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# OPTIMUM DESIGN OF A PARA RUBBER-TAPPING MACHINE

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## Abstract

Generally, rubber tapping requires many workers working in the field, and tapping processes rely on experts who have ability and experience to get a large amount of latex and do not damage the rubber tree surface. Nowadays, technology and tools have been developed and applied in rubber tapping processes, such as automatic rubber tapping machines, but it consumes high budget to invest and likely to be lost as well. For these reasons, rubber field owners continue to use a traditional method by using manual workers to tap rubber. In this research, there is a conceptual design to create equipment helping farmers for rubber tapping that can reduce tapping time and does not need very skilled workers. The design guidelines will focus on easy installing and using. It has low production costs, no complicated mechanisms, and easy maintenance, therefore, it would greatly optimize in practical use. The rubber tapping machine is made of metal designed to have three main components which are 1. the rubber tree attachment, 2. the device bracket, and 3. the rubber tapping system (including tapping rails). The procedures start from placing the rubber tapping knife used into the tapping machine (part 3), hold the handle of the knife and drag the knife along the cutting rail installed on the rubber tree. It will help the workers work faster with precise depth, long slit, and angle. From the test results obtained from the traditional rubber tapping using a normal tapping knife compared with the rubber tapping device, it is obviously found that using assistive devices can reduce the time in incisions by 65-80%, get precise incisor, notch length, and correct incline angle. Besides, it is also reasonable price, and it can be used for a long time.

Keywords: Rubber tapping system, Rubber tree, Tapping knife, Tapping machine.

## 1. Introduction

Latex is a very important and necessary product in many industries around the world, such as the automotive industry and made medical equipment. Currently, rubber trees which produce latex are grown in many countries and many continents around the world. Although, there is advancement in technology but rubber tapping still uses the same methodology as in the past. In Thailand, rubber production in the past was mainly employed by household workers. Then, rubber tapping techniques are passed to the family members. However, now the children in the family have higher level of education causing them to work in the city and they are not interested in being farmer. Therefore, it is imperative to hire workers to tap rubber instead of the family.

The government has encouraged enhancing rubber to create more value in industrial businesses, then the rubber production is expanded to a wide range of sectors. However, Thailand has a shortage of skilled workers in rubber tapping compared to a high demand. As a result, workers who tap rubber today are mostly low-skilled, causing the rubber tree to be destroyed in the tissue area after tapping. Consequently, the tapping life of the rubber tree is reduced due to the use of the wrong tapping method. When workers lack the necessary skills and expertise, it results in decreasing rubber producing capacity and may cause the rubber tree to be damaged by incorrect tapping.

If the rubber shell is cut too thick, it will waste a lot of rubber shell, the time for getting the latex will be shortened, and the latex product will be less compared to tapping with lower consumption of rubber shell. Cutting too deep into the wood will destroy the tissue layer. It will unevenly regenerate new rubber shell and make it unable to be cut repeatedly. On the other hand, if the incision is not deep enough to cut the rubber tube, the latex produced will be less as well. On average, an expert worker applying half-spiral downward tapping can do 450-500 trees per day, and for one-third-spiral tapping, a person can do 650-700 trees per day. In reality, the optimal tapping time is between 3 a.m. to 6 a.m. only, every other day. For other periods, the heat in Thailand will cause the amount of latex flowing to be reduced. The actual number of rubber trees that can be tapped is only about 300 trees per day (for one third-spiral tapping). For the inexperienced worker, the rubber can be decreasingly tapped. For this reason, many studies have been conducted to increase the efficiency of tapping rubber to increase the amount of latex.

For example, Chantuma et al. [1] developed a rubber tapping method by conducting an experiment with rubber trees in Thailand to add one more cut (the double cut alternative tapping system) to increase the yield of latex per year. The proposed method could increase latex yield 9%, but it requires workers to spend almost double time tapping rubber. Michels et al. [2] compared the traditional rubber tapping with the development of rubber tapping patterns. For example, amount of daily cutting, incision length to be half the circumference, and one quarter of the circumference. It found that new method has a greater increasing latex.

