7. ALTERNATIVES FOR WASTE UTILIZATION#

It is quite clear that the densified leaves is not a desirable end product because it, although serves the objectives of the project in the sense of reducing fire hazard, is not different from fuelwood. The densified wastes can not compete with the fuelwood because the fuelwood in the rubber growing region is

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 # This section was not included in the proposal but the authors believed it is worth to study.

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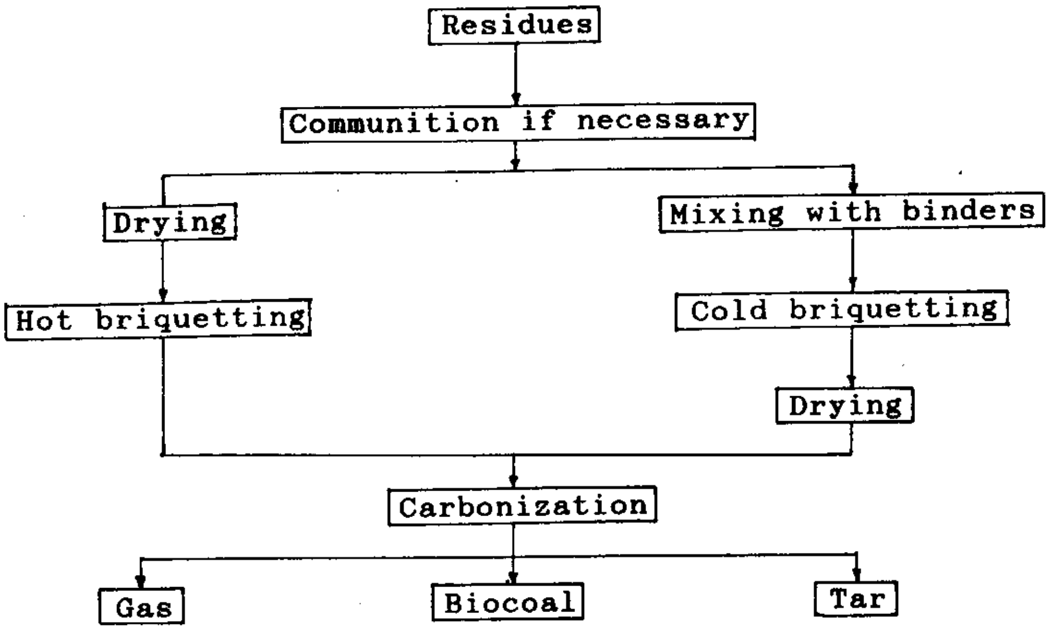
still abundant. The present situation would not allow the compacted leaves be competitive because of the complication of the process and cost. The failure of briquettes to compete with fuelwood prices is evident in many countries (Eriksson & Prior 1990). Therefore, the end product must be of higher value than just the compacted leaves.

Carbonized leaf briquettes was considered as the option. Charcoal is one of the major household fuels in Thailand especially in the rural. In the light of growing pressure on the reserve of forest wood in the country, briquetted charcoal produced from agricultural residues could be seen as an option to meet the growing charcoal demand. There are two possible ways to make charcoal from the leaves; carbonization before briquetting (C-B) and briquetting before carbonization (B-C). Figure 5 illustrates the two processes. According to the previous experience (section 3.3) there is no doubt that the former process was chosen. There are other advantages of the carbonization-briquetting process such as,

