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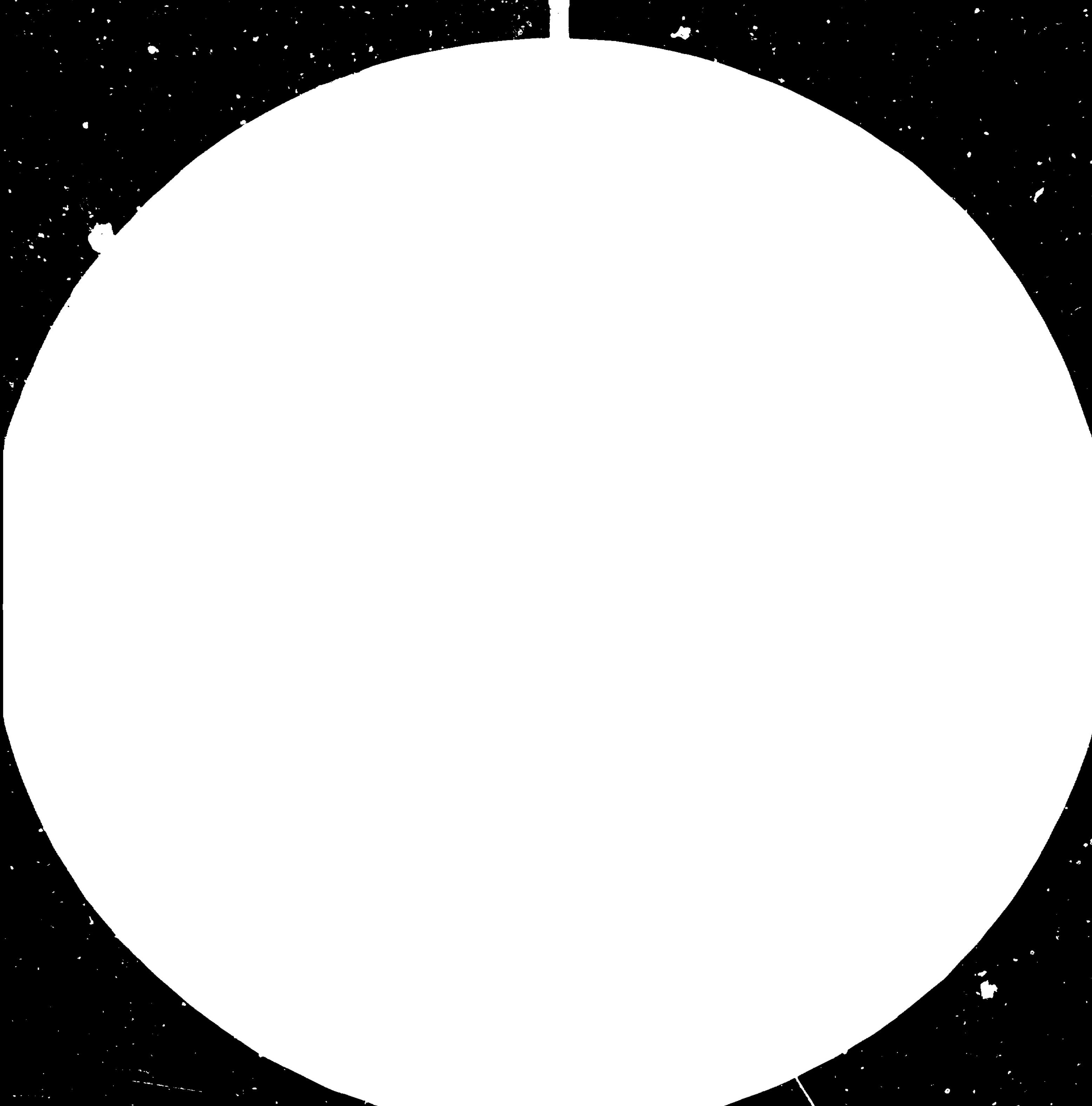

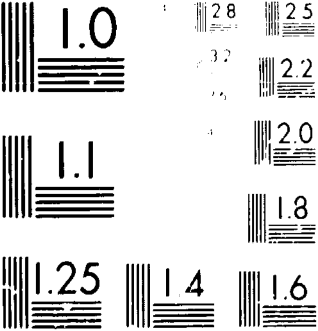
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INDUSTRIAL CHARCOAL MAKING FROM FORESTAL AND AGRICULTURAL WASTE *

by

W. Emrich **

3489

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ABSTRACT

By pyrolytic conversion, untapped forestal and agricultural wastes represent valuable energy resources for many countries. The Partial Pyrolosis process yields charcoal, pyrolytic oils and heating gas. All three products have well established markets and the demand for them is rising.

The Partial Pyrolysis plant can be designed for manual and continuous operation as well, also its capacity can be adapted to the small scale producer.

The achievable energy recovery from the raw material input is 60 percent higher as compared to traditonal charcoal making methods, which makes the Partial Pyrolysis attractive to the investor.

Introduction

The residues of the wood industry and of the agricultural production represent large energy resources in many countries.They remain however widely unused because utilisation technologies are little known to the holders of those sources.

Besides of fermentation and gasification the Partial Pyrolysis is one of the oldest processes in use.

The term pyrolysis in general describes the thermal decomposition of organic matter by the application of heat in the absence of oxygen.The Partial Pyrolyis process uses enough air to support a chemical reaction to generate the heat required for pyrolysis.

These processes produce three different types of fuel:solid fuel in form of char/charcoal ,which are consequently briquetted, pyrolytic oil and heating gas.All these fuels have their established markets and applications in industry and households and it is referred to later.

