CHAPTER I

INTRODUCTION

1.1 Anthracite

Coal is a rock derived from vegetable matter through the process of metamorphism, which requires that heat and pressure act over long periods on this matter, altering both its chemical and physical characteristics. The initial stage of coal formation is peat, decomposed organic matter. The three main ranks of coal are *lignite*, *bituminous coal*, and *anthracite*. *Lignite* is closely related to peat but has a lower moisture content. It has the lowest heating value of any of the ranks of coal. *Bituminous coal* is more dense than lignite and is black in color. Bituminous coal is the most commonly used of the ranks of coal for industrial purposes, both for the generation of electrical power (unless prohibited because of sulfur or other impurities) and for the production of COAL TAR and COKE through destructive distillation. *Anthracite* is the hardest of all the ranks of coal and typically has a lustrous black appearance.

Anthracite sometimes also called "hard coal," anthracite was formed from bituminous coal when great pressures developed in folded rock strata during the creation of mountain ranges. This occurred only in limited geographic areas. Anthracite has the highest energy content of all coals and is used for space heating and generating electricity. Some billon tons of anthracite enough for 500 years is still in four distinct fields. All anthracite shares the advantage of high carbon content but one of the deposits yield a grade of coal that is of extraordinary quality. This deposits is found in Pennsylvania the USA. The processing of anthracite coal is show in **Figure 1.1**.