Arjun et al. [3] designed a battery-operated semi-automatic rubber tapping machine with a sensor system to help cutting, reduce working time and energy to cut but the device is weighty from battery. So, it is still inconvenient to use. Susanto et al. [4] designed a rubber tapping knife that can control depth and thickness of incision, but it needs skilled workers to use. Wang et al. [5], Huang et al. [6] developed and tested electrical rubber tapping knives using battery model 4GXJ-I

commonly used in China by improving the set of blades in the machine to fast slit the rubber tree surface smooth and making the latex flow better. They reduced the weight to be lighter, but it still weighs 0.5 kg including the battery.

Ramesh et al. [7] designed a user-friendly rubber tapping device for less-skilled workers. It does not require as much of taking care and inexpensive. This research is done in India. A machine designed to use battery power to operate with four types of equipment, ranging in weight from 1 -2 kg. Chen et al. [8] offered vertical tapping using Ethephon Stimulation to increase latex yield. There is a comparison of length of incision and concentration of used substances. This method is easier to tap than the tilt type; however, it is more likely to destroy layer of rubber tree's growth membranes because the slits will cut through vertical growth membrane. Unlike the inclined type, when compared with vertical length at same cutting distance, it has shorter vertical tapping.

For development of automatic tapping system, Kunghun and Tantrapiwat [9], Kunghun et al. [10] proposed a method for automating camera processing using a program to determine distance between rubber trees and rubber tapping position. Wongtanawijit and Khaorapapong [11] designed a system for detecting rubber tapping position and harvesting cup by using the Faster-RCNN system in conjunction with MobileNetV2. Wongtanawijit and Khaorapapong [12] studied and developed an original rubber tapping detection algorithm to be used with an extension system for rubber tapping system with robots. It can provide more precision.

Nowadays, automation technology has been used to replace shortage of skilled workers, but due to high price of the automatic machine (approximately 5000 baht used for 1 rubber tree as of August 14th, 2020), condition of rubber price forecast (price of raw latex in Thailand is 1.37 USD per kg as of August 14th, 2020) makes investing in automation is not worth to widely continue. The rubber tapping machine with high price also causes the farmers to continue using traditional method, namely human labour in tapping rubber. For this reason, this research provides concept to design and create a machine to help the farmers in tapping faster, use less skills in tapping, and reduce the damage of rubber trees from inexperience tapping. It has low production costs and easy maintenance. It can also be used as a guideline for developing equipment to help tapping rubber in the future.

Recently, the rubber tapping machines reported in other research works have been quite heavy, which makes them quite difficult to control during the tapping and there are many expensive parts in the machine that may have to be changed every time after use. In this work, not only can the reported rubber tapping machine help the unskilled workers/farmers perform the tapping correctly and decrease the tapping time, but it is also cheap and light weight. It can also be permanently attached to the rubber tree so that the farmer only needs brings only a knife to the job.

## 2. Design

Rubber tapping machine in this research (as shown in Fig 1) contains three main components; 1. equipment attached to the rubber tree, 2. device bracket, and 3. rubber tapping system, as shown in Fig 2, Fig 3, and Fig 4, respectively. To design part 1, it will focus on ease of use, and it does not damage the rubber tree by using straps tightly around the tree. (This rubber tapping machine will be attached to the

rubber tree) and then designed to hook on with a strap. It has the following characteristics shown in Fig. 2, comprising four arm-like mechanisms attached to the machine. The end is a groove on the strap fixed to the rubber tree. In designing part 2: device bracket, it will take into account to size of the machine that can be used with rubber trees aged between 7.5 years up to 15 years (information of rubber trees in Thailand, it commonly used RRIT251, RRIT226 and BPM 24 for the production of latex), which is the suitable age for tapping with a trunk diameter of not less than 50 cm. The machine must be able to use with rubber trees with a diameter of 50 cm or more. The structure is shown in Fig. 3.