1. The Raw Materials: Literally hundreds of various feed stocks have been tried successfully by pyrolytic conversion during the last decade.In general all left-overs from clear cuttings of forest like brushes,branches,leaves,roots make a good feed,wastes of the lumber mills and the furniture industry,saw dust,slabs and wood shavings are an ideal raw material.The rejects of the pulp and paper industry,especially bark can be utilised also.On the agricultural side a wide field of feed stocks are open to pyrolytic conversion.In the first place all nuts,nutshells and husks of nuts are sought-after materials and can be economically collected in developing countries in particular.Rice hulls and sugar cane bagasse ,waste from coffee plantations and coffee processors,cotton stocks and waste of cotton gins,etc.

The list of feedstocks could be continued almost limitless. All these waste materials and residues can undergo the pyrolytic conversion either as such or as blends with others.

Even strange stuff like slaughter house waste and chicken droppings have undergone pyrolysis in a small scale but successfully.

Of course to compose the mix of locally available feed stock various factors have to be considered and the specifications and requirements for the desired finished products have to be evaluated before setting up the plant.

2. Process Description: For the Partial Pyrolysis a generalised process flow diagram is shown in Figure 1.The following is a brief description of the unit operations.

The raw material is received,reduced in size by hogging(if necessary),and stored.Additional unit operations such as ferrous metals removal,glass removal,etc. ,may be performed before storing the sized material.

From storage the hogged feed is retrieved and conveyed at a metered rate to the dryer.Here the moisture content of the feed is reduced to less than 10 percent(wet basis),and the dried feed is then conveyed to a surge bin for temporary storage.

The dried feed is retrieved and conveyed from the surge bin at a metered rate to the pyrolysis unit.Here the feed is thermally converted to char(charcoal),oil (pyrolytic oil) and gas vapors (heating gas).The charcoal is discharged from the bottom of the converter at a metered rate into a sealed srew conveyor where it is cooled with a water spray.It then passes through a rotary valve into a conveyor which takes it to the char storage bin.

The oil and gas vapors are drawn through a port in the top of the converter into the off-gas system by the variable -speed induced-draft fan.This stream flows through a scrubber-chiller

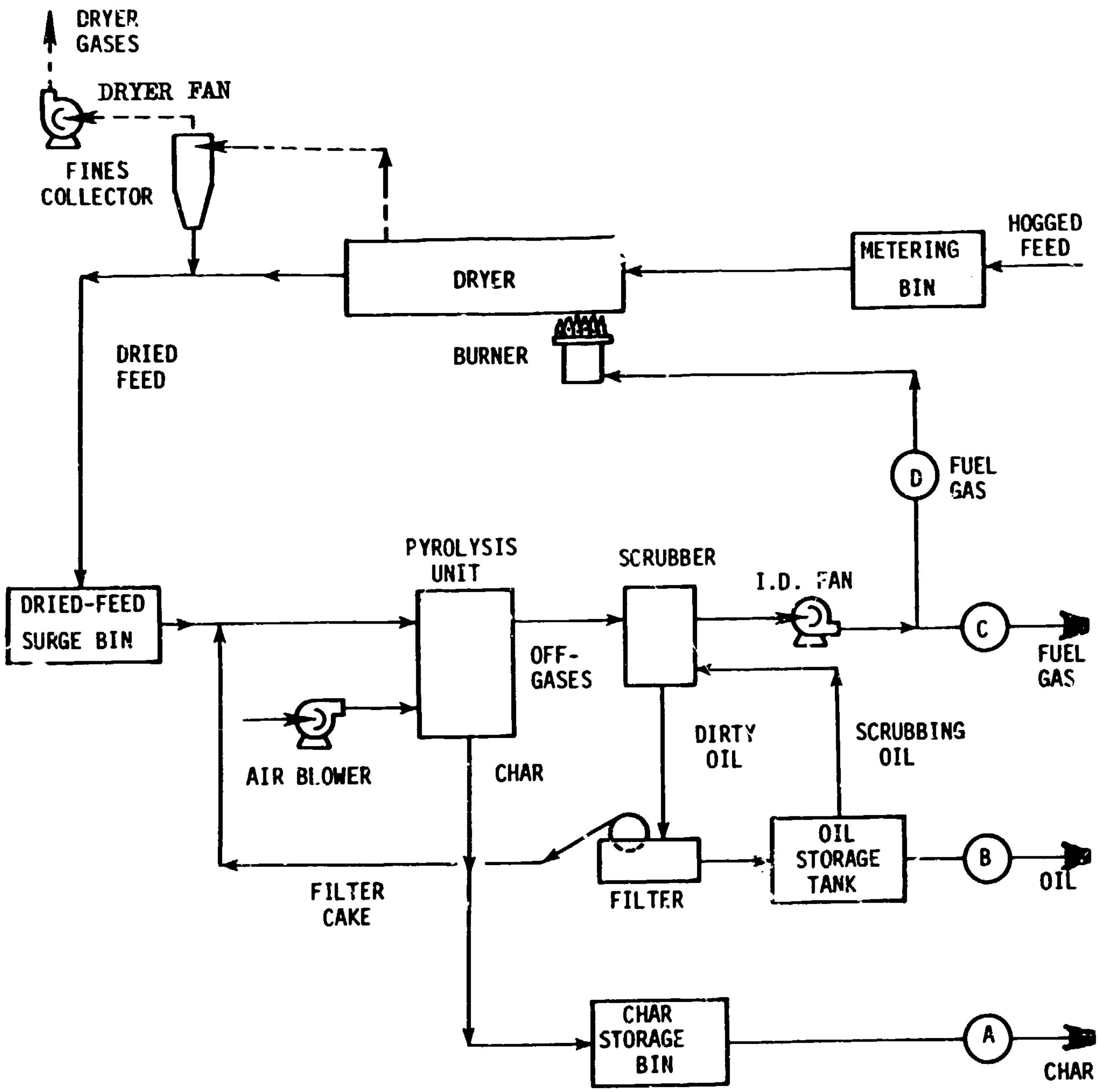


FIGURE 1. Generalized Flow Diagramm for the Integrated Pyrolysis Process (IPP).
Char Briquetting Plant not included.

