Cost and Benefit Analysis for Rubber Product Transportation

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Abstract

Existing transportations are extensively developed to serve a variety of needs. While most agricultural product transportations are designed for multi-purpose functions, farming activities and agro-processing industries may need specific types of transportations. Being versatile could benefit general truck users, but there can be some limitations as the trucks do not possess the most economical and efficient way to transport specific products. Natural rubber product is one example that represents the lack of product-specific transportation vehicle. This study investigates the fundamental requirements and the associated cost for rubber product transportation. Normally, there are three types of rubber products including natural latex in liquid form, and rubber sheets and cup lumps in solid form. The survey was conducted in the areas that are considered the major sources of Thailand's rubber products. The stakeholders of interest are categorized into four tiers including farmers, local buying sites, regional middlemen, and rubber product processing plants. One observation from the survey shows that the most urgent chain that needs specific rubber-transportation vehicle is the transportation of natural latex from local buying sites to regional middlemen due to relatively strong demand on labor-saving equipments and product quality preservation option. Thus, it is interesting and potentially beneficial to explore and propose a new vehicle design exclusively for this particular activity. The cost and benefit analysis shows that the proposed solution can potentially reduce the cost and processing time of transportation, increase product quality, and facilitate users.

Keywords: Natural Rubber, Transportation, Cost and Benefit Analysis, Vehicle Design

1. INTRODUCTION

Thailand is among the largest natural rubber producing countries. To remain economically competitive in the global market, agricultural technology takes an important role in making the farming more profitable and less vulnerable to market fluctuations. Making the transportation more efficient is one of the promising solutions. Currently, there are several types of vehicles used for rubber product transportation, depending on the types of rubber

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products, the amounts of product transported, and distances to travel. Based on the nature of transportation, natural rubber products can be categorized into three basic types: natural latex, rubber cup lumps, and rubber sheets.

When transporting small amount of products, i.e. between plantation areas and local buying sites, motorcycles with or without sidecars are typically used by farmers for all types of rubber products. It is also practical to ship large amount of natural latex and rubber sheets in multi-purpose pickup trucks. For the largest shipping capacity, tank trucks are used to transports natural latex to processing plants, and six-wheeled trucks for the rubber sheets and rubber cup lumps.

Most commercially available selections of vehicles for agricultural product in Thailand are multi-purposed. These multi-purpose trucks are sometimes modified to serve farmers' needs. For instance, frames are fixed on the bed sidewalls to extend the loading space, or the suspension is modified to sustain higher loads. Although the modified trucks serve agriculturists' needs to an acceptable level, it may be beneficial to develop new vehicle designs specifically for particular farming activities, especially when the transported crops are the nation's major economic crops. To our knowledge, no previous studies have been done to challenge if designing rubber-product vehicle is financially viable.

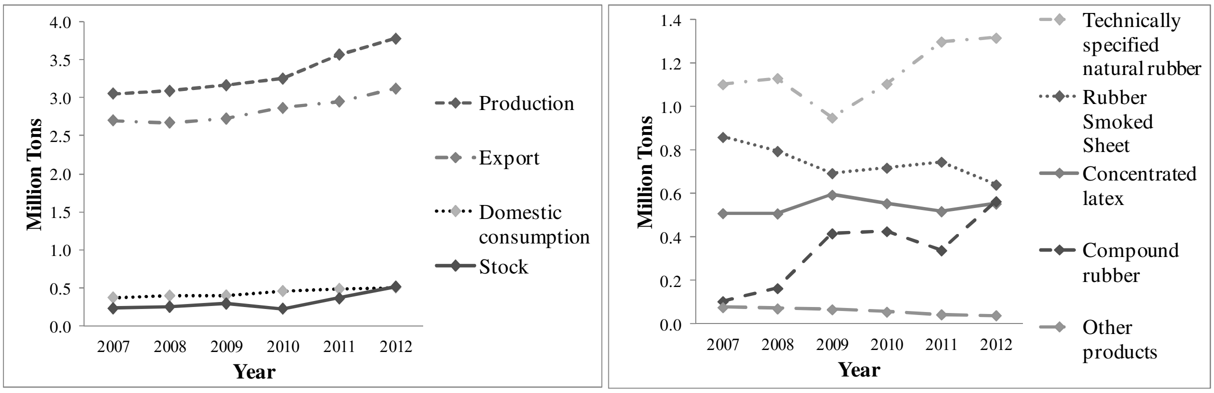
This study aims to develop the most economical and efficient way to transport natural rubber products. Rubber plantations, harvesting activities and transportation-related tasks are the fundamental information that needed to be closely observed. Additionally, users' expectations and preferences should be evaluated and prioritized. Particularly, product-specific designed transportation vehicles primarily decrease the cost of transportation by reducing not only the fuel consumption, but also the time spent in loading and unloading the product. Moreover, the new vehicle design can essentially seek for better product quality preservation.