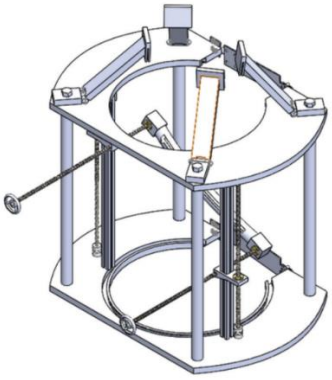


**Fig. 1. Rubber tapping machine.**

**Fig. 2. Equipment attached to the rubber tree**.

In part 3: rubber tapping system, it is designed to use rubber tapping knife that the farmers use as tapping device. In the design, direction of tapping knife will be directed to rubber tree at an angle of 30 degrees (a slope angle of 30 - 35 degrees from horizontal level allows latex to flow smoothly and does not flow outside cutting area). For tilt angle from tapping mechanism, thickness of indentation of the rubber tree bark vertically to the root is 1.5 mm thick (a good tapping shears should not more than 2 mm per time) and tapping depth (length of tapping the rubber tree into the trunk) slits approximately 1 mm in depth on soft bark part. When combining the cork and hard bark, it may have a slit depth of approximately 3 mm (depending on the thickness of the cork and hard bark). The tapping depth should be about 3 mm, as suggested by the Rubber Authority of Thailand.

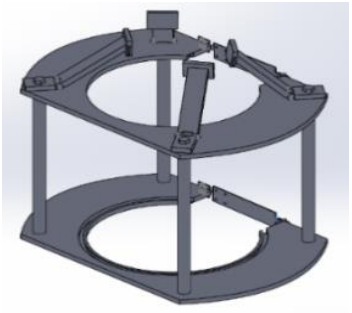
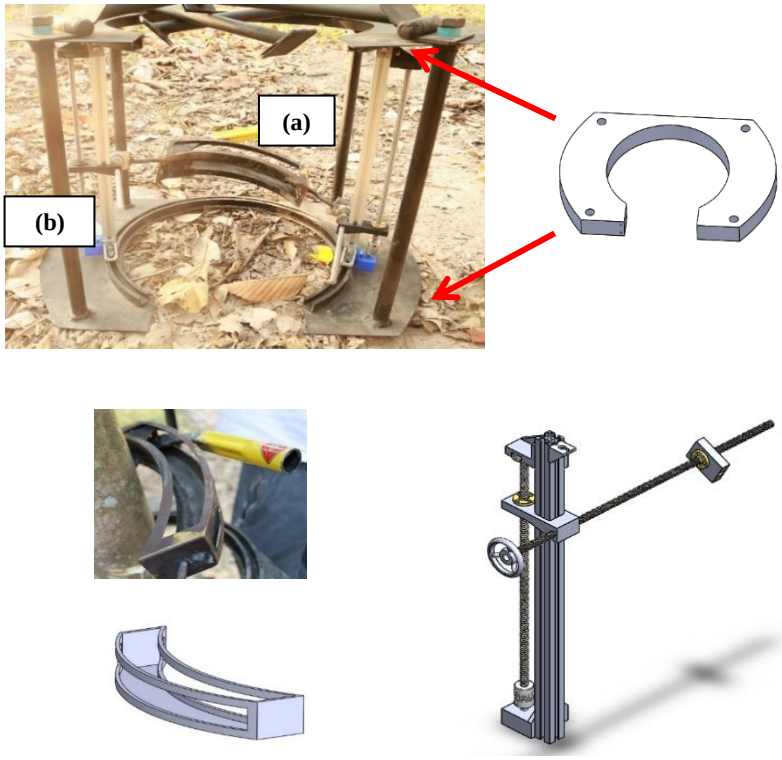


**Fig. 3. Device bracket**.

A rubber tapping box is set to control the cut depth to the desired distance, as shown in Fig. 4(a). In addition to design of tapping system to accommodate with traditional blade and various directions suitable for tapping rubber, it can adjust distance for the next tapping of original tree that has to be tapped deeper with a machine attached to it by adding threads on both sides of a tapping rail to adjust the tapping distance. It is shown in Fig. 4(b), with a rubber tapping knife is not attached to the machine. It can be used with other machines attached to other rubber trees and it can be removed and cleaned easily.

All the parts shown in Figs 2, 3, and 4(a) are made from anti-rust painted metal, while part 4(b) is made from aluminum. These three parts have been designed purposefully based on characteristics of rubber trees in Thailand. If it will be used in other countries, characteristics of rubber trees suitable for tapping should be studied more and adjust appropriate design guidelines to obtain a tool that increases efficiency of rubber tapping.




