CHAPTER-1

INTRODUCTION

The diminishing reserves and apparent negative effects such as green house gases and acid rain of fossil fuel have led the world community to recognize the importance of renewable and cleaner energy in recent years. The use of biomass as an energy source is an issue of great importance, as it constitutes part of an alternative solution for the replacement of fossil fuels. Even though raw biomass has significantly less energy content than petroleum, it has certain other advantages compared to fossil fuels. First, biomass is the only renewable organic and most abundant resource. Second, biomass fixes carbon dioxide balance in the atmosphere by photosynthesis.

Biomass feedstock’s, such as agricultural residues, wastes from the paper, forestry and food industries, municipal wastes and energy crops have attracted great attention as renewable energy sources available world-wide. Because of the ease of production and supply advantages, certain crops have been adopted as renewable sources in the production of liquid fuels. Soybean and rape seed, sunflower, cotton, euphorbia species and safflower are among the most promising renewable sources that have already been studied from the pyrolysis parameters and fuel properties point of view. It is necessary to develop technologies which make possible the conversion of biomass to a more suitable form, such as solid, liquid or gas. The nature and characteristics of the feedstock’s plays an important role in the design of a thermo chemical conversion system.

The recovery of energy from a renewable source like biomass involves chemical, biochemical and thermo chemical processes, depending on the nature of the source. The main advantages of using biomass are its negligible sulphur, nitrogen and metal content. The utilization of biomass for energy generation has lead to reduced carbon dioxide, sulphur dioxide emissions and importantly prevents the green house effect and acid rain. The net flow of carbon dioxide to the atmosphere, and thereby the global potential, is reduced when fossil fuels are replaced with
sustainably produced biomass. Consumption of agricultural residues for energy production would also reduce the environmental damage.

Among the thermo chemical processes, pyrolysis has become an attractive alternative because of the ease of operation. Its suitability to produce fuel for energy production and as feedstock’s for chemical industries, relatively few polluting emissions, carbon dioxide neutral cycle and ease of reproduction makes pyrolysis oil a favourable option. The proportion of gas, liquid and solid products depend very much on the pyrolysis technique used and on the reaction parameters. Depending on the operating conditions, the pyrolysis process can be divided into three sub classes such as conventional pyrolysis (carbonization), fast pyrolysis and flash pyrolysis. Slow pyrolysis processes are performed at a low-heating rate and a long residence time. The longer residence times can cause secondary cracking of the primary products reducing yield and adversely affecting bio oil properties. In addition, a low heating rate and long residence time may increase energy input. All of these are not attractive for commercial application of liquid fuel production. The preferred technology for production of oily products is fast or flash pyrolysis at high temperatures with very short residence time. The pyrolysis oil from biomass waste was found to be highly oxygenated and complex, and chemically unstable. Thus, the liquid products still need to be upgraded by lowering the oxygen content and removing residues.

The solid char can be used as a fuel in the form of briquettes or as a char–oil/water slurry or it can be upgraded to activated carbon and used in purification processes. The gases generated have a low to medium heating value, but may contain sufficient energy to supply the energy requirements of a pyrolysis plant.

Pyrolytic oil has strategic value because, as a liquid with high calorific value, its handling, storage, transportation, and utilization are similar to that of oil. It can be upgraded to obtain light hydrocarbons for transport fuel. Furthermore, compared to most coal- and petroleum-derived fuels, biomass oils contain low levels of aromatics and sulfur.

The plant that is generally cultivated for the purpose of extracting jatropha oil is jatropha curcus. The seeds are the primary source from which the oil is extracted. Owing to the toxicity of jatropha seeds, they are not used by humans. The major goal of jatropha cultivation, therefore, is performed for the sake of extracting jatropha oil.
Literature survey shows that analysis of jatropha curcus seed shows the following chemical compositions (56).