which uses cooled pyrolysis oil as the medium. Here the entrained solid particles are scrubbed from the stream and most of the pyrolysis oil vapors are condensed. The uncondensed gases, with some entrained aerosol mists, then flow through a demister which coalesces the mists into a separate liquid oil stream. The remaining fuel gases are drawn through the draft fan and forced into burners to supply heat to the dryer and to the other on-site units briquetting **dryer,** fire chambers of steam boilers, etc.

The newly condensed pyrolysis oil together with the scrubbing oil, are combined into a single stream which flows to a rotary vacuum filter where solid particles are removed. Then the clean oil flows to a storage tank where a portion is drawn off, cooled and supplied to the scrubber-chiller. The surplus oil is available for use as a liquid fuel. The filter cake-solid char fines and pyrolysis oil is recycled into the converter with fresh feed material.

The previously stored char is taken from the storage bin and conveyed to the briquetting plant, which is usually set-up next to the converter station to make convenient use of the ejected heating gas from the pyrolysis process. The diagram of the briquetting plant is not shown in Figure 1.

After crushing (if necessary) the prepared feed is carried over continuously into a paddle mixer. By providing sufficient retention time the crushed char is mixed with an energy extender and a binder. The energy extender provides longer burning times to the briquettes and lime stone can be used. The binder may consist of starch or another material, for instance molassis.

After thorough mixing the raw product is released into the adjacent briquetting press. The formed "green" briquettes **receive** their necessary **strength** in the following drying and curing process. Vibrating feeders with a grate for fines removal draw the briquettes from the storage bin to the packaging equipment.

A wide array of types and sizes of baggage scales are available to meet the specific requirements. .Simple,manually operated units are in use as well as completely automatic systems.

The following illustration shows a briquette press(Fig. 2). The type of press is selected depending on the kind of raw products and plant capacity.

FIGURE 2.

Briquette press ejecting pillow briquettes

EQUIPMENT DESCRIPTION
(Pyrolysis Part)

Experience has shown,that most of the equipment can be build locally.Producers tend to use second hand equipment and modify it,henceforth depressing initial investment costs.

2.1 Raw Material Preparation:

Raw material is received from a drag chain or by truck.The material passes over a screen,which sorts out the oversized pieces and sends them to a hammermill(hog)for size reduction.The hogged material together with the undersized materials,is conveyed to a bucket elevator which loads the storage bin.

From storage,a screw conveyor carries the sized material to a small metering bin to feed the dryer.The metering bin has sensing devices which control the storage bin unloader in an on-off method.

2.2 **Dryer**:

The Dryer could be one of several types:

- a single - pass rotary dryer
- a three - pass rotary dryer
- a screw conveyor dryer of special design

In each of these dryers,hot gases are passed through the material.The inlet gas temperature varies with dryer design and ranges from 200^{o} to 700^{o}C.The dryer effluent gas is passed through a cyclonic type separator to remove the entrained solid particles.

2.3 **Thermal Converter**:

The thermal converter(pyrolysis unit) consists of an outside steel shell,a composite refractory lining,an output feed mechanism at the bottom,a lower plenum,a char srew,a char discharge airlock, an insulated top,and an air injection system.The converter is normally run at a pressure slightly below atmospheric and is sealed to prevent in-leakage of outside air.

Dried feed material is fed through the airlock near the top of the converter.The flow rate through the converter is controlled by the output system,and a nuclear level detector which controls the rate of feed into the converter.

As the material flows downward through the converter,it is heated to a maximum temperature of about 900^{o}C and thermally decomposes into char(charcoal)and gaseous vapors.The char is discharged into the lower plenum where it is water-spray cooled and conveyed through the screw and air-lock to conveying equipment which takes it to storage.The hot gaseous vapors flow upward through the bed, heating the downward flowing solids, and exit through a port at the top of the converter into the off-gas system.

Several safety features are incorporated to protect the converter:

- pressure-relief doors
- automatic temperature shutdown
- automatic cooling-water shutdown

2.4 Off-gas System:

All internals of the system are made of stainless steel for corrosion resistance. The functions of the off-gas system are:

- the gaseous vapors leaving the top of the converter are scrubbed and chilled to remove entrained solids and lower the temperature to condense the pyrolytic oil.
- the clean gaseous vapors then pass through a demister where the remaining oil mist is collected and removed.
- the fuel gas then passes through an induced-draft fan for conveyance to the dryer burner, other on-site users and/or the flare stack. The purpose of the flare stack is to allow any or all of the fuel gases to be burned cleanly and dumped into the atmosphere should the process burner demand cease. The flare may be used for the start-up until the desired gas quality is achieved.

Several safety features are incorporated in the off-gas system:

- pressure relief tops, they are spring-loaded and vent about 300 mm of water
- automatic high -temperature shutdown. Should a fire start in the off-gas system, the fan will be shut down. At the same time, the air supply will be cut off and the converter will be gated off, residual gases will be vented through the emergency flare.

- electric power failure. If a total power failure occurs, the air supply and the draft fan stop and all shut-off gates remain in the pre-failure condition. Without air the process shuts itself off. Residual gases will flow to the flare stack where they are safely burned.

2.5 **Char Handling and Storage**:

The char discharged from the airlock on the converter output screw is transported in a screw conveyor to a bucket elevator which loads the char storage bin. All these components are extra-heavy duty design.