**(a) The box of the rubber tapping knife that determines the incision depth.** **(b) Slitting mechanism that determines the tapping angle.**

**Fig. 4. The rubber tapping system.**

## 3. Rubber Tapping Test

The researcher used the proposed machine to actually cut the rubber tree bringing results to improve productivity according to the set objectives. The results of rubber tapping are compared with traditional tapping (using a rubber tapping knife without a tool). The results are divided into the following items (the results will be a test from a research team with 10 rubber trees with a diameter of approximately 50 cm to find an engineering statistical average)

### 3.1. Completeness of tapping

The first priority of a rubber tapping machine, shown in Fig. 5(a), is ability to tap rubber without damaging rubber trees and resulting in next rubber tapping to not

reduce latex due to damage of tapping. The main reason for incision causing damage is the deep cut destroying the latex tube. The incision with tapping machine will be no more than 3 mm depth as tapping box can control the knife depth. Cut depth should not exceed distance to destroy latex tube. At some point, tapping mark is too shallow due to nature of the rubber tree that is not completely cylindrical. From using rubber knife directly, shown in Fig. 5(b), results found that it depends on skill of tapping rubber in which the depth is uneven. It has a depth about 2-5 mm and some parts are deeper than 3 mm, the rubber trees in that area are damaged. On the contrary, in area that is too shallow about 2 mm, the amount of latex that can flow is low. Therefore, result from the rubber tapping machine found that the rubber cut which is certainly not deeper than 3 mm will not damage the latex tube. This affects completeness of the rubber trees to tap in the future. In addition, the rubber tapping machine can improve the tapping rate of unskilled workers from 15 mm/s to 30 mm/s, i.e., about two times, compared with tapping with a knife.

(**a) Rubber tapping with machine.** **(b) Rubber tapping with knife.**

**Fig. 5. Rubber tapping with knife and machine**.

## 3.2. Amount of obtained latex

This section measures volume of latex obtained from a rubber tapping machine compared with volume of latex obtained from tapping knife. The results are shown in Fig. 6 and Table 1. The tapping using a slitting knife yields higher volume of latex because the rubber tree does not have a complete cylindrical shape, resulting in assisted tapping. Tapping rubber in some areas will get a too little deep, causing less latex to flow out. The obtained results from experiment showed that volume of latex is about 10% difference.

**Table 1. The results from tapping using a rubber tapping knife and a rubber tapping machine.**

| Time (min) | Volume of latex from a rubber tapping knife (mL) | Volume of latex from rubber tapping machine (mL) | % Different volume of latex |
|---|---|---|---|
| **1** | 0.8 | 0.5 | 37.50 |
| **5** | 5 | 3.2 | 36.00 |
| **10** | 8 | 6.4 | 20.00 |
| **15** | 10.5 | 9.5 | 9.52 |

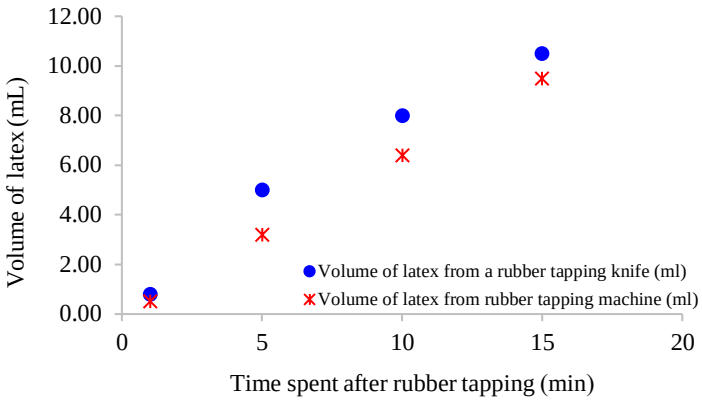



**Fig. 6. Comparison chart of latex volume using a rubber tapping knife and a rubber tapping machine.**

### 3.3. Time required for tapping rubber

The main purpose of this machine is to reduce tapping time. The testers have different tapping skills making rubber tapping time very different. However, results are compared between using a rubber tapping machine and a knife found that the rubber tapping machine can obviously reduce tapping time up to 65% of time spent with a normal rubber tapping knife. The skilled workers (one third-spiral tapping about 300 trees per day), and unskilled workers (one third-spiral tapping less than 200 trees per day) can reduce tapping time up to 80%.