The team began by reviewing the overall information of rubber plantations in Thailand, and selected to investigate sampling groups that represent the rubber plantation characteristics. The growing demand of rubber products and the area selection are described in Section 2. The team then conducted field trips to targeted regions to observe the overall procedures of rubber product transportation from farmlands to processing plants. Interviews and questionnaires were given to all stakeholders along the transportation chain. The overall routine task observation is described in Section 3.

After data collecting and information gathering process, the team performed a cost structure analysis to understand the fundamental monetary cost for each stakeholder, as described in Section 4. Other measurements besides monetary value are also considered including the time and product quality. Section 5 explains the difficulties faced by the selected target group. The surveys were given to representatives within the target group, and the results are shown in Section 6. The proposed designs or solutions are given to fill the gap of need of rubber product-specific vehicles, as described in Section 7. Finally, Section 8 provides the overall conclusions of the study.

2. RUBBER PLANTATION IN THAILAND

Thailand produces more than three million tons of rubber products per year. Figure 1(a) illustrates the growing production quantity over the past seven years. The produced rubber is subsequently processed into various forms of rubber products including technically specified natural rubber (TSR), which is the most produced rubber product in Thailand, rubber smoked sheet, natural rubber latex, and other rubber products that are less produced. The majority of the products is exported and can be categorized into various product types as shown in Figure 1(b).



(a) (b)

Figure 1: Thailand rubber statistics in (a) production quantity and (b) export rubber by product types (Rubber Research Institute, 2012)

In Thailand, the south is the most humid region with relative humidity ranges from approximately 60% to 95% over the course of the year. Although often times, the south can have relatively dry season during December to February, rubber plantations are popular in this region. Surat Thani, a province in the south of Thailand, has the largest percentage of rubber plantation areas. Since rubber plantations are lucrative, they have increased dramatically over a decade not only in the south, but also in other regions.

A survey was conducted to investigate the entire process of harvesting and transporting rubber products. The table below shows the locations where the investigation was conducted.

Table 1: Observation areas

Area condition	**Provinces**
Farmland	Surat Thani
Local/Village buying sites (For natural latex)	Surat Thani, Trad
Regional middlemen (For natural latex)	Surat Thani
Local/Village buying sites (For cup lump and rubber sheet)	Surat Thani, Trad, Nongkai, Bungkun
Processing plants	Surat Thani, Trad

From the above table, we investigated the areas where the majority of the local farmers plant rubber. Most of the product being transported in the South is in the form of pure natural latex since processing plants are nearby. However, a few farms may transform pure natural latex into cup lumps or rubber sheets before selling depending on their preferences and equipments. In some other regions, farmers prefer to transform their crops into solid forms due to the lack of nearby natural latex processing plants.

3. ROUTINE TASKS OBSERVATION

Activities were observed to be slightly different between types of rubber products. Transferring solid rubber products is relatively straight-forward since the multi-purpose trucks serve most fundamental needs. The possible minor modifications might be on hydraulically operated dump bodies and/or flat beds. However, the obvious need of product-specific vehicle is on natural latex transportation since it requires a few extra functions such as special tank with stirring tool to preserve quality and pump to transfer the latex. The process of harvesting and transporting pure natural latex is shown in Figure 2 below.