Explosions are always a potential problem when handling a dusty material, or one which containes gaseous vapors. Thus, the bin is designed with an explosion relief top which lifts to vent the gases when the internal pressure reaches the preset limit. This serves to protect the structural integrity of the bin. In addition, four dead-weight relief doors are incorporated on the top of the bin.

3. MATERIAL AND ENERGY BALANCES

The Partial Pyrolysis process can be operated to provide a variable yield from almost any feed material, with a corresponding variation in the gas and oil yields. This is primarily controlled by the air-to feed ratio, and can be demonstrated by the following example taken from a commercial plant:

3.1 **Pine Sawdust and Hogged Bark**:

For purpose of presentation, the distribution of energy among the three products, expressed in terms of char yield, is shown in Figure 3 for a blend of pine saw dust and hogged bark. The solid curves are based on several runs. The commercial plant has been operated at char yields ranging from 10.5 to 38.6 percent,and the pilot plant results have been obtained at char yields from 8.0 to 45.0 percent.The heating values of the three products vary with the char yields.

The energy recovered in the form of char in Figure 3 continues to increase as the char yield increases,with of course ,a corresponding decrease in the energy of the fuel gas.It should be noted that a constant amount of energy is set aside to provide fuel gas for the dryer.In this case it is a specially designed dryer and approximately 1.600 Btu are required per pound of water removed. The energy in the net fuel gas is that available after the drying requirement has been satisfied.The energy recovered as pyrolytic oil increases slightly as the char yield increases from 10 to 25 percent,and then decreases at higher char yields.

The gross energy recovery in the form of products is approximately 95 percent of the energy in the dry feed.The higher heating value normally associated with a blend of pine sawdust and hogged bark is 8.700 Btu per pound of dry feed.Note in Figure 3 that the sum of the energies of the products at 10 percent char yield is 8.260 Btu per pound of dry feed.

The energy distribution curves shown in Figure 3 point out the flexibility of the Partial Pyrolysis process.The sytem can be controlled to maximize those products of greatest value or to match the sytem to on-site requirements.

The distribution of energy among the products also varies with the type of feed material.Data are presented in Table 1 for pine-tree-top chips,a blend of pine sawdust and hogged bark.They are obtained from measurements at a commercial plant and various pilot plant tests also.Shown are the heating values of the input

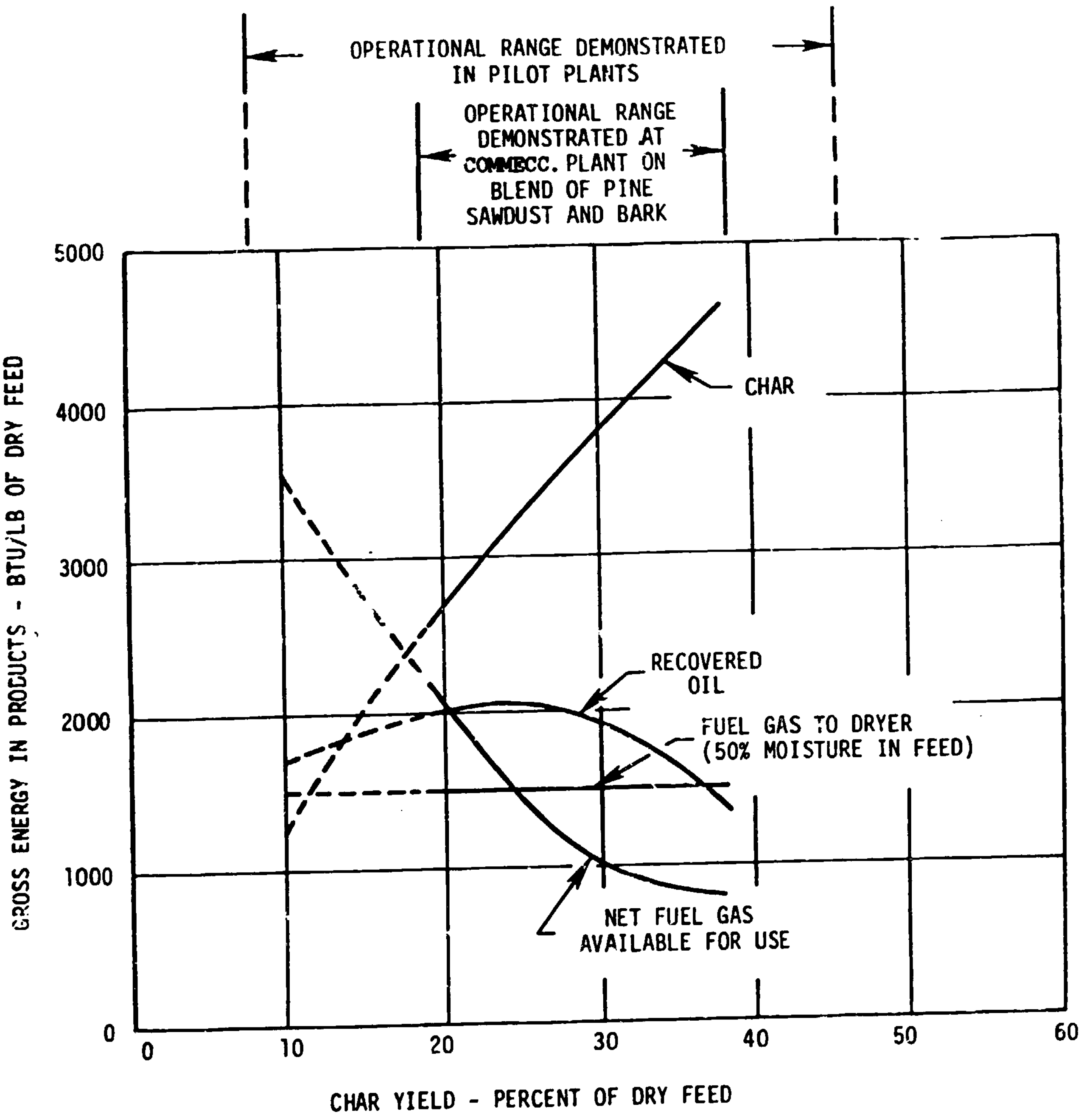


FIGURE 3. Product Energy Distribution Versus Char Yield for Pyrolysis of Blend of Pine Sawdust and Hogged Bark