## 4. Summary and Result Analysis

The rubber tapping machine from designing, building, experimenting, improving and comparing with a normal tapping knife shows that it can prevent the rubber tree damage from wrong tapping and reduce tapping time up to 65-80% depending on expertise of rubber tapping. Besides, there are still some concerns that need to be improved to use with a completely non-cylindrical rubber tree. In the test, it found that latex is less than normal knife tapping. In the case of the rubber tapping knife box, it has to be adjusted to be flexible to fit in with the shape and form of the rubber trunk. In addition, the device size should be reduced in size to be smaller and lighter weight for convenient transportation and installation on the rubber tree. In terms of price, mass production will cost no more than US$10 per tree (excluding rubber tapping knives). For more in-depth analysis of different scales, a greater number of rubber trees and different time intervals should be studied.

## References

1. Chantuma, P.; Lacote, R.; Leconte, A.; and Gohet, E. (2011). An innovative tapping system, the double cut alternative, to improve the yield of Hevea brasiliensis in Thai rubber plantations. *Field Crops Research*, 121(3), 416-422.
2. Michels, T.; Eschbach, J.-M.; Lacote, R.; Benneveau, A.; and Papy, F. (2012). Tapping panel diagnosis, an innovative on-farm decision support system for rubber tree tapping. *Agronomy for Sustainable Development*, 32(3), 791-801.

3. Arjun, R.N.; Soumya, S.J.; Vishnu, R.S.; and Bhavani, R.R. (2016). Semi automatic rubber tree tapping machine. *Proceedings of* 2016 *International Conference on Robotics and Automation for Humanitarian Applications* (*RAHA*), Amritapuri, India, 1-5.
4. Susanto, H.; Ali, S.; and Hanif (2019). The design of flexible rubber tapping tool with settings the depth and thickness control. *IOP Conference Series: Materials Science and Engineering*, Indonesia, 506: 012002, 1-10.
5. Wang, L.; Cao, J.; Zheng, Y.; Huang, C.; and Wu, S. (2019). The development and application of advanced design and manufacturing techniques on type 4GXJ-I of cordless brushless tapping knife. *IOP Conference Series: Materials Science and Engineering*, 592: 012143, 1-5.
6. Huang, C.; Wang, L.; Cao, J.; Zheng, Y.; and Wu, S. (2019). The technology research on cutting test of 4gxj-i tapping knife for rubber tree. *IOP Conference Series: Materials Science and Engineering*, 592: 012070, 1-5.
7. Ramesh, B.; Krishnakumar, N.M.; and Ramesh, R. (2019). Mechanised rubber tapping devices. *International Journal of Innovative Technology and Exploring Engineering* (*IJITEE*), 8(12), 2248-2252.
8. Chen, Q.; Chen, X.; Wang, J.; and Lin, W. (2020). Effects of ethephon stimulation and cut length by vertically tapping on rubber yield and latex quality. *International journal of Horticulture, Agriculture and Food science* (*IJHAF*), 4(4), 132-138.
9. Kunghun, W. and Tantrapiwat, A. (2018). Development of a vision based mapping in rubber tree orchard. *Proceedings of* 2018 *International Conference on Engineering, Applied Sciences, and Technology* (*ICEAST*), Phuket, Thailand, 1-4.
10. Kunghun, W.; Tantrapiwat, A.; and Chaidilokpattanakul, P. (2019). Navigation of autonomous vehicle for rubber tree orchard. *IOP Conference Series: Materials Science and Engineering*, 639: 012036, 1-7.
11. Wongtanawijit, R. and Khaorapapong, T. (2019). Rubber tapping position and harvesting cup detection using faster-RCNN with MobileNetV2. *Proceedings of* 2019 23*rd International Computer Science and Engineering Conference* (*ICSEC*), Phuket, Thailand, 335-339.
12. Wongtanawijit, R. and Kaorapapong, T. (2018). Rubber tapped path detection using k-means color segmentation and distance to boundary feature. *Proceedings of* 2018 15*th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology* (*ECTI-CON*), Chiang Rai, Thailand, 126-129.