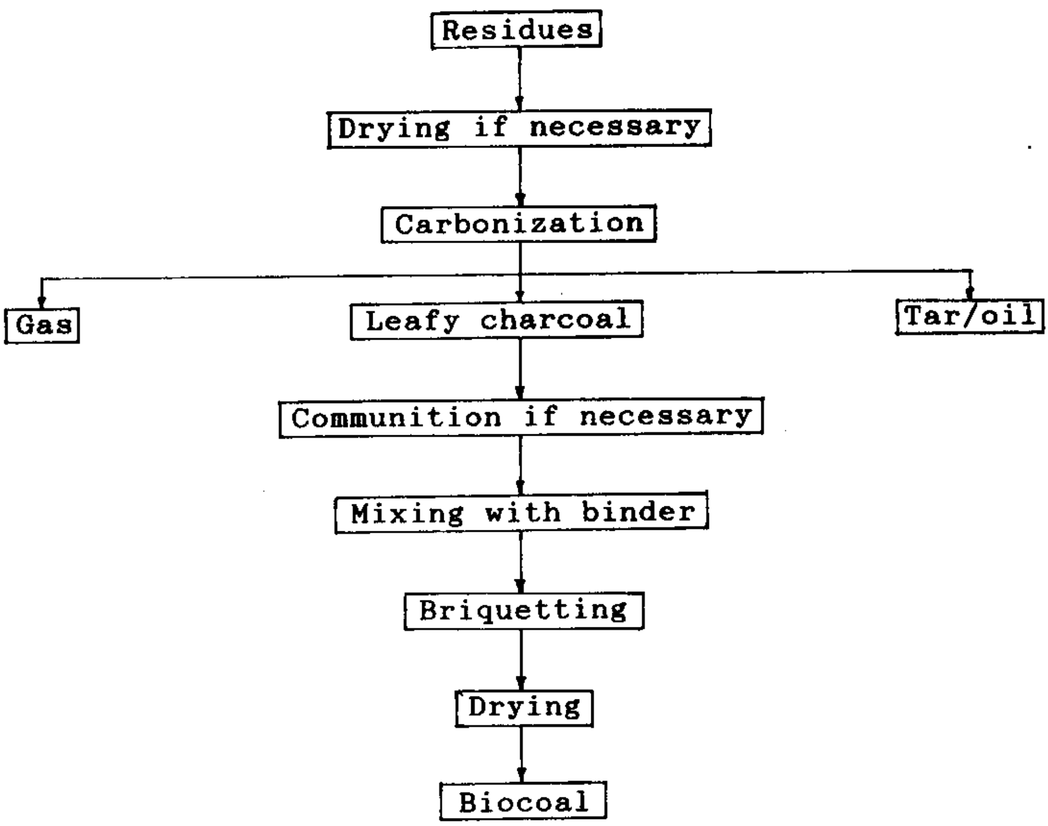
(a) The B-C process consumes electrical energy in the range of 342-395 kWh/ton compared with 178-192 kWh/ton in the C-B process (Bhattcharya 1990).

(b) The B-C process always associates with wear of the screw press which will signify the operating cost.

(c) The C-B process requires less time and heat input in the carbonization process since the surface to mass ratio of the



(a) Briquetting-carbonization process



(b) Carbonization-briquetting process

Figure 5. Process flow chart for briquetting-carbonization and carbonization-briquetting

leaves is very high. This enables the continuous process as shown in Appendix B.

7.1 Carbonization Method

It seems impossible at the first glance that the thin dry leaves can be carbonized because the rapid burning of the leaves will leave only ash at the end. The leaves can not be carbonized in the same fashion as the wood can. However, after trial tests the leaves can successfully be carbonized by an indirect fired process. The leaves were filled in a steel cylinder of 2.5 inch diameter. Two circular plates tightly closed both ends by mean of a pass-through bolt and nuts, Figure 6. A small hole was drilled in the middle of the cylinder for the insertion of a thermocouple and acted as a vent for the volatile matter to escape. The stuffed cylinder was placed in a wood furnace. It was found that the minimum time for the carbonization process was 7 minutes. The corresponding temperature in the middle of the cylinder was 307 °C. Transformation rate from dry leaves to carbonized leaves was 45.75% by weight, i.e., 100 g of dry leaves weighed 45.75 g when carbonized. This figure is quite large when compared with 39.06% (Bhattcharya et al 1987) and 25-30% (Chantepa 1984) ever been reported. The carbonized leaves and rubber wood charcoal were analysed by the Department of Science Services. The results are tabulated in Table 7.

In general, the carbonized rubber leaves have poorer quality in all aspects when compared with the rubber wood charcoal. The carbonized leaves contain lesser carbon and higher in ash and