feeds,mass yields and energy yields.The potion of the energy contained in the char is approximately the same for all of the feeds at the same char yield.However at a char yield of approximately 20 percent,the energy recovered as pyrolysis oil was highest for the chips and lowest for the bark.As exspected,the value for the mixture of sawdust and bark lies between these two.The highest char yield obtained to date was 45.7 weight percent from a bark feed stock.

An initial study also has been performed on the minimum char yield obtainable without encountering slagging conditions. The data from this study ,obtained from a 72-hour pilot plant run on pine chips,are presented in Table 2.Two models of operation were studied in the once-through mode,the material made a normal single pass through the unit.In the recirculation mode,the char output was increased to an equivalent 20 percent yield and screened. The coarse particles were reinjected into the unit with fresh feed material and the fine char and ash passing the screen were removed.A char yield of 8.2 percent was obtained in the once-through mode.With recirculation of char,the net yield(fines passing the screen)was lowered to 3.8 percent.Even at low char yields,the unit was operated as a pyrolysis system with an oil yield only slowly below that obtained on pine-tree -top chips(Table 2)at a 20 percent char yield.Char recirculation simply offers another option with efficient conversion of wastes to gas and oil with a minimum amount of char.This technique can also be used to avoid slagging conditions in the converter bed and obtain low char yields when the ash content is high.

The latter effect becomes of great importance for the pyrolytic conversion of some agricultural wastes which have incorporated a high degree of inorganic non-combustibles.

TABLE 1.

SUMMARY OF MASS AND ENERGY DATA FOR PYROLYSIS OF SEVERAL WOOD FEEDSTOCKS

		Wood Feedstock						
		Pine-Tree-Top Chips		Blend of Pine Sawdust and Hogged Bark			Hogged Pine Bark	
Item	Units	Run A	Run B	Run A	Run B	Run C	Run A	Run B
Higher Heating Value	Btu/lb df[a]	8935	8935	8837	8609	8663	8912	8801
Moisture Content (Wet Basis)	%	5.7	5.8	1.4	.5	13.5	12.2	7.4
Mass Yield								
Charcoal	%[b]	20.5	25.6	20.5	24.4	38.2	18.9	45.7
Oil	%[b]	34.6	31.9	19.2	23.7	17.5	7.8	12.8
Fuel Gas	%[b]	76	71	103	103	111	116	88
Energy Yield								
Charcoal	Btu/lb df	2631	3412	2768	3311	4664	2422	5738
Oil	Btu/lb df	3498	3174	2179	2249	1076	834	1235
Fuel Gas	Btu/lb df	2470	1987	3067	2953	2222	5250	1316

a Btu per pound of dry feed

b Percent of dry feed

TABLE 2.

SUMMARY OF DATA FOR MINIMUM CHAR YIELD TESTS ON PINE CHIPS

Item	Units	Operational Mode		
		Once Through		Recirculation of Screened Char
		Run A	Run B	
Injected Air	lb air/lb dry feed	0.56	0.69	0.92
Maximum Bed				
Temperature	°F	1865	1885	2065
Mass Yield				
Charcoal	% of dry feed	10.9	8.2	3.8
Oil	% of dry feed	25.3	32.3	30.7
Fuel Gas[a]	% of dry feed	119.8	128.5	157.5
Energy Distribution				
Charcoal	% of dry feed	16.7	12.2	5.4
Oil	% of dry feed	28.0	36.1	33.2
Heat Losses[b]	% of dry feed	4.6	4.6	4.6
Fuel Gas[a]	% of dry feed	50.7	47.1	56.8

a Computated by difference

b Assumed value based on previous data

4. END USE MARKETS AND APPLICATIONS FOR THE PRODUCTS OF THE PARTIAL PYROLYSIS

In general the market value of all pyrolytic products will depend on the degree of meeting the specifications. Presently there are not yet commonly acknoledged standards or norms available in any country.However industry and traders in wholesale as well as the retailer will set their own requirements.

Therefore, before setting-up a new venture the market goals and the marketing strategies have to be investigated carefully. Observing these basic rules will prompt a profitable business in an market with an unusual path of increase for the next decade.

4.1 Charcoal Briquettes

Early man found out already that charcoal is an excellent smokeless fuel for cooking food.Besides of this it can be carried far easier than fire wood.
Since then charcoal cookery made its move from the cave to the public square,the patio and to the backyards,beaches and camp-grounds in the industrialised countries.

Last year the amount of charcoal sold for leisure cooking in North America and European countries exceeded well the 1.8 Mio tons mark.Market forecasts for the year 1981 predict a rise of 9 - 10 percent.

During the passed fifteen years the charcoal briquettes has gained ground against the traditional lump charcoal and makes up approximately 75 percent of the above mentioned amount of charcoal already.

One of the reasons for this progress of the briquette is the fact that consumers are becoming aware that charcoal briquettes

provide longer burning times than the lump charcoal.With the high prices for all fuels this consideration becomes more and more important for the retailer and the department stores.
But there are other reasons also which influence the choice of the consumer: briquettes can be handled cleaner and the dosage due to the uniformity of the product is easier.

