APPENDIX A

Economic Analysis of the Harvest and the Use of Rubber Leaves

1. Introduction

It is envisaged that in the commercial scale mechanization will be implemented in all stages of operation. The machines involved are for collection, separation and densification. Given below is the economic analysis. The analysis is based on the conceptual design of mechanization described in section 5.

2. Economic analysis

2.1 Annualized capital cost

Assuming interest rate of 15 %, the annualized capital cost is given in Table A.1

Table A.1

Annualized Capital Cost

Item	life (years)	Cost (Baht)	VESL (Baht)	CRF	Annual Cost
Two stroke engine (10HP)	5	10,000	1,000	0.29832	2,834
Push cart	5	3,000	300	0.29832	850
Duct system and suction head	5	2,000	0	0.29832	596
Blower and accessories	3	4,000	500	0.43798	1,608
Filter bag	1	1,000	0	1.15000	1,150
Screw press	5	20,000	2,000	0.29832	5,670
Construction cost (paid in the first year)	perpetual	5,000			750
Total annualized capital cost					**13,458**

CRF = Capital recovery factor of 15% interest and n years.
VESL = Value at the end of service life
*Annualized cost = (Cost-VESL)(CRF i,n) + VESL*i*

2.2 Annual operating cost

Basic data:-

Waste collecting period is limited by 2.5 months after when the rain, weed and latex tapping season prohibit the collection.

Waste collecting period	= 2.5 month/year
Waste collecting rate	= 1 rai/hr
Working hours	= 7 hr/day
Petrol for waste collection	= 10 Baht/hr
Lubrication	= 100 Baht/year
Labour wage	= 80 Baht/day

The annual operating cost for 2 different sizes of the screw presses is shown in Table A.2.

Table A.2

Annual Operating Cost

Description	**Size of screw press (kW)[b]**	
	20	**4**
Petrol for collection	5,250	5,250
Lubrication	100	100
Labour[c]	12,000	6,000
Transportation[a]	8,723	8,723
Electricity for the screw press	25,515	24,834
Total	51,588	44,907

The analysis in Table A.2 is based on an assumption that the leaves are obtained free of charge. Total harvested leaves by each machine is calculated by 1 rai/hr.7 hr/day.30 day/month.2.5 month/yr. 227.3 kg/rai = 119,332 kg/year. Paragraphs below explain the calculation of costs in Table A.2 which marked by superscripts (a), (b), and (c).

(a) Transportation cost:- The basic data give the total collection area of 525 rais per year. Rubber plantations, although are owned by small holders, can be treated as a single vast area. Working in the middle of 525 rai plantation means the range of the transportation is 0-1 km. Assume the leaves are delivered by a pickup truck which costs 5 Baht per trip and the truck capacity is 3 m^3. Hence, the annual transportation cost is,

5 Baht/3 m^3. 1 m^3/22.8kg. 119,332 kg/year = 8,723 Baht/year.

(b) Size of screw press:- It was reported that in order to produce densified biomass at a rate of 150 kg/hr by a heated die screw press, the machine has to be powered by a 15 kW motor and 3 kW heater (Eriksson & Prior 1990). It is desirable that the hourly production rate of the combined collection and densification processes is for the wastes of 1 rai so that there is no storage cost (of the bulky leaves). Assume further that for the densification of 227 kg of rubber leaves (dry leaves of 1 rai) per hour, the machine requires power input of 20 kW. The monthly electrical energy requirement for 7 hour/day operation is 4,200 kW-h. Electricity costs progressively and at present the highest unit cost is 2.43 Baht/kW-h when the monthly consumption exceeds 801 kW-h. In fact, it is not necessary to use the 20 kW motor in order to finish the densification within 2.5 months and pay the highest electricity cost.

In practice, the smallest size of the motor is considered by the longest allowable densification period, which is 12 months. Assuming that the production rate decreases linearly with the decrease in kW of the motor. Therefore, the smallest motor-heater unit is 4.17 kW (use 4 kW for analysis). The operating cost of the 4 kW unit is shown in the last column of Table A.2. The 4 kW motor will consume 840 kW-h/month which unfortunately exceeds the 801 kW-h limit. Thus, it is impossible to reduce the annual electricity cost for the screw press whatever the size it is.

(c) Labour cost:- It was assumed that the high production rate of the 20 kW screw press (227 kg/hr) needs to employ 2 workers (3 workers including the owner) and the 4 kW unit employs 1 worker (2 including the owner). The employment occurs during the 2.5 months only. The labour wage is 80 Baht/day.

Therefore, the minimum of total annual cost is the sum of annualized capital cost and the minimum annual operating cost which is 13,458 + 44,907 = **58,365 Baht/year**

2.3 Earning from the Wastes

One cubic meter of stack wood was reported to weigh 720-840 kg (Jongjitirat 1983, Lim 1986) depending on moisture content, size and variety. Assuming that the densified leaves which have moisture content of 6.7 % weigh 600 kg/m³. The average price of firewood bought by rubber smoking factories was reported as 128

Baht/m^3 (Prasertsan et al 1991). Assume the densified leaves are sold at 100 Baht/m^3 at the production site. Thus, the annual income will be 119,332/600x100 = 19,888 Baht.

It is obvious that the densified rubber plantation wastes is not economically feasible. The electricity cost alone can overwhelm the income. If the electric motor is replaced by a diesel engine (assume the same cost), the break even occurs at the running cost of the engine at -13,643 Baht/year. This is impossible.

It should be noted that reducing the size of the screw press is not necessary reduce the capital cost since extra cost must be paid for the leaves storage. In this analysis we assumed that the capital cost was independent of the size of the screw press.