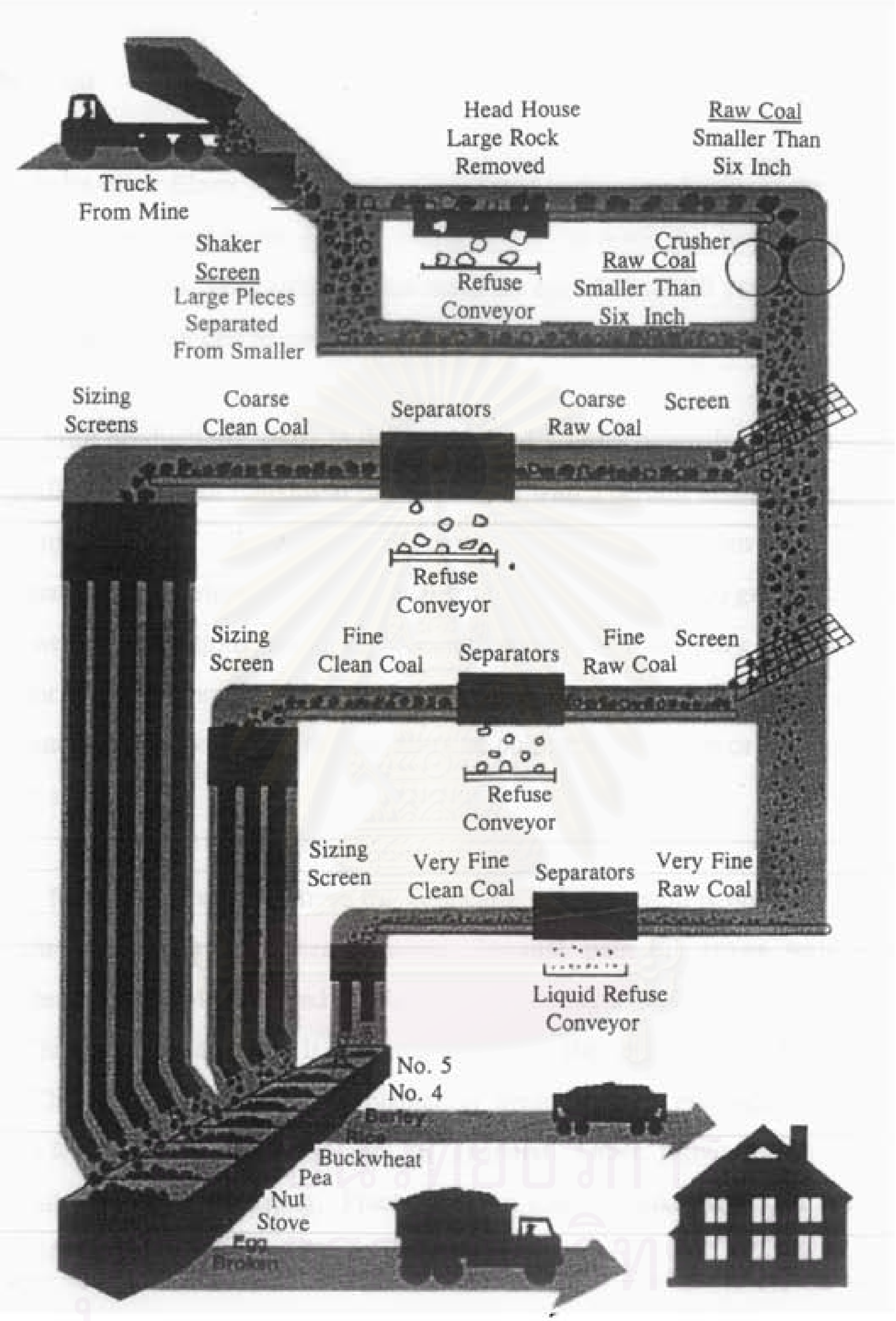


Figure 1.1 Representation of typical coal processing include anthracite coal.

1.2 Palm-oil

Palm-oil or *Elaeis guineensis* Jacq[1] belongs to the same family as the coconut. Its origin may be traced to the African continent. It can reach the height of 15 to 25 meters, growing wild. The palm-oil[2] can reach the age of 80 to 120 years; its fertility, however, comes to an end much earlier, namely about 60 years.

Fruit production[2] starts in the 3rd to the 4th years onwards and increases up to the 8-10th years, then remains at the same level with a certain amount of variation for a long time, but mostly falls off more or less rapidly from the 20th year, approximately. The weight of an individual fruit varies between 4-20 grams according to local weather conditions, manuring and cultivation. The fruits vary very greatly in size, color, composition and shape, according to variety. An individual fruit consists of the outer exocarp or skin, the mesocarp of pulp, the endocarp or shell, and the kernel or seed.

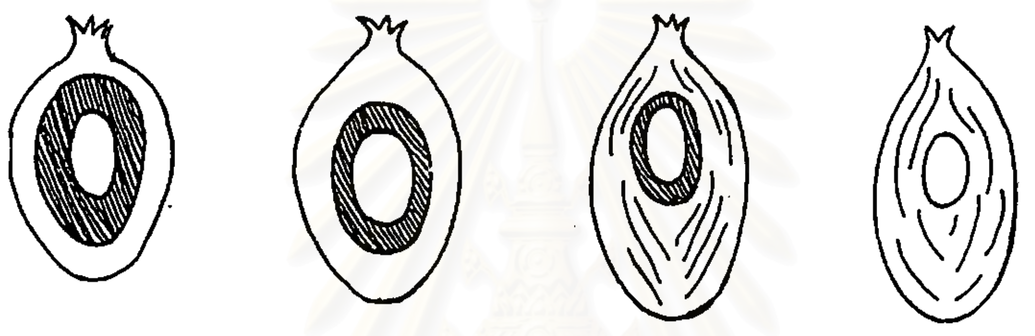
Palm-oil is extracted from the mesocarp, and kernel oil is obtained from the kernel after the endocarp has been removed. Because palm-oil grows well in hot zones where there is plentiful and regular rainfall throughout the year, the southern part of Thailand is ideal for it. It is grown mostly in the provinces of Krabi, Surat Thani, Chumphon and Satun. The plantation areas in these provinces account for about 95% of palm-oil growing area in Thailand. Other provinces where it is sporadically planted are Trang, Prachuab Khiri Khan, Phuket and Yala. Palm-oil strains[3] include the following (**Figure 1.2**):

- *Macrocaya strain*. It is an old strain gives low yield and therefore is not often grown.

- *Dura strain*. It is similar to the old strain. The skin of the fruit is rather thick. It is commonly grown, but is preferred as a breeding strain for the improvement of new strains.

- *Pisifera strain.* It has thick outer flesh (mesocarp) and high oil yield. However it is not commonly used in cultivation, though preferred as a breeding strain for the improvement of new strains.

- *Tenera strain.* It is a cross between Dura and Pisifera strains, with outstanding characteristics. It gives high yield of large fruits with thick outer flesh, thin inner flesh, thin skin and high oil content. This strain is therefore widely planted.



DURA		TENERA	PISIFERA
African	Deli		
Thick shell	Medium shell	Thin shell	No shell
45% pulp	60% pulp	75% pulp	92% pulp
40% shell	30% shell	15% shell	0% shell
15% kernel	15% kernel	10% kernel	8% kernel

Figure 1.2 Palm-oil strains in Thailand[1].

Palm-oil cultivation in Thailand has shown increasing economic signification with its expanding market demand at an average growth rate of 15% a year. Estimates of the Bank of Thailand put palm-oil plantation areas in Thailand at 957,600 rai (1991), mainly concentrated in the southern part of Thailand. Expansion of the palm-oil industry was followed by the generation of enormous amounts of by-products at plantation grounds, oil press and refineries. It has been estimated that the pressing process produces about 292,367 tons of palm mesocarp fiber, 157,428 tons of palm-oil shells and 742,163 tons of empty fruit bunches as waste in 1997.