Today modern charcoal industry has learned to stretch the heating time of briquettes by adding energy extenders which release the heat slowly but steady.

For the charcoal producer however it is most important that charcoal briquettes can be made from any raw material,wheras lump charcoal can be produced from wood of a certain size and diameter only.

Normal specifications of charcoal briquettes are:

Ashes	8 %
Energy extender	12 %
Moisture	5 %
Binder	6 %
Fixed carbon	55 %
Volatiles	14 %
Shape	pillow 40 x 50 x 25 mm

Figure 4 shows the typical charcoal briquettes being demanded by the consumer markets today.Besides of the pillow briquette other forms are in use: small bricks,oblong shapes,etc.No one of these forms has reached the market potential of the pillow.

Since several years another form however is gaining market momentum rapidly. An extruded product of a length of 40 mm and a diamater of 22 mm consisting of a high grade char with special binder and henceforth very high heating value also. These so called "extrudates" are made for producer gas gasifers. The gasifier

-engine has been improved during the last years and serves in trucks,agricultural machines and also provides the fuel gas for many electric generators ,especially in developing countries.

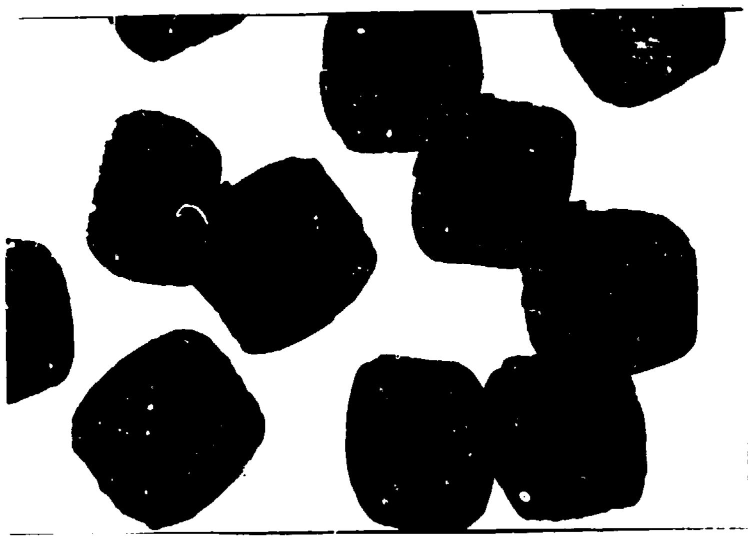


FIGURE 4.

Pillow Briquettes

4.2 **Converter Char:**

This is the charcoal as it is released from the pyrolytic converter.It consists of a more or less coarse material.Outlets for the converter char can be found to many industries.

In the first place manufacturers of activated carbons will show interest in the converter char,if produced from certain raw materials,for instance nut shells.Activated carbon is a product with great variations and it is used by the filter industry for water purification,gas cleaning,solvent recovery.it has manifold applications also in the chemical and petro industries.

Therefor it is not possible to summarise all the different specifications and requirements the raw material converter char must meet.

Most recently several processes for the production of pig iron with charcoal fines have been developed and are being commercially introduced now.The importance of these processes for the future cannot be overlooked. It certainly will become a market with great potentials for all developing countries engaging in steel production, but without having the necessary mineral coal deposits.

The classic example is Brazil where approximately 2.2 Mio tons of charcoal are being consumed by the iron industry annually.

Other applications for the converter char may be found in the animal feed stuff industry(additive), tobacco industry (cigarette filter), pharmaceutical industry, etc.

4.3 **Pyrolytic Oil**:

Typical data for an oil produced from wood waste are presented in Table 3. Note the moisture content is 26%. Normally, the condensation process is operated to provide an oil with a moisture of about 20 percent.

The water contained in the pyrolytic oil serves to lower the viscosity for improved handling and atomization and it appears to enhance combustion. At 26% moisture, as shown in the Table 3, the heating value is 9,081 Btu per pound, or approximately 90,000 Btu per gallon which is 60% of the heating value of No. 6 fuel oil. This is an important fact for all applications where the oil is utilized as fuel in burner chambers to produce steam.

The pyrolytic oil is corrosive to mild steel, but the corrosion rate is a fraction of a **mild** per year for 304 stainless steel and copper.

Besides of the fuel value of the pyrolytic oil it represents a valuable raw material for the chemical industry also. Depending on the raw material mix and species it contains several hundred chemical compounds. Some of the most commercially utilised are:

TABLE 3.

TYPICAL DATA FOR OIL FROM PYROLYSIS
OF BLEND OF PINE SAWDUST AND HOGGED BARK

Item	Units	Value
Chemical Composition		
Carbon	% by weight	49.4
Hydrogen	% by weight	4.7
Oxygen	% by weight	19.7
Nitrogen	% by weight	0.16
Water	% by weight	26.0
Ash	% by weight	0.04
Viscosity		
@ 68°F	SSU	276
@ 100°F	SSU	114
@ 150°F	SSU	90
Higher Heating Value	Btu/lb wet oil	9081
Density	lb/gal	9.88 to 10.27
Flash Point (open cup)	°F	262 to 305
Pour Point	°F	+2

acetic acid,methanol,phenoles,creosotes,tar.They all have their firm markets in other industries like food,paint and wood preserservation.(Table 4).

High attention is paid to the methanol fractions of the pyrolytic oil today. These are an excellent alternate fuel for cars and can be blended with regular gasoline up to 17 percent.Engines utilizing pure methanol are past the developing status already.