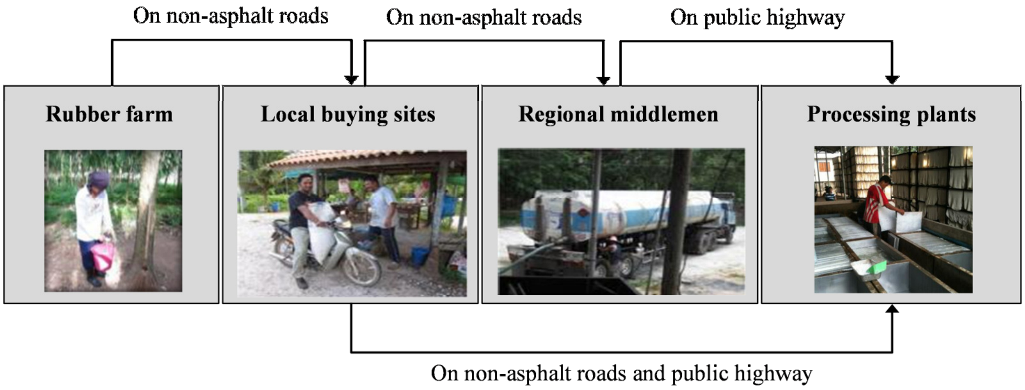


Figure 2: Natural latex transportation

From Figure 2, the harvesting process begins when farmers tap rubber trees, wait for latex to fill up the containers, and collect the latex. Farmers typically use large plastic bags to gather natural latex from every containers (total weight is usually around 60 kilograms), and use motorcycles (with or without sidecars) to transport the bags to sell at local buying sites. At each local buying site, typically, natural latex is poured into metal buckets while it is being sampled to test for the dry rubber content. After measuring the weight, latex is poured into either a tank attached to a pickup truck or a stationary tank. Only when the tank is full or it is the end of buying site' business time, the truck will carry the container to sell latex either at a processing plant or at a regional middleman depending on the offered price. For regional middlemen, they will collect latex until they have sufficiently large amount of natural latex (roughly about 30-40 tons) which will be transported and further sold at a processing plant.

To perform the cost structure analysis, information was collected by short interviews and task observation. The travelling distance and the time required to complete each activity is shown in Figure 3 and Figure 4. The typical distance between a farm and a local buying site is usually no more than 35 km which takes up to 7% of the average total traveling distance of the product. The activities with relatively long distance are the transportation from the local buying sites to the regional middlemen (approximately 40 km), and the transportation to the processing plants (approximately 60 km).

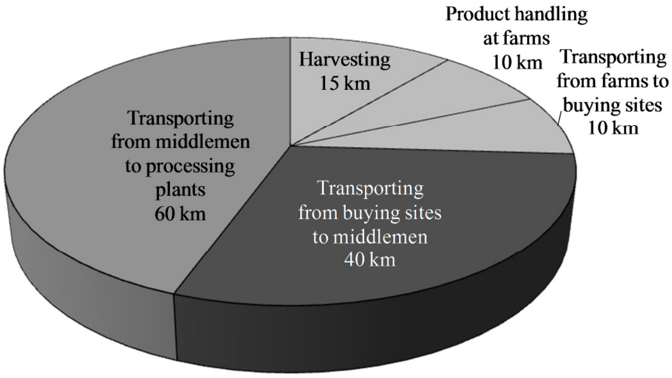


Figure 3: Natural latex travelling distances

When the associated time is considered, agriculturists spend the majority of time harvesting for rubber products. While the local buying sites and regional middlemen have the majority of work time dedicating to the process of transportation. The research team also observed some difficulties and inefficiencies in the vehicle usage which will be described in section 5. Moreover, the short interview clearly showed that there are possibilities to improve the transportation at the local buying sites.

To quantitatively assess the activities and the allocated costs, the following cost structure analysis was conducted in the next section. The analysis considered vehicle costs, labor costs, and maintenance cost.