The superior adsorption properties of palm-oil shell activated carbon are due to the natural characteristics of the palm-oil shell, viz.

- High porosity
- Large surface area
- Favourable pore size
- High mechanical strength
- Low impurities

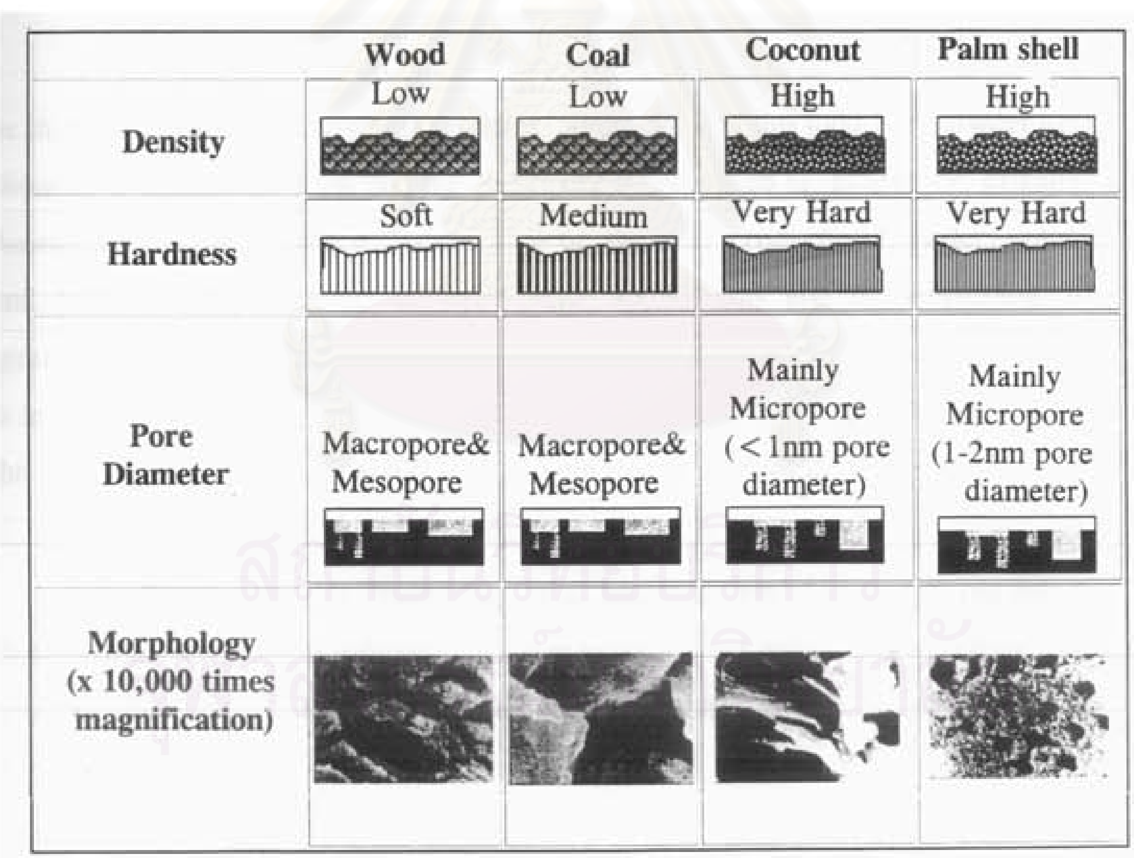


Figure 1.3 Some comparisons of raw materials for activated carbon.

1.3 Markets for activated carbon

The term "activated carbon" defines a group of materials with highly developed internal surface area and porosity and hence a large capacity for adsorbing chemical from gases or liquids. Activated carbon is extremely versatile adsorbents of major industrial significance and are used in a wide range of applications which are concerned principally with the removal of species by adsorption from the liquid or gas phase, in order to effect purification or the recovery of chemicals. They also find use as catalysts or catalyst supports. The strong market position held by activated carbon adsorbents relates to their unique properties and low cost compared with that of possible competitive adsorbents.