- Moisture: 6.20%
- Protein: 18.00%
- Fat: 38.00%
- Carbohydrates: 17.00%
- Fiber: 15.50%
- Ash: 5.30%

Jatropha curcus, also known as Ratanjyot or Jangli erandi, is a drought-resistant perennial plant which grows almost anywhere- in marginal/ poor soil even on gravelly, sandy and saline soils. It can thrive on the poorest stony soil. It can grow even in the crevices of rocks. It is a small tree or shrub with smooth gray bark, which exudes whitish colored, watery, latex when cut. Normally, it grows between three and five meters in height, but can attain a height of up to eight or ten meters under favourable conditions. Fig 1.1 shows the jatropha curcus plant.

Fig 1.1 Jatropha curcus plant
Fig 1.2 Jatropha seed

Fig 1.3 Jatropha oil cake

Fig 1.2 shows the jatropha seed and Fig 1.3 shows the jatropha oil cake. Literature survey shows that the oil cake is rich in nutrients and will give bio-gas and very good bio fertilizer for soils which are getting increasingly deficient in carbon and nutrients. The press cake constitutes some 70 - 80 percent of the total mass of the seeds, depending on the extraction rate. The press cake cannot be used in animal feed because of its toxic properties. Because of its content of nitrogen (6 % N₂), phosphorous (2.75 % P₂O₅) and potassium (0.94 % K₂O), which is similar to that of chicken manure, it is valuable as organic manure.
One ton per day biodiesel plant produces 2.5 to 3 tons of seed cake. Oil seed cake is a by-product obtained from the oil extraction process. Literature survey shows that the jatropha oil cake has the following properties and nutrients (55).

- **Moisture**: 4.58%
- **Nitrogen (N₂)**: 3.2 - 6.0%
- **Phosphorus (P₂O₅)**: 1.4 - 2.75
- **Potassium (K₂O)**: 0.94 - 1.68%
- **Crude Protein**: 58%

The seed cake is unusable as feed for livestock due to its toxicity. Disposal of Seed Cake of Jatropha, can be achieved by several other means like incineration, landfills etc. Incineration can lead to respiratory illnesses. Landfill and dumping can pollute water bodies.

Thermal degradation of the waste would serve many purposes such as:

1. Environment friendly disposal of waste, which is the need of the hour, considering mass pollution everywhere.
2. Generation of fairly good amount of fuel oil and gas, which will definitely support the dwindling energy resources.
3. Generation of high quality char, which could be used for several practical uses.

### 1.1 Oil from *jatropha curcus*

The oil content is 25-30% in the seed. The oil contains 21% saturated fatty acids and 79% unsaturated fatty acids. These are some of the chemical elements in the seed, curcin, which is poisonous and render the oil not appropriate for human consumption.

Oil has very high saponification value and being extensively used for making soap in some countries. Also oil is used as an illuminant in lamps as it burns without emitting smoke. It is also used as fuel in place of, or along with kerosene stoves.

Jatropha curcus oil cake is rich in Nitrogen, Phosphorous and Potassium and can be used as organic manure. By thermodynamic conversion process, pyrolysis, useful products can be obtained from the jatropha oil cake. The liquid, solid (char), and gaseous products can be
obtained. The liquid can be used as fuel in furnace and boiler. It can be upgraded to higher grade fuel by transesterification process.

It is significant to point out that, the non edible vegetable oil of jatropha curcus has the requisite potential providing a promising and commercially viable alternative to diesel oil since it has desirable physical chemical and performance characteristics comparable to diesel. Cars could be run with jatropha curcus without requiring much change in design.

Jatropha oil expelled from seeds and filtered through filter press can replace kerosene or oil lamp. Jatropha oil can be used as liquid fuel for lighting and cooking. It will also be used in big Diesel engine based electricity generating sets, pump sets, heavy farm machinery, where the viscosity of oil is not an issue.

The seeds of jatropha contain (50% by weight) viscous oil which can be used for manufacture of candles and soap, in the cosmetic industry, for cooking and lighting by itself or as a Diesel /paraffin substitute or extender. The latter use has important implications for meeting the demand for rural energy services and also exploring practical substitute for fossil fuels to counter greenhouse gas accumulation in the atmosphere.