APPENDIX B

Economic Analysis for Carbonized Leaf Production

As it was found that the carbonization of the leaves can be achieved by the indirect fired method, the design of a carbonizing apparatus arrives at the concept shown in Figure B.1

It was assumed that the transformation rate of dry leaves to carbonized leaves is 40% by weight (see section 7.1) and heat for the carbonization process is obtained from burning the rubber leaves of the same amount. That is, each kg of rubber leaves can produce carbonized leaves of 0.20 kg.

It is reasonable to assume that the carbonizing apparatus costs 20,000 Baht (the same as the screw press). This makes the annualized capital cost remains 13,458 Baht. The operating cost will be a lot lesser since a much smaller motor is used. The power is only needed for turning the driving screw in the carbonising chamber at a very low speed and densifying the brittle carbonized foils. Assume a 1 kW motor is used and the production period is 3 months. The electricity cost is 1.76 Baht/kW-h (range 151-300 kW-h/month). This means the total annual electricity cost of 1,108 Baht. Therefore, the annual operating cost is calculated as 21,181 Baht. The total annual cost is then 13,458 + 21,181 = 34,639 Baht.

The yield of the carbonized leaves is 0.2x119,332 = 23,866 kg/year. Carbonized saw dust briquettes were reported to be sold at 5.2-18 Baht/kg in central grocery store in Bangkok

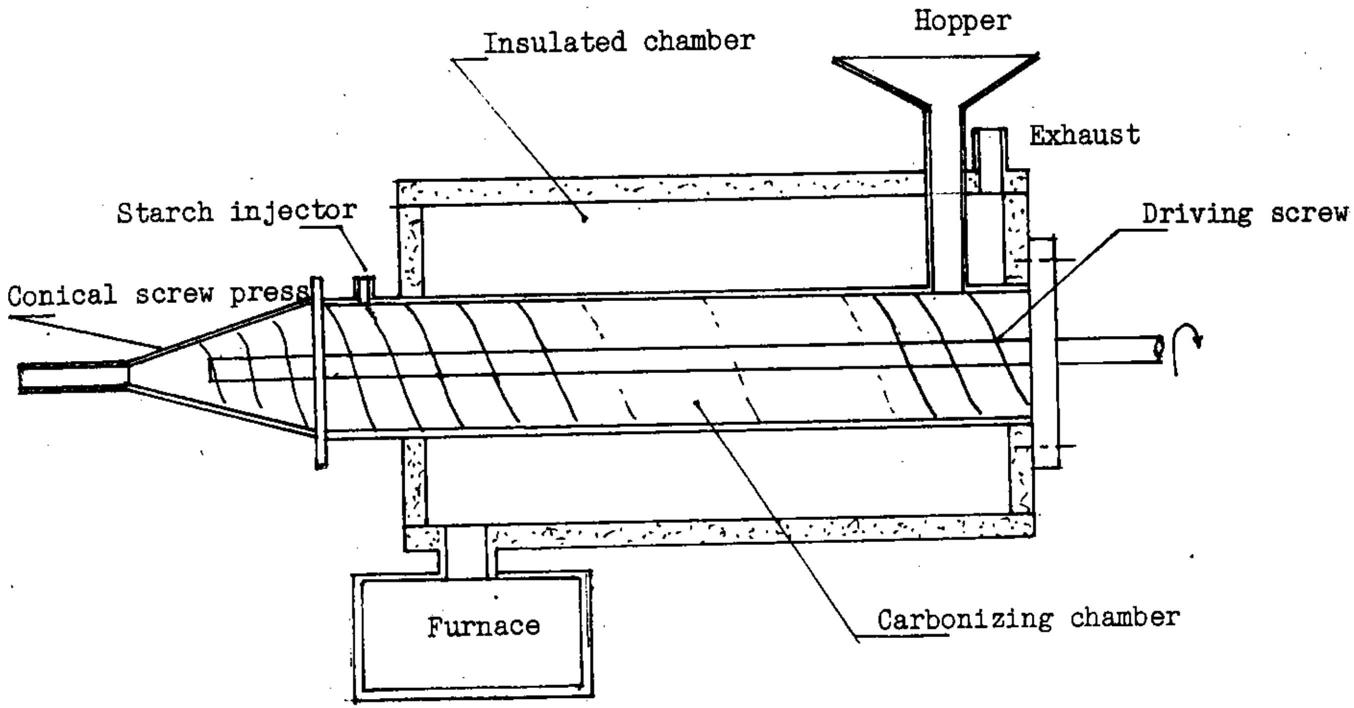

Figure B.1 Conceptual design of leaf carbonization apparatus

(Bhattcharya 1990, Eriksson & Prior 1990). The price at the factory door of biocoal was reported as 1.50 Baht/kg and 2.70 Baht/kg for carbonized rice husk briquettes and carbonized saw dust briquettes, respectively (ERD,TISTR 1984, Jongjitirat 1983). If the figure 2.70 Baht/kg is used (rice husk product has poorer quality because of high ash and silica content), the annual income can be estimated as **64,438** Baht. Comparing with the annual cost of 34,639 Baht, it can be concluded that the rubber plantation wastes can be feasibly harvested for energy production in the form of carbonized leaf briquettes.

Bhattcharya (1990) suggested that the production of the biocoal should aim for exporting since the price is much higher. At present in most of the domestic biocoal markets, it is less expensive than wood charcoal sold in small quantity but more expensive than charcoal sold in large quantity. Biocoal is mostly used by food vendors who sell food from mobile stalls. The quantities of fuel bought by them each time are relatively small and just enough to meet the daily requirement. This makes the biocoal cheaper than wood charcoal. The attributes of biocoal that most users like include no-sparking characteristic, low smoke generation, low ash content, economy and long lasting fire.