The breaking down of the pyrolytic oil in its components naturally affords sophisticated destillation systems.Therefor it is done by the larger charcoal producers only in industrialised countries.The small enterprise limit their activities to more simple operations with surprisingly good commercial results.

4.4 Heating Gas:

In most cases part of the gas from the Partial Pyrolysis process is burned to supply the heat to the raw feed dryer and to the dryer of the briquetting plant.

Studies have also been made of the use of the gas as a fuel for an internal combustion engine .The power output of the engine was slightly over 60 percent of the engine's output with gasoline.

Calculations have shown that it is reasonable to expect that the heating value of fuel gas can be increased to about 400 Btu per cubic foot,so that engines already developed for Bio-gas can be used.These modifications would involve removing all of the condensible fractions from the gas and reducing or eliminating the process air.

Preliminary estimates have indicated only a small penalty in energy with incineration of the low -energy-content liquid efflueent produced in this case.

TABLE 4.

Char coal and by-products

Product	Raw material	Application
Charcoal, lump	hard wood, soft wood	activated carbon, ferro-silicon, grill coal, metal working, sodium cyanide, carbon disulfide, Sweden steel, silicon
Charcoal, granular	charcoal, lump	activated carbon, additive to animal food, fillings compound for bottled gas, hardener
Charcoal,dust	charcoal, lump	activated carbon, lining of moulds in metal foundries, production of briquettes, cementation granulate, pyrotechnique
Pyrolytic oils	hard wood, soft wood, agricultural wastes	fuel for steam boiler furnaces, solid fuel fired engines, metallurgy, fire brick factories, etc., raw material for chemical industry
Wood gas	hard wood, soft wood, agricultural wastes	heating gas for all types of operations using solid or liquid fuels, gas engines
Wood vinegar	hard wood, soft wood	preservation and flavouring of meat and smoked fish, perfume and aroma industry
Wood tar	hard wood	rope industry, veterinary medicine, pitch, creosote
Crude methanol	wood alcohol	methyl acetate
Solvent	wood alcohol	cellulose esters and agglutinants, synthetics, laquers
Methyl formate	crude wood vinegar + crude methanol	cellulose esters and agglutinants, synthetics, laquers
Methyl acetate	crude wood vinegar + crude methanol	cellulose esters and agglutinants, synthetics, laquers
Acetic acid	crude acetic acid	chemical, pharmaceutical, food, convenience food, rayon, textile and film industries, vinegar
Propionic acid	crude acetic acid	pharmaceuticals, flavour and fragrancies
Butyric acid	crude acetic acid	pharmaceutical and perfume industries

5. THE INTEGRATED PARTIAL PYROLYSIS PLANT

The term "integrated" designates a concept of a Partial Pyrolysis project incorporated into an existing system to serve the domestic economy to the highest degree. In other words the new plant is being designed to make optimal use of available raw material resources and the finished products.

Since charcoal, pyrolytic oil and gas are easy tr rtable energies it is not necessary to build the plant near to eady existing industries. In reality pyrolytic plants are normally erected closer to the raw material source rather than to the customer site. This saves some of the transportation costs because the bulky feed undergoes sizable reduction during pyrolytic conversion.

Examples for **interlocking** industries are given in Figure5. A pyrolytic plant may deliver its char to an activated carbon producer, setting aside the portion for its own briquetting operation for export, and at the same time supply a brick factory, particle board plant, distilleries, etc. with pyrolytic oil to fuel a steam boiler or a burner, as in the case of the brick factory.

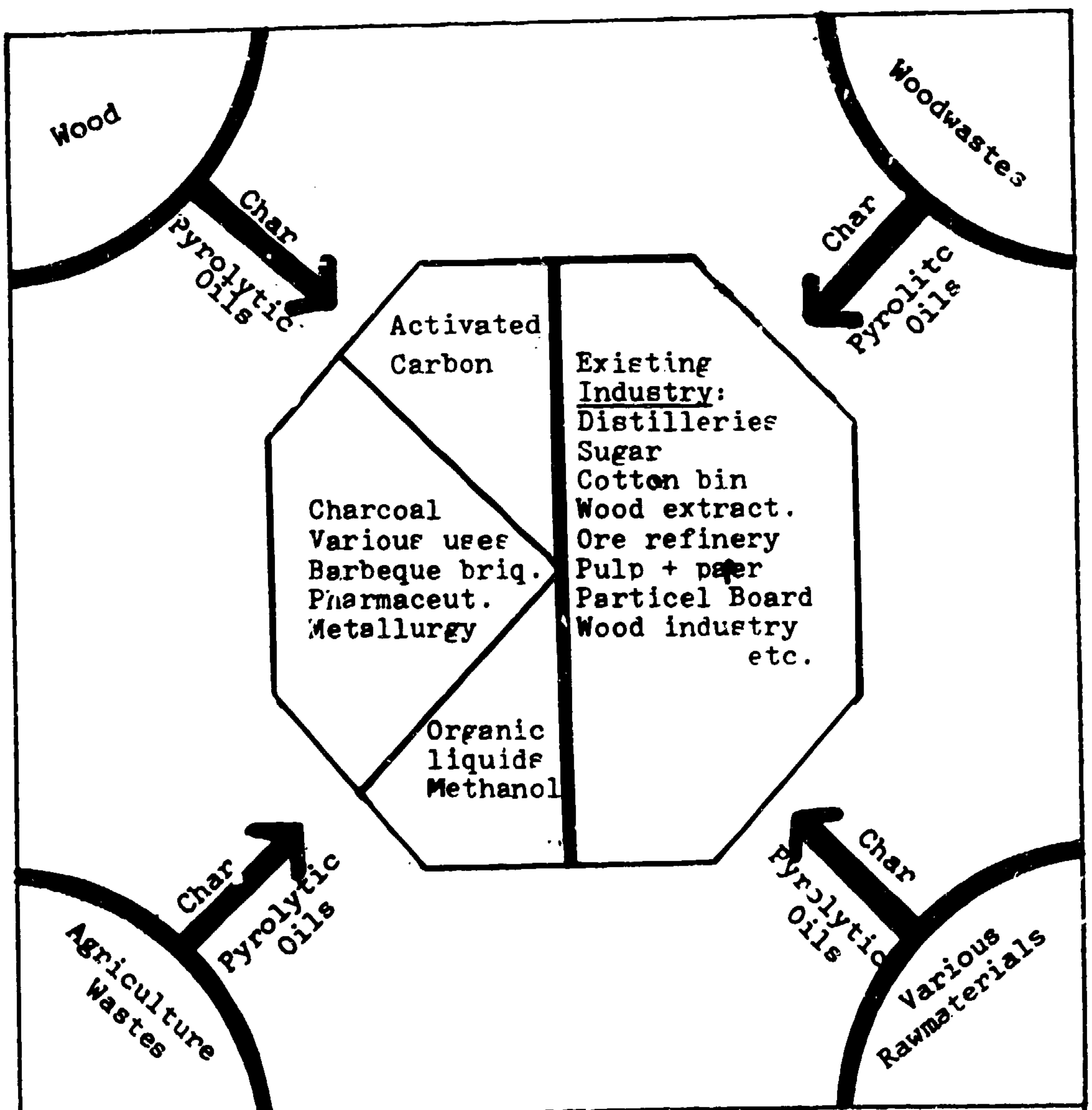
The attached Figure 5 can convey only some ideas. It has been found that the combinations vary from **country** to country greatly and it has to be sorted out what is feasible and what is not.