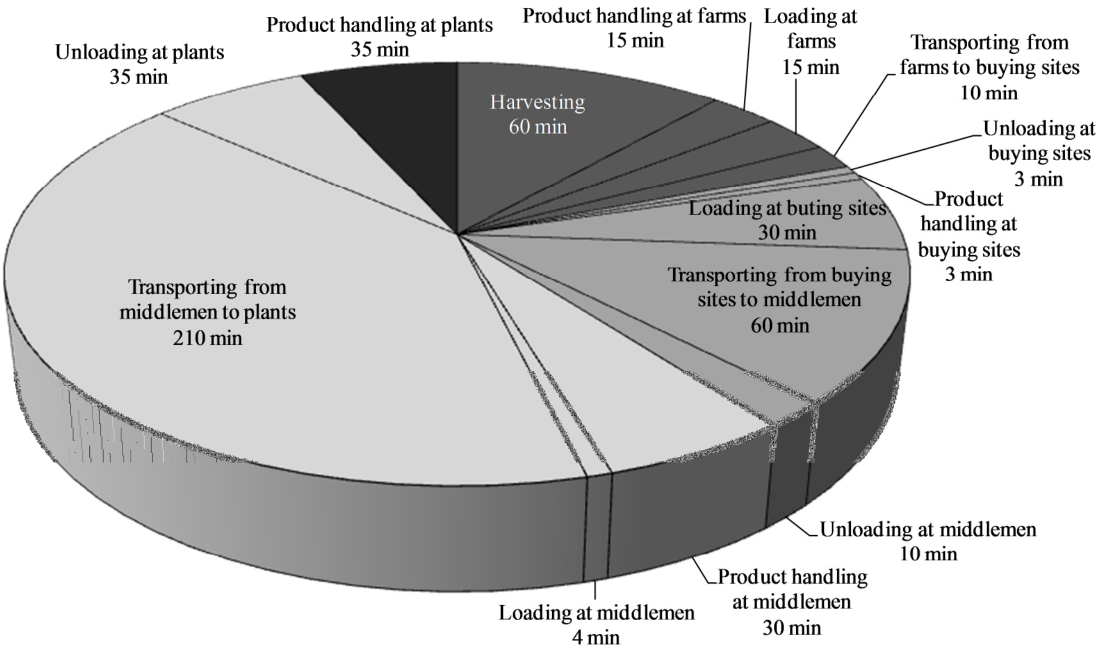


Figure 4: Time required for tasks

4. COST STRUCTURE ANALYSIS

The team considers three dimensions of the cost structure including the economic monetary value, the time required to complete each step, and the natural latex quality.

Economic value

When considering the cost structure of harvesting and transporting natural latex, the calculation takes into account the vehicle cost, labor cost, and operating and maintenance cost. The vehicle cost considers depreciation, fuel, maintenance, tax, and insurance. Sukkua & Sriwarin (2008) surveyed and found that the average rubber plantation area for a typical farmer is 14.2 Rais (approximately 23,000 square meters) and their result was used in the analysis. The cost structure is being constructed for the three stakeholders including farmers, small-scaled buying site owners, and regional middlemen owners, as shown in Figure 5.