The world annual production of activated carbon in all forms is estimated to be in the range of 300,000-400,000 tonnes. About 55% of this total is in powder form, about 35% in granular form and the remainder is produced as pellets or extrudates. According to one reference[9], about 80% of the total production (powder, granular and formed carbon) is used in liquid-phase applications and the remaining 20% (granular and formed carbon only) in gas-phase applications. The highest consumption is in Japan and the USA ; per capita annual consumption is 0.5 kg in Japan, 0.4 kg in the USA, 0.2 kg in Europe and 0.03 kg in the rest of the world.

Consumption is increasing at a reported rate of about 7% per annum[4]. Growth areas are in air purification, solvent recovery and groundwater treatment and new applications are emerging, particularly those related to environmental protection, that will tend to sustain the level of demand.

The approximate average selling price for granular or formed carbon is between US$ 1500-4000 per tonne. For powder carbon, it is between US$ 500-1200 per tonne. The actual price will vary with the level of activity (surface areas commonly fall in the range 800-1500 m^2g^{-1}), the strength and attrition resistance and whether impregnants have been added to enhance adsorption selectivity[7].

Quantity and value of import and export of activated carbon in Thailand between 1988-1999 are shown in **Table 1.1** and **Figures 1.4-1.5**.

Table 1.1 Quantity and value of import and export of activated carbon between 1988-1999 (Activated carbon code 3802.100-004)[5].

Year	Import		Export	
	Quantity (kg)	Value (baht)	Quantity (kg)	Value (baht)
1988	1,932,203	52,327,284	260,802	8,118,737
1989	2,649,582	72,244,916	378,375	13,348,250
1990	2,321,914	75,358,548	663,917	25,001,383
1991	2,641,830	77,949,916	1,056,294	36,448,330
1992	2,706,967	101,418,463	1,027,313	34,008,219
1993	2,908,243	96,311,517	478,921	15,885,489
1994	2,816,400	103,186,178	522,068	18,246,436
1995	2,883,399	124,605,555	1,764,739	48,257,484
1996	3,047,195	100,836,897	2,937,245	75,682,676
1997	3,598,415	127,139,283	2,807,200	99,373,426
1998	3,141,163	114,681,336	2,736,697	120,315,042
1999	2,890,777	99,498,333	315,000	11,521,003

Source: Department of Business Economic, Finance Ministry.

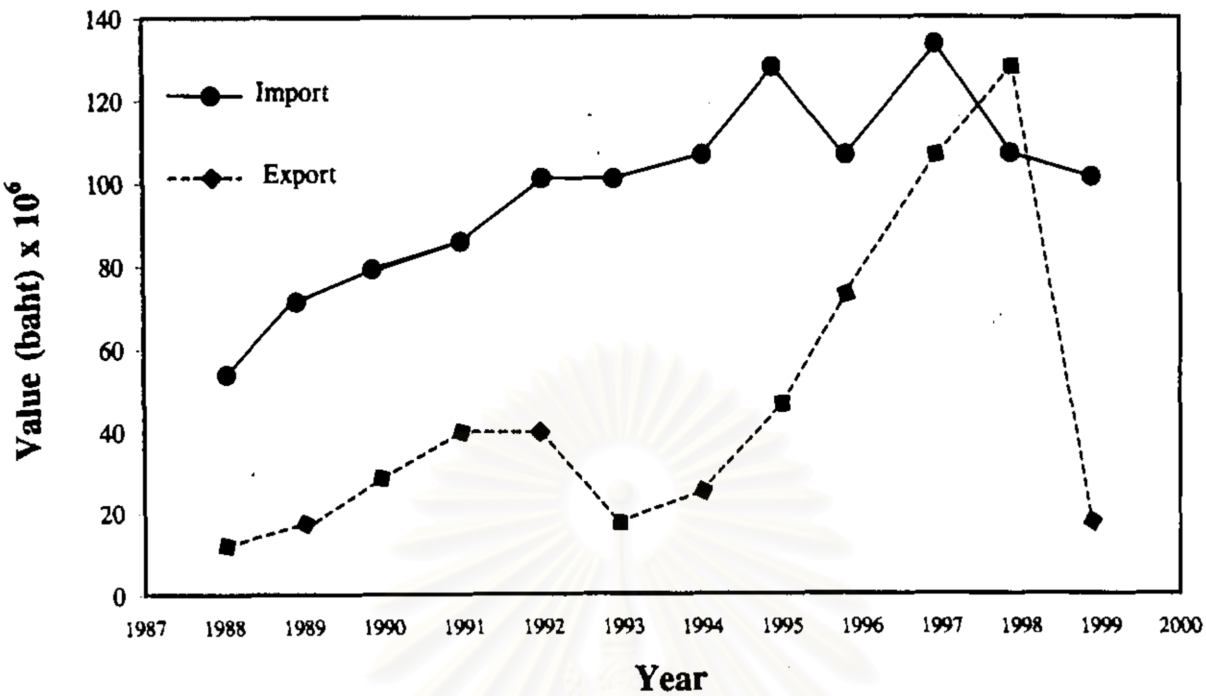


Figure 1.4 Value of import and export of activated carbon in Thailand between 1988-1999.