There are in use many Partial Parolysis Plants in industrialized countries which tend to employ **auxiliary** steam boilers, to be fueled with the total amount of off-gases without going into condensation operations.

The produced steam then is sold metered "over the fence" to adjacent industries.

Tests have also been completed for the usage of pyrolytic

FIGURE 5.



Fully Integrated Charcoal Production
with four Carbonizer Units

oil for the usage in cement kilns.For several morhts kilns were fired with a blend of No. 6 fuel oil (20 percent).In anothe test series the same oil **produced** from an equal raw material mix was fired to several No. 6 fuel guns in a lime kiln.

Both tests proved the feasibility and demonstrated the great potentials of the "integratioh" for all countries.

A Partial Pyrolysis converter can be considered as a principal gas generator yielding part of the energy input as solid fuel.Also an activation carbon kiln **undertakes basically** the same functions. Therefor the combination of both operations will represent a powerful gas generator,as demonstrated in many plants.

Therefor thorough considerations have to be made in advance to prove the feasibilty of such an integrated concept.Otherwise the planner is running the high risk that the available energy can not be utilized reasonably.The consequence will be waste of energy, henceforth depressing the economics of the plant.

5.1 **Plant Capacity**:

The term Partial Pyrolysis process is sometimes misleading and will be associated with large scale production,labor saving techniques and sophisticated equipment.In a real sense however it distinguishes traditional methods of charcoal making from high energy efective processes.

The equipment for the Partial Pyrolysis process can be designed to serve the small business as well as the very **large producer.** It also can be designed for manually operated plants,if it is desirable,as well as for the full continuous operation.

It is generally acknowledged that the most economic plant sizes will range between an input capacity of .5 and 7.0 tons per hour dry feed. For production throughputs of above 7.0 tons per hour the converter has to be modified, differing very much from the model described earlier, also manual operations are not more feasible.

During many years of experience in different countries it has been found, that the investment costs cannot be brought in line. The expenses for engineering, equipment costs, etc. vary greatly from country to country. **Therefore the plant capacity will not** be of great influence for the initial costs.

On the other side a pyrolysis plant can use second hand equipment very well. The longtime producer tends to purchase in advance this equipment for further expansion as soon it becomes available on the market.

The write-off of the investment costs of a well planned pyrolysis operation should usually not exceed the period of eighteen to twenty-four months.

5.2 Partial Pyrolysis and Resource Conservation:

Looking at the energy balance which the traditional charcoal maker with the Earth Mound method can achieve, he will not recover more than 15 - 17% of the total, contained in his raw material.

The ones who are using a more advanced technology - Beehive kilns, Reichenbach furnaces, retorts - their energy balance sheet will look better compared to the **Earth Mound builder. In optimal situations** he may achieve 35-38% of the **energy input.**

Due to the fact that the Partial Pyrolysis plant is designed for the complete by-product recovery, well insulated and set-up to an integrated concept the highest energy yields can be expected. Some of the plants are displaying regular results by topping the

the 87 percent bench mark.

For many years the common belief even in the Forestry Departments prevailed,that charcoal making is to blame for the steady source depletion and the recess of the forested areas in many countries.Although the existence of a very large scale charcoal industry in industrial countries proved controversial, only recent studies in developing countries seem to be corrective.

However it is obvious that the Earth Mound builder does a very bad job and his axe cuts deeper into the forest every year as the demand for charcoal is growing.On the other side the firewood cutter of the village,the goat and sheep herder are doing the same harm to precious resources and continue to deplet them.

Therefor it is of importance to point out to the state and industrial planner,the forester and resource conservator,the private entrepreneur,that there are technologies readily available for the utilisation of so far untapped reserves which can be employed for the benefit of many people ,to close energy gaps and retrieve very much needed hard currency on the other side.

It is also most important to emphasize the fact that these techniques have been proved economic value and technical feasibility by producing millions of tons of transportable energy.