論文の内容の要旨

森林科学専攻

平成 23 年度博士課程　入学

氏名　リアントラクーン　ラッダワーン

指導教員名　酒井秀夫

論文題目 Establishment of biomass supply chain of residue from rubber plantation regeneration

(ゴムプランテーション更新における廃材のバイオマスサプライチェーン構築)

Rubber tree (*Hevea brasiliensis*) is a high value economic crop producing both latex and wood. It has been cultivated in Thailand from 1900 and the initial purpose was latex products. After the logging ban in 1989 in Thailand, rubber wood had become one of the most popular timbers and increased the demand. The rubber wood can be obtained when the production of latex is uneconomical; 25-30 years rotation period. Rubber wood are harvested by clear cutting to prepare the site for replanting. Short wood method is a normal method for rubber tree harvesting, which are composed of felling, delimbing, and cutting to desired length. The object of this study was to investigate and analyze the rubber wood harvesting to improve the efficiency of wood biomass supply chain.

Chapter 1 is the general analysis of rubber wood utilization in Thailand. Nowadays, whole rubber tree was utilized including trunk, branch, and stump/root. There were various products from rubber wood biomass such as veneer, particle board, lumber, medium-density fibreboard, charcoal, and wood chips.

Chapter 2 analyzes the short wood harvesting in rubber plantation. Study areas were located in private rubber plantations in southern part of Thailand. The rubber wood harvesting system involves felling and processing in stump area, and transportation from plantation to sawmill. Felling method based on manual and mechanized methods. Manual felling method used chainsaw while mechanized felling method utilized bulldozer. The bulldozer was modified by attaching the tree pusher over the blade to provide the leverage when push the tree. Then felled trees were bucked with chainsaw to the desired length. Finally, all bucked logs were transported to sawmill by pickup truck. Time study, productivity, time prediction model, and cost analysis were described in this chapter. The average time consumptions for felling with chainsaw and bulldozer were 39 and 76 seconds per tree, respectively. Stump diameter was used to establish the time prediction model on both felling method. The bucking operation averaged 114 seconds per one cycle and the time prediction model could be described by the number of logs and the log volume per tree. Thus, the productivity models on felling and bucking with chainsaw were obtained. The time consuming for transportation including manual loading and unloading was approximately 133 minutes per one round trip by pickup truck with 13 km distance between plantation and sawmill. The average travel speeds with load and empty were 19 and 20 km/h, respectively. The range of log weight was between 2500-3200 kg per truck. The travel time was significantly affected by the travel distance, velocity, and other related operation time. Cost estimation based on machine rate method for felling with chainsaw, bulldozer, bucking, and pickup truck transportation were US$0.90, 1.57, 0.98, and 15.28 per cubic meter, respectively. It was recognized that the transportation cost including loading, travelling, and unloading cost was the main cost of short wood system in rubber wood harvesting.

Chapter 3 analyzed the stump harvesting techniques and its utilization. The investigation data were conducted during forest road construction in Japan and site preparation in rubber plantation in Thailand. In Japan, small excavators with bucket were used to remove the stumps of the obstacle trees on the planned route. There were two techniques which could be distinguished by the positions between excavator and stump. On steep slopes, the position of excavator was lower than the stumps and it was easy to scoop the soil and stumps. On the other hand, when the excavator and stumps were same level; removing technique started from digging around stump, and leveraged and lifted. This technique was also used in rubber stump removal and the operation at rubber plantation was faster because of large excavator. The overall techniques were affected by machine specifications, area conditions, stump properties, position of machine and stump, and operator experience. However, rubber stump could be removed by felling method with bulldozer. In addition, current removal of tree stumps for bioenergy is uncommon in Japan; and stumps are placed on the slopes at the roadside to increase slope stability. On the contrary, rubber stumps have become a new source of biomass. The potential of biomass utilization of rubber stumps was about 38,200 kg/ha or 14% of total biomass of a rubber tree.

Chapter 4 develops a cost estimation of rubber wood supply chain based on short-distance transportation. The Google Maps API was applied to find the shortest route between rubber plantation and sawmill. The advantages of Google Maps API were free for non-commercial user, updated data frequently, and easy to obtain the information of road networks covering local and highway roads. The interface of cost estimation required the location of plantation and sawmill, and quantity of rubber wood in that plantation. The shortest distance was retrieved by the working of direction service function from Google

Maps. The models from Chapter 2 were applied to estimate harvesting and transportation cost based on chainsaw and pickup truck operations. The samples of rubber plantations were located in southern part of Thailand and obtained from the rubber wood auction market. The results showed route directions on the map and total cost of harvesting system. This system will be useful for plantation owners, wood harvesting contractors, and sawmill owners to manage and design the rubber wood supply chain.

Chapter 5 provides the summary and conclusion of the research. The tactics of future research was also pointed. For example, the environmental effect by bulldozer operation was recommended to be researched. Due to the recent high competition in rubber wood markets, improving the harvesting operations will be needed.