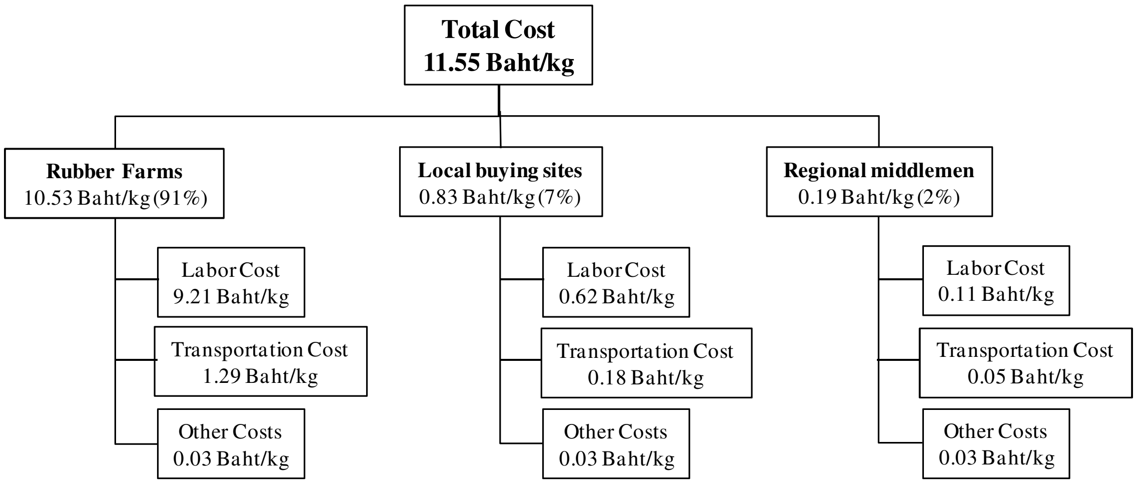


Figure 5: The cost structure of harvesting and transporting natural latex

From this figure, the total cost for harvesting and transporting natural latex is 11.55 Baht/kg. This 11.55 Baht/kg can be divided into the three stakeholders such that a farmer faces with 10.53 Baht/kg, a typical local buying sites faces with 0.83 Baht/kg, and a typical regional middleman faces with 0.19 Baht/kg. The cost to a farmer per kilogram is the largest since the farmer is responsible for the entire harvesting process of rubber product, resulting in the largest labor cost. The costs per kilogram to both local buying site and regional middleman are relatively smaller than that to the farmer since they are responsible for only collecting, transporting, and selling natural latex to processing plants. Although the observation shows that transportation cost per kilogram is relatively small compared to labor cost, local buying sites and regional middlemen still need to transport a very large amount of natural latex. Consequently, improving vehicles that reduces transportation cost (and may help reducing labor cost) can significantly improve the entire rubber production and transportation processes.

The cost structure can be divided into various activities for each stakeholder as follows:

Farmers

Approximately 80% of the total cost to farmers is the cost of tapping rubber trees. The remaining costs are mostly transportation and operating costs.

Local buying sites

The cost to local buying sites can be divided into various activities as shown in Figure 6. The largest cost at local buying sites is for hiring labors to perform normal operations, which is accounted for approximately 70% of the total cost to buying sites' owners. The labors are responsible for transferring, weighting, and measuring DRC of natural latex. For local buying sites, activities that incur the next largest percentages of cost are the process of transporting natural latex to processing plants, and the process of taking empty trucks back to the sites (approximately 30% of the total cost).