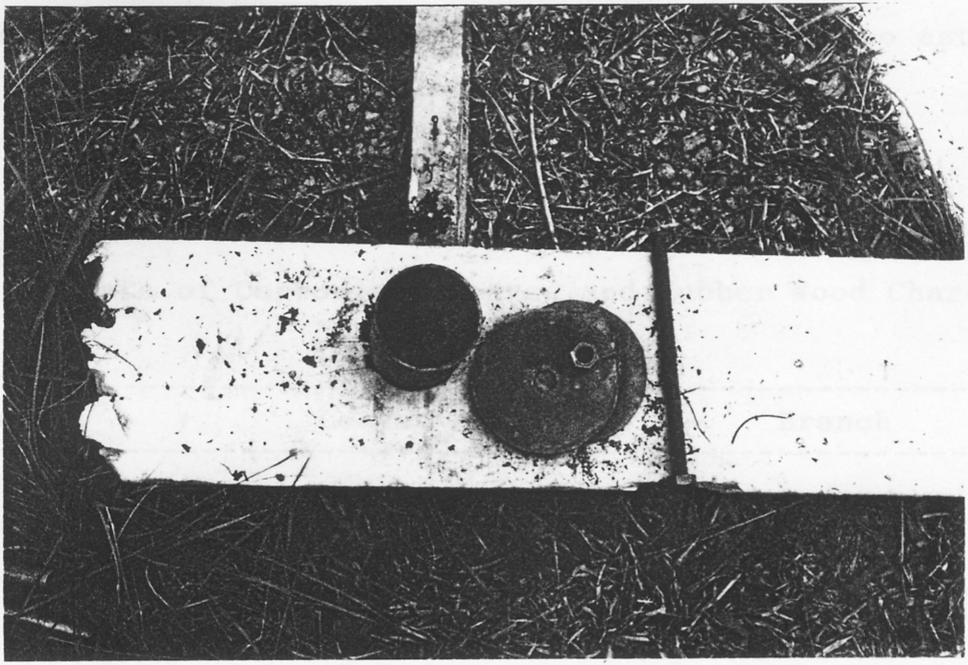


Figure 6. Indirect fired carbonizing cylinder

volatile matter. This resulted in lesser heating value (weight basis) of the carbonized leaves. However, the characteristics shown in Table 7 indicated that the leaves might not be completely carbonized. Carbonization in this experiment occurred at the shortest possible time (7 minutes) in order to establish the minimum energy requirement for the carbonization.

Table 7

Analysed Data of Carbonized Leaves and Rubber Wood Charcoal

Components	Leaves	Branch
Proximate analysis		
Moisture %	5.1	7.8
Ash %	13.3	2.6
Volatile matter %	35.9	8.1
Fixed Carbon %	45.7	73.7
Ultimate analysis		
Carbon %	55.5	75.4
Hydrogen %	5.0	3.6
Oxygen %	24.2	17.9
Nitrogen %	1.6	0.49
Sulphur %	0.42	0.04
Calorific value cal/g	5,767	7,263

7.2 Densification of the Carbonized Leaves

The carbonized leaves are dry brittle and absent of lignin which make it is impossible to be densified by an ordinary press. The brittleness of the leaves is a beneficial characteristic because the carbonized leaves can arrange themselves to effectively fill the die and be compressed in a constrained boundary. However, binder is needed to keep them in shape. The usual binder is starch from any source, whichever is the cheapest. Although other binders have been used such as china clay and molasses they do not produce as satisfactory briquettes as starch (FAO Paper 63, 1985). The binder must not produce an objectionable odor or smoke on burning. The binder must be fairly resistant to fermentation and bacterial attack during storage. All these considerations tend to favour starch as the best all-round binder. An experiment was performed having cassava flour as a binding agent. Ten percent (by weight) of cassava flour was stirred well with water and mixed with the carbonized leaves. The compound was then densified at pressure of 5,500 psi. The densified mass was heated for 2 minutes in a microwave oven and oven dried at 45 °C, Figure 7. The final densified mass had characteristic as followings.

Dry weight 149.06 grams,
Moisture content 27.3% (before oven dried),
Dimension 3.5 inches in diameter and 2 inches in length,
Density 0.634 g/cm^3 and 0.481 g/cm^3 before and after oven dried, respectively,
No change in length but diameter expanded by 1.8%,
Hard and strong to withstand repeated 1 meter drop tests.

7.3 Economic Analysis of Carbonized Leaves

Economic analysis for the carbonized leaf briquettes is given in Appendix B. In summary the process requires less electrical energy because the carbonized leaves are brittle and less in friction. The briquetting process does not occur at pressure as

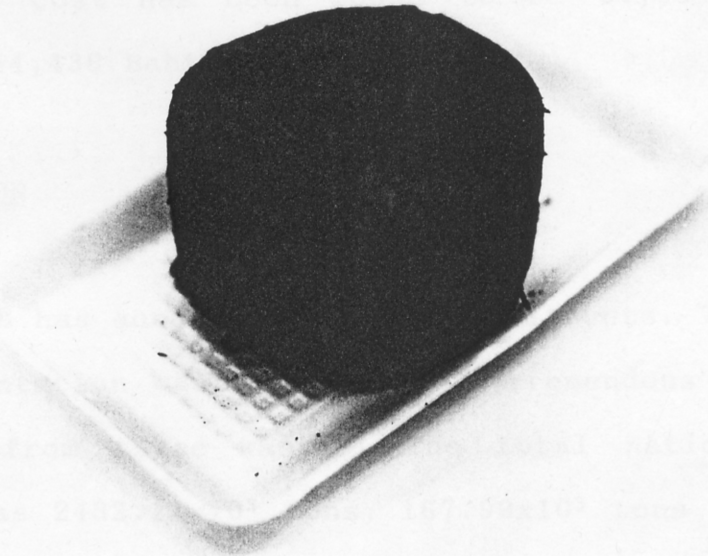


Figure 7. Densified carbonized leaves

high as the briquetting of the dry leaves. The amount of mass to be densified is 80% less than the original material. The carbonized leaf briquettes are expected to be sold at higher price (than the dry leaf briquettes) at 2.7 Baht/kg.

The annual cost has been found to be 34,639 Baht while the income is 64,438 Baht.