There are a number of varieties of jatropha. Best among these are jatropha curcus. The oil is a strong purgative, widely used as an antiseptic for cough, skin diseases and as a pain reliever from rheumatism. When jatropha seeds are crushed, the resulting jatropha oil can be processed to produce a high-quality biodiesel that can be used in a standard diesel car, while the residue (press cake) can also be processed and used as biomass feedstock to power electricity plants or used as fertilizer (it contains nitrogen, phosphorous and potassium).

1.2 Jatropha Oil Extractions

Jatropha oil can be extracted from the seeds by three ways. They are mechanically, chemically and enzymatically. Here is a chart that describes the process of oil extraction from the seeds. Fig 1.4 shows the jatropha oil extraction chart.
Below are some of the methods that are usually followed to extracts the oils from jatropha seeds.

1.2.1 Oil Presses

Oil presses method is used to extract the oil using simple mechanical devices. It is also done manually. The most commonly used oil presses method is the Bielenberg ram press method.

Bielenberg ram press method is a simple traditional method that uses simple devices to extract the oils. With the help of this method 3 liters of oil can be obtained with 12 kg of seeds.

1.2.2 Oil Expellers

Oil expeller’s method is also used for jatropha oil extraction. The most commonly used method is the Sayari oil expeller method. This method is also called as Sundhara oil expeller. Komet oil expellers are also used.
These sayari oil expellers was developed in Nepal and is a diesel operated one. Now it is developed in Tanzania and Zimbabwe mainly for the production jatropha oil. Heavy oil expellers are made of heavy cast iron and the light ones are made up of iron sheets. Electricity driven models are also available.

Komet oil expeller is a single oil expeller machine that is used not only to extract the jatropha oil as well for the preparation of the oil cakes.

1.2.3 Traditional Methods

Traditional methods are used in the rural and developing areas for extracting the oils. Traditional methods are simple and the oil is extracted by hand using simple equipment.

1.2.4 Hot oil extraction

The process of extracting the oil at high pressure is called as hot oil extraction method. The press cake that remains after extracting the oil have less oil content which might be 3 to 7 % approximately. During the oil extraction method many stuffing of the seeds are converted into gum like substances and some non organic substances. These are unwanted products and so they have to be refined.

1.2.5 Modern Concepts

Modern methods are followed to extract more oils from the jatropha seeds. In these modern concepts chemical methods like aqueous enzymatic treatment is used. The main idea in researching the modern concepts is to extract a greater percentage of oil from the jatropha seeds.

1.2.6 Jatropha oil uses

Jatropha oil is also a kind of vegetable oil that is produced from the seeds of jatropha that has the capacity to grow in marginal and common lands. Below are some of the benefits of jatropha oil.

i) Used as an alternative for diesel as a renewable source.

ii) Have the properties that are similar to diesel fuel.
iii) It is an oxygenated fuel and is also an eco friendly.
iv) Contains less sulphur.
v) Can be used in the diesel engine with little modification in the engines.
vi) Emission of exhaust gas is reduced.

1.2.7 Use as biodiesel

In order to meet the decreasing foreign exchange reserves it is essential to find a renewable resource that is better for this problem. So to meet the growing demand non-edible seeds from the jatropha plant has a potential effect on this increasing requirement. The oil that is extracted from the jatropha plant is used as a substitute for diesel in many parts of the world. The biodiesel that is prepared from the jatropha oil is more economical than any other diesel.

Trans-esterification is the process that is used to produce biodiesel from jatropha oil. In these process triglycerides is converted into methyl esters. And the oil is mixed with alcohol and catalyst and is kept at the reaction temperature for a specific duration of time under agitation. Then it is sent to the settling tank. At last the ester is collected and washed to get pure biodiesel. It is also used as Jet fuel, Light hydrocarbon fuel, and Myanmar biodiesel.

In this study, the pyrolysis of jatropha oil cake was investigated in a fluidized bed reactor. Particularly, the influences of pyrolysis temperature, particle size and nitrogen gas flow rate on the product yields were studied. In addition to this the properties of pyrolysis oil and pyrolysis gas composition were also determined.