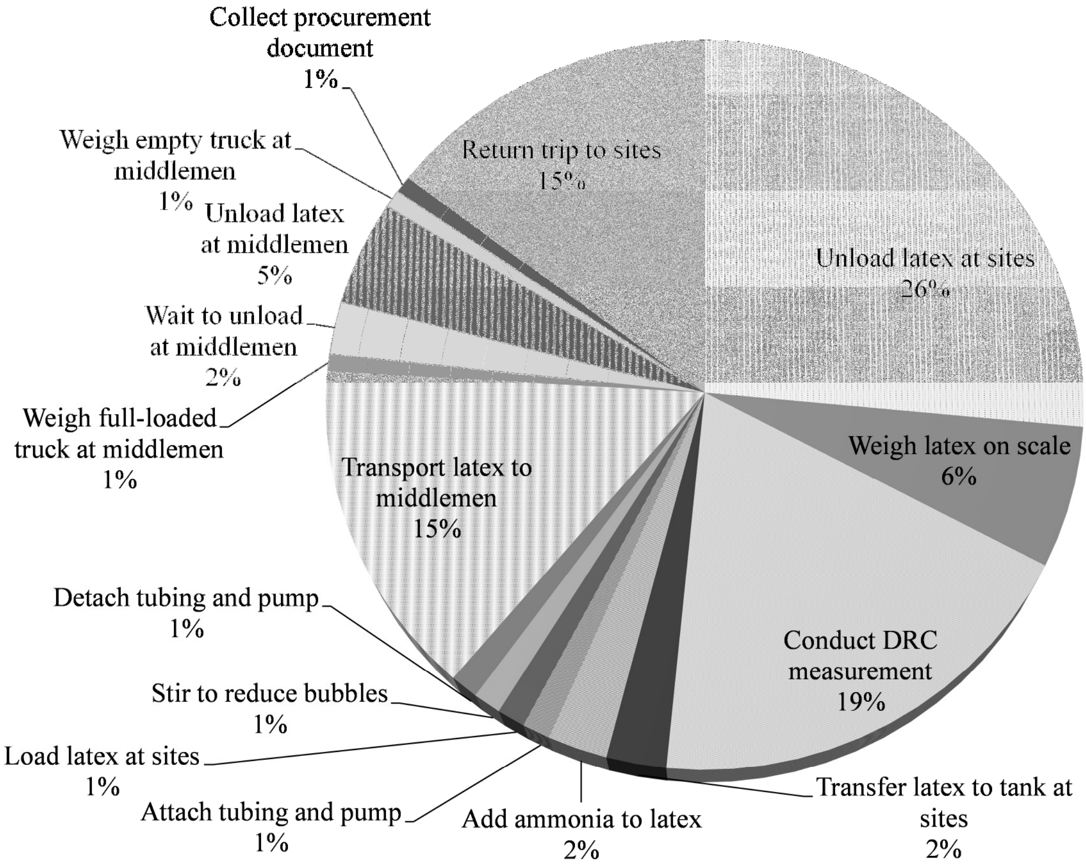


Figure 6: Cost structure of local buying sites for all activities

Regional middlemen

Similar to the local buying sites, approximately 55% of the total cost to regional middlemen is the labor cost. The regional middlemen also incur large percentages of cost (approximately 45%) to transport natural latex to processing plants and to take empty tank trucks back to the sites.

Time required for each step

The time required for each step was calculated and illustrated in Figure 4 in Section 3.

Product quality preservation

The frequency of transferring natural latex is the key index of interest to the deterioration of its quality. The pouring and pumping action produces air bubbles dispersing in natural latex, resulting in the coagulation of natural latex. On average, natural latex will be transferred twice as it is unloaded and loaded at each tier. At rubber processing plants, natural latex will be transferred only once. Hence, the total number of transfer throughout the entire natural latex harvesting and transporting process is seven times.

5. TARGET GROUP

After considering the three measures of natural latex harvesting and transporting processes, the target stakeholders that seem critical for an improvement of product-specific vehicles are the local buying sites. The observed problems and difficulties include:

(1) The tanks sitting on the bed of the pickup trucks also need a lot of improvements. Commonly, they are mounted on top of small trucks, either permanently by welding to the chassis, or temporarily by mounted to the pickup beds. During the entire natural latex collection process, which generally takes approximately 3-4 hours each day, the truck equipped with the storage tank is to be placed at buying site. Consequently, there is a loss in opportunity cost of the idle trucks. In addition, trucks with permanent tanks are idle not only during the natural latex collection process, but also during the non-harvest season, which lasts around 2-3 months depending on geographical regions.

(2) As the natural latex slowly coagulates when it is exposed to the air and becomes powder-like sludge, the sludge is settled and accumulates at the bottom of the tanks, which subsequently needs to be manually cleaned weekly. The tanks cost approximately 20,000 Baht per 2,000-liter tank, which is considered to be expensive.

(3) When transferring natural latex into tanks, the buying sites' workers have to repeatedly stir the latex to decrease the formation of the air bubbles.

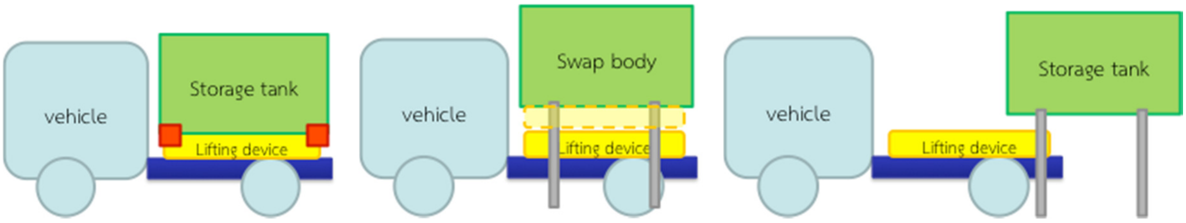
(4) At some sites, pumps are installed either permanently or temporarily to the trucks for loading the latex. Because of the latex sludge, these pumps are clogged frequently, resulting in pump cleaning scheduled once or twice a week.

(5) At local buying sites, both farmers and workers at the sites have to work together to inconveniently lift 60-70 kilogram bags containing pure natural latex from farmers' motorcycles to weight and pour into tanks or containers at the sites, as illustrated in Figure 7.

