CHAPTER I

# INTRODUCTION

The twilight of civilization was perhaps marked by the first fire lit by a primeval cave man. Making fire was the first conscientious utilization of the world's energy resources. Fire is one of the five elements making up the world.

The world population is growing at an exponential rate and hence energy use per caput is steadily increasing. World energy consumption increased by 4.9 per cent annually from 1960 to 1972. The projected annual rate of increase from 1972 to 1990 is 3.3 per cent. The declining energy supplies, rapidly increasing consumption and increasingly severe environmental constraints sharply focus attention on the need for the additional amounts of clean energy sources. Conversion of the plentiful of organic solid wastes into clean energy forms provides an opportunity to expand the energy resource base while reducing the pollution now associated with waste disposal.

Some recent studies (Woodwell, 1978 ; Woodwell, et al, 1978 ; Stuiver, 1978 ; Siegenthaler and Oeschger, 1978) indicate that the biosphere might no longer be as effective a sink for $CO_2$, and that the continuous increase in $CO_2$ levels of biosphere is caused to a very large extent by the burning of fossil carbon. This indicates that the ratio between photosynthesis and biodegradation has decreased. The decrease might be caused either by a reduced rate of the former or an increased rate of the latter. The increased

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absorption of heat radiation by $CO_2$ should result in a warming trend of the climate. This might be an ultimate concern in relation to how much carbon is handled in the biosystems (National Academy of Science, 1975 ; MIT press, 1971). The climatic effects of $CO_2$ in the atmosphere might be of concern only around year 2020 in the Northern Hemisphere, but probably earlier in the Southern Hemisphere. It appears at this point highly desirable to increase photosynthesis and the gross and net bioproductivity. The management of these processes and the alternative uses of the biomass will be the subject of debate during coming years.

The Board on Agriculture and Renewable Resources of the National Academy of Sciences organized the "Renewability" program. It defines a "renewable", a material that can be restored when the initial stock has been exhausted. The dynamic nature of the concept of renewability is recognized. A renewability ratio is defined as the ratio of replenishment rate to depletion rate. Broadly speaking, renewable resource is used as a synonym for a resource of biological origin while non-renewable resource is used as a synonym for a resource of geological origin. The existing areas of renewable resource use confronts such needs as :

(i) Safeguarding raw material supply
(ii) Less capital intensive technology
(iii) Less energy intensive process
(iv) Improved environmental control
(v) Less dependency on depletable resources and
(vi) Better utilization of all resources.

Biomass in its various forms is an attractive source of energy. Through photosynthesis, biomass collects and stores low intensity solar energy which can then be harvested at will and released through direct combustion, thermochemical or biochemical conversion. Plant matter fuels have numerous advantages : they are renewable, they contain little sulphur and they have high thermodynamic availability. Furthermore, the combustion of biomass fuels does not modify the carbon dioxide or thermal balance of the atmosphere.

The beneficial use of agricultural fuel probably dates back well over a thousand years. For centuries, the chinese burned a mixture of rice straw and husk in an open top burner for cooking. The resultant black ash (char) was then used as an absorbent for human waste and this mixture spread on the fields as fertilizer. More recently, a furnace designed to utilize agricultural wastes as fuel, was developed in 1880 by C.R.Cowie of the English firm, in a few years every Burmese rice mill was powered with a waste fired boiler. In 1913 P.Poli suggested research on the utilization of agricultural waste as fuel. It has been reported that such utilization was practiced extensively in Brazil in 1915, and by 1925 most commercial rice mills in the world were operated by steam engines, generally of British, French or German manufacture, and usually of improved superheat design. Continuing development and use of steam equipment and processes appeared to lag shortly thereafter, primarily as a result of the advent of electrical power. New mills utilized this source of energy or diesel power and many

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of the existing mills were converted to electricity, which appeared to be inexhaustible, cheaper and a readily available source of power for milling purposes.

