cost to 90 baht per rai, increasing efficiency by 60%. The average harvesting cost of fresh sugarcane harvesting was 250 baht per rai, and by using the sugarcane cutting tractor accessory, it was able to reduce the harvesting cost to 190 baht per rai, increasing efficiency by 76%. The average harvesting cost of harvester harvesting was 250 baht per rai, and by using the sugarcane cutting tractor accessory, it was able to reduce the harvesting cost to 190 baht per rai, increasing efficiency by 76%. The average efficiency is greater than the three types of original harvesting, which was 70.67 percent.

#### IV. SUMMARY

In this research can be summarized as follows;

##### A. *To study the type of sugarcane harvesting.*

There are three main types of sugarcane harvesting in Chai Badan District, Lopburi Province: fresh sugarcane harvesting, burning sugarcane harvesting, and harvester harvesting. Burning sugarcane is the most using type. Using the community's knowledge then able to understand the height of the sugarcane cutting, which makes its stump suitable to be able to continue growing in the next year. A sugarcane plantation in the area is planted with a height range of 1.2-1.4 meters, limiting the use of normal sugarcane harvesting machinery and there are also restrictions on the area's texture and size.

##### B. *Design and creation the innovation of sugarcane harvesting*

A small size tractor is a basic tool that is used in the local agriculture area. Therefore, the concept was created in accordance with the technique, engineering knowledge, and knowledge of the community to add more function for sugarcane harvesting. Using the Solid Work program for design and analysis, using Finite Element Methodology to analyze the structural strength of the sugarcane cutting tractor accessory which can create the phototype base on community knowledge such as suitable height for sugarcane harvesting, Falling characteristics of sugarcane, and resources in the community with engineering knowledge.

##### C. *Performance of Sugarcane cutting tractor accessory*

This can compare the performance with other harvesting types. Details are as follows:

1. Time performance, Fresh sugarcane harvesting could be harvested faster than the burning harvesting. It can reduce the harvesting cost of burning sugarcane by 90 baht per rai, or there is efficiency increase of 1,746.15% and fresh sugarcane by 190 baht per rai, or there is efficiency increase of 3,740%. But once compared to harvester, the sugarcane cutting tractor accessory cuts more slowly than 14.4 rai per day or reduced efficiency by 60%.
2. Cost performance, a model can be reduced the cost of burning sugarcane harvesting for 90 baht per rai or increased the efficiency by 60%, in fresh sugarcane and harvester harvesting can be reduced the cost 190 baht per rai or increase efficiency by 76%.

#### V. DISCUSSION

This research can be discussed as follows;

1. There are three main types of sugarcane harvesting in Chai Badan District, Lopburi Province: fresh sugarcane harvesting, burning sugarcane harvesting, and harvester harvesting. Using the community's knowledge then able to understands the height of the sugarcane cutting, which makes its stump suitable to be able to continue growing in the next year and get the appropriate weight of sugarcane for selling which conform to the research that study the qualitative losses of Khon Kaen 3 sugarcane in Khon Kaen and Chaiyaphum provinces [17]. This is consistent with the sugarcane harvest, affecting the weight reduction of sugarcane for sale to the factory.

2. Design and creation innovation combined with engineering knowledge, using the Solid Work program for design and analysis, using Finite Element Methodology to analyze the structural strength of the sugarcane cutting tractor accessory which conform to the research of solving the problem of burning sugarcane leaves before harvesting by using a sugarcane cutting machinery which

conform to the research that application of finite elements method for structural analysis in a coffee harvester [18]. Which Finite Element Methodology is used for structural strength analysis.

3. Sugarcane cutting tractor accessory can reduce the time and harvesting cost accordingly as the research of the problem solving in sugarcane leave burning before harvesting by harvester. There are using of agricultural machinery to solve the problem of sugarcane which conform to the research that solving the problem of burning sugarcane leaves before harvesting by using sugarcane cutters [11] and sugarcane cutting machine [19] which and can reduce the problem of sugarcane harvesting time and the high cost of sugarcane harvesting.