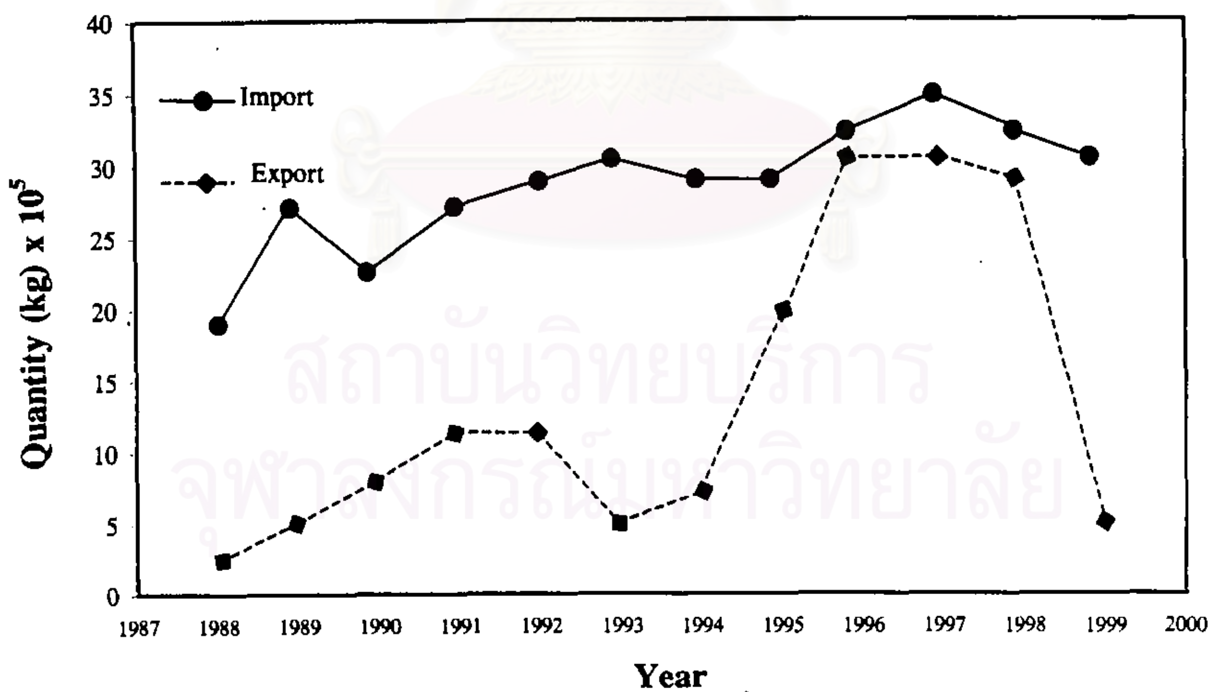


Figure 1.5 Quantity of import and export of activated carbon in Thailand between 1988-1999.

1.4 Objectives

The objectives of this work are following:

1. To find the optimum process for removal of zinc deposited in the production of activated carbon from anthracite and palm-oil shell by zinc chloride activation.
2. To study the physical and chemical properties of the produced activated carbon.

1.5 Scope of the research

Production of activated carbon from anthracite and palm-oil shell by zinc chloride activation, the appropriate parameters such as temperatures, time, sizes of the raw material and concentrations of zinc chloride were studied. The following list outlines the procedures followed:

1. Literature survey and in-depth study of this research work.
2. Carbonization of palm-oil shell crushed and sieved to four different particle sizes of 0.25-0.50, 0.50-1.18, 1.18-2.36 and 2.36-4.75 mm.
3. Proximate analysis of anthracite and palm-oil shell charcoal.
4. Production of activated carbon from anthracite and palm-oil shell by zinc chloride activation and manipulating the following parameters so as to attain the optimum condition:
    (a) The optimum activation temperature.
    (b) The optimum thermal activation time.
    (c) The optimum concentration of zinc chloride.
    (d) The optimum size of palm-oil shell.
5. Investigation of the properties of the activated carbon such as bulk density, iodine number, methylene blue number, B.E.T. surface area and investigation of deposition of zinc by X-ray Fluorescence Spectroscopy.
6. Summarizing the results.