Figure 7: Activities at local buying sites

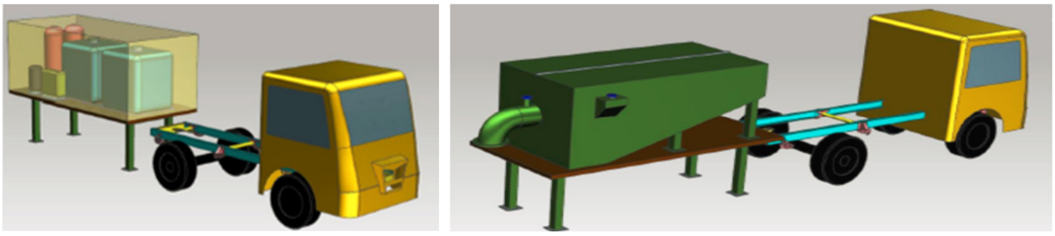
6. PROPOSED DESIGN/SOLUTIONS AND DISCUSSION

In this study, the pickup truck concept with the storage tank changing device is proposed as a potential solution for natural latex collection and transportation. As illustrated in Figure 8, the natural latex tank, which equipped in the truck, allows the maximum capacity of 2,000 liter as needed by most local buying sites. By means of the developed swap body lifting mechanism, the tank can be lifted above the level of the vehicle frame. After the so-called "swap" body of the tank is supported with four up-folding legs as shown in Figure 8, it can be left anywhere. The great benefit is that the vehicle may be used for other purposes by replacing the natural latex tank with other equipment such as water tank and flatbed without using a crane or hoist (as shown in Figure 9), or make multiple trips with a single vehicle.



(a) (b) (c)

Figure 8: Proposed design of a pickup truck with the storage tank/swap body changin g device



(a) (b)

Figure 9: Proposed design of a pickup truck with swap body changing device; (a) a d esign for drinking water transportation and (b) a design for natural latex transportation

To avoid air bubble formation during the latex transfer, baffled tank and a stirrer located at the bottom of the tank can be used (Torré, Fletcher, Lasuyec, & Xuereba, 2007). By means of the designed obstructing vanes, the surface vortex and consequently the amount of air-bubbles can potentially be reduced. In addition, the natural latex pumping system, which is integrated in the vehicle, is designed to simplify the daily cleaning process. Hence, the pumps could be redesigned so that obstructions in the pump and tubes might be effectively avoided in the system.

7. BENEFIT ANALYSIS

Based on the proposed vehicle design, natural latex transportation process at local buying sites can be improved. As shown in Figure 10, the transportation cost for this particular chain can be reduced by 33%, from 0.15 to 0.10 Baht/kg. Moreover, the storage tank can be left at any local buying sites without the vehicle; therefore, the local buying site owners can use the vehicle for other purposes. The new design can also save time to pump natural latex from buying sites' containers to a tank on the truck. The benefit of the swap body idea is obvious especially when there is a long waiting line at regional buying sites or at a rubber processing plants since the owner can leave his swap body at those locations and use the vehicle for other purposes. In terms of increasing product quality, the baffled tank with integrated stirrer can potentially increase the storage efficiency, and at the same time, preserve product quality by reducing the number of air bubbles when adding natural latex from other buying sites into the tank of the first buying site (for the case when the local buying site owner owns more than one site).

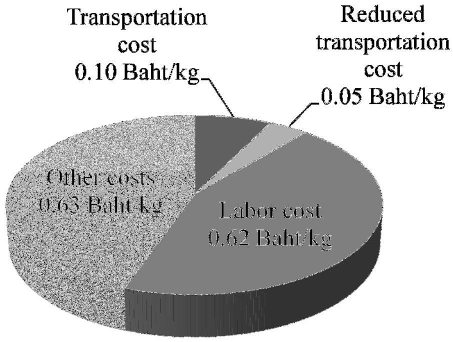


Figure 10: Calculated transportation cost reduction with the proposed vehicle design

8. CONCLUSIONS

Product-specific vehicles were considered to be a potential way to reduce the natural latex operating and transportation costs. The tasks performed were carefully observed at the rubber farms, local buying sites, regional middlemen, and rubber processing plants. Data collection and short interviews were conducted to gather information for the cost structure analysis, including three measures: the economic monetary value, the time required in each step, and the rubber product quality preservation. Five problems were noted at the local buying sites as follows: (1) the loss in opportunity cost of the idle trucks, (2) the sludge settled and accumulated at the bottom of the tanks, (3) the formation of the air bubbles in the tank, (4) the latex sludge clogging up the pumps, and (5) the 60-70 kilogram bags which are too heavy to handle. Most of these problems can be solved by the proposed design of the product-specific trucks that benefits not only the reduction of the transportation cost, but also the increased users' convenience and the improved vehicle utilization. The design involves the storage tank/swap body changing device, the baffled tank with an integrated stirrer, and the redesign of the pump and its system.

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