Casual interest in agricultural wastes as a fuel began to reappear in the 1950s, but largely as a means to facilitate disposal of the nuisance waste. Some mills were using agricultural wastes in their steam boiler furnaces to facilitate their disposal and in several countries many continue to use them. By 1970, the realization that the increasing consumption of energy derived from fossil fuels represented a serious energy problem became firmly established, and interest in renewable energy sources was rekindled. In the united states, there was talk of rejuvenating old technologies and turning to the beneficial use of non-fossil energy resources. In France, interest aroused by publicity on a German built automobile that had completed 15000 miles of tests running on a fuel produced from straw. It is obvious that the utilization of agricultural wastes for energy purposes is not necessarily confined to rice mills.

Jute stick, paddy straw, rice husk and other agricultural wastes such as groundnut shells, cotton sticks, corn cobs etc., represent some of the renewable agricultural-based fuel materials in the world. The present annual production of biomass on the land area of the world is $10^{11}$ metric tons of dry matter. This is an energy equivalent of six times the current worldwide energy consumption.

India produces about 2 million tonnes of jute stick, 160 million tonnes of paddy straw, 16 million tonnes of rice husk, 51 million tonnes of wheat straw, 5 million tonnes of barley straw, 9 million tonnes of maize straw, 2.7 million tonnes of maize pith, 29 million tonnes of sugarcane bagasse, 3.1 million tonnes of cotton stick, 2.2 million tonnes of groundnut shell and 30 million tonnes of other crop wastes. Thus India is having 310 million tonnes of agricultural wastes and byproducts out of which only 50 million tonnes are used as a fuel. Assuming an average calorific value of 3000 kcal/kg, the total offal may represent an energy source equivalent to about 155 million tonnes of coal every year. Optimum utilization of this vast amount of offal, through commercial or other useful application could provide a favourable impact on the economy of related industries in particular and on the economy of the countries in general. These renewable fuel resources may form an important alternate energy source both in agricultural and non-agricultural sectors.

Thus agricultural fuel now appear very attractive as a raw material particularly in a " vertically integrated" energy system, wherein the raw material is used to produce energy while the resultant residue is marketable at higher prices than the raw material. However, in order to receive full benefits, it will be necessary to develop new methods of burning to produce maximum energy per unit of fuel and higher grade and more uniform residues than are now obtainable with existing methods. Therefore, a basic need exists for developing more efficient methods to extract maximum heat from agricultural fuel in a salable fashion consistent with feasible utilization of the residue. There is a continuing challenge to develop heat conversion processing units (furnaces, boilers and reactors) for the efficient conversion of agricultural wastes and byproducts into salable heat and residue.

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Preliminary developmental work on cyclone furnace, horizontal groundnut shell fired furnace and vertical pressurized combustor proved that the efficiency of cyclone furnace is greater as compared to the grate firing as it incorporates a number of special features for efficient combustion. The cyclone firing ensures ease in ash removal and also in attaining higher and uniform temperatures inside the furnace. For a particular capacity, cyclone furnace would need a smaller combustion space than the grate type one. It is most suitable for higher feed rates and requires smaller volume than any other furnace for the same thermal load. Other advantages rendered by the cyclone firing are (i) uniform interaction of fuel and air resulting in complete combustion, (ii) more uniform temperature distribution in the furnace, and (iii) saving in labour and maintenance cost.

Keeping in view the points raised in the foregoing paragraphs, the focal point of this study is the pressing need to utilize agricultural wastes and byproducts as an energy source. The present project was undertaken with the following specific objectives :

(i) To establish the fuel characteristics of agricultural fuel similar to that of coal

(ii) To determine ideal air fuel ratio for perfect combustion of agricultural fuel and develop Ostwald charts for perfect and partial combustion

(iii) To study kinetics of combustion of agricultural fuel at different levels of air fuel ratio and depth of fuel bed in stationary and fluidized bed conditions for establishing ideal combustion conditions of agricultural fuel.

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(iv) To design and develop a vertical cyclone furnace for agricultural fuel on the basis of results of above studies

(v) To test the designed furnace for producing ash free flue gas for use in dryers or steam boilers.

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