## VI. ACKNOWLEDGMENTS

Thankful for Thailand Science Research and Innovation (TSRI) for supporting of fund in this research and thankful Phranakhon Rajabhat University for supporting of all facilities in this research.

## REFERENCES

- [1] J. Suriya, "Ministry of Industry overhauled the cane and sugar industry," *Office of the Cane and Sugar Board*, Ministry of Industry., November 26, 2021
- [2] L. Wongchaisit, "Modern Agriculture Development According to Thailand 4.0 Policy, Case Study of Organic Vegetables," *National Defense College*, The National Defense Course Class. 2017
- [3] W. Ekapat, "Refusing to buy burnt sugarcane," *Office of the Cane and Sugar Board*, Ministry of Industry, January 26, 2022
- [4] T. Wu, et al., "Chopper sugarcane combine harvester with middle-mounted primary extractor," *Sugar Tech*, 22(4), January 2020
- [5] H. Dai, et al. et al., "Analysis and experiment of flow field in sugarcane leaf cutting and returning machine," *Materials Science and Engineering*, 735(1), January 2020
- [6] L. Xie, et al., "Optimisation and finite element simulation of the chopping process for chopper sugarcane harvesting," *Biosystems Engineering*. Vol. 175, pp. 16-26, November 2018
- [7] L. Xie, et al. et al., "Optimisation and dynamic simulation of a conveying and top breaking system for whole-stalk sugarcane harvesters," *Biosystems Engineering*, Vol. 197, pp. 156-169, September 2020
- [8] D. Zhou, "A new design of sugarcane seed cutting systems based on machine vision," *Computers and Electronics in Agriculture*. Vol. 175, August 2020
- [9] T. Leetrakul, "Development of cutter knife in sugarcane harvester to compare hardness," *Industrial Engineering Network Academic Conference 2012*, Cha-am, Phetchaburi, 17-19 October 2012
- [10] T. Kraisinburasak, et al., "Design and development of the mechanism of sugarcane leaf cutting machine for cutting sugarcane for breeding," *Agricultural Journal*, 34 (1), 76 – 94, 2016
- [11] A. Buntham, et al., "Solving the problem of burning sugarcane leaves before harvesting by using sugarcane cutters," *Report on research and development on plants and agricultural technology*. 2008
- [12] Z. Qiu, "Analysis of blockage and wrapping by leaves in the cutting mechanism of a sugarcane leaf shredder," *College of Engineering*, South China Agricultural University, China, 2020
- [13] S. Mandal and P. Maji, "Design Refinement of Two Row Tractor Mounted Sugarcane Cutter Planter". *Agricultural Engineering International: the CIGR E-journal*, Vol. 5. February, 2008
- [14] N. Meesungnoen and K.Taweekul, "Factors Affecting Decision Making on Sugarcane Cultivation of Farmers in Khao Suan Kwang District Khonkaen Province," *KhonKaen University*, pp. 625-630, 2019
- [15] R. Suchato, A. Patoomnakul, N. Photchanaprasert, "Alternative cropping adoption in Thailand: A case study of rice and sugarcane production," *Department of Agricultural and Resource Economics*, Faculty of Economics, Kasetsart University, 2021
- [16] M. Norsuwan, " Stop burning sugarcane. Stop destroying the environment" Retrieved on January 30, 2022, from <http://www.ocsf.or.th/Article/art-2.pdf>.
- [17] Kanya Kosoom, "A study on quantitative and qualitative losses in sugarcane chopper harvester for harvesting Khon Kaen 3 sugarcane variety in Khon Kaen and Chaiyaphum province areas," *Agricultural and Food Engineering School of Engineering*, Suranaree University of Technology, 2018
- [18] Evandro Pereira da Silva, Fábio Moreira da Silva, Ricardo Rodrigues Magalhães, "Application of Finite Elements Method for Structural Analysis in a Coffee Harvester," *Engineering*, Vol.6, No.3, pp. 138-147, 2014
- [19] V. Jamadar, et al., "Sugarcane cutting machine," *National Conference on Design, Manufacturing, Energy & Thermal Engineering (NCDMETE-2017)*, Vol. 4, Special Issue 1, January 2017