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Design & development of a filter press unit, gasifier and feasibility of using coir pith for absorption and recovery of oil from contaminated sites

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Introduction

India being an agrarian economy produces huge quantities of agro residues in the process of producing good gains. One such agro residue produced that is produced in large quantities is Coir pith, which is produced as a by-product from the coir industry in India. The annual production of the coir pith from industry in the country is estimated as 6.8 lakh tonnes in the year of 2002 (ref). Presently coir pith in various forms is used as a bio-manure, hydro phonics medium, etc which consumes less than 5% of the total annual production. A bulk of the solid waste generated is used as a landfill at the production site itself, which leads to leaching out pollutants and badly affecting the local environment.

To manage the waste profitably and to abate the pollution norms prescribed by enforcing agencies, TERI in collaboration with Coir Board has taken a study to find effective usage of coir pith and value addition to the coir pith as a product. Feasibility of using coir pith to absorb & recover the oil from the oil spillage areas, a mechanism to extract the absorbed oil from the coir pith was designed and tested. The results of the tests regards coir piths oil absorption capacity, oil recovery ratio, heat content of residual coir pith to use for thermal applications are presented in the report in detail. The project was undertaken based on the guidance of the Chairman, Coir Board, during the meeting held in April 2008.

Overall objective of the project

The main objectives of the project are:

a) To study the feasibility of using coir as an absorbent pith for oil recovery in the areas of oil spillage
b) Design a screw press to squeeze out absorbed oil from the coir pith
c) To quantify the value addition of the coir pith after oil extraction, to use it as fuel having high calorific value.

Process

In the process of separation of coir from the husk of the coconut, it is soaked in water and mechanically thrashed to separate the coir and coir pith. Due to the process, the coir pith available from the factory containing very high moisture content to the level of 30 to 35%. The wet coir pith initially sun-dried before using for oil absorption and oil recovery. The dry coir pith is spreaded on the oil spillage areas for absorption of oil in the coir pith.

The coir pith with oil is placed in a screw press which is designed for oil recovery from coir pith. The screw press is manually operated to remove the oil. The residue coir pith after recovering the oil, has higher calorific value in comparing with the coir pith before oil absorption. A block diagram showing the process & components are given in Fig. 1. Property of the coir pith as available in the coir factory is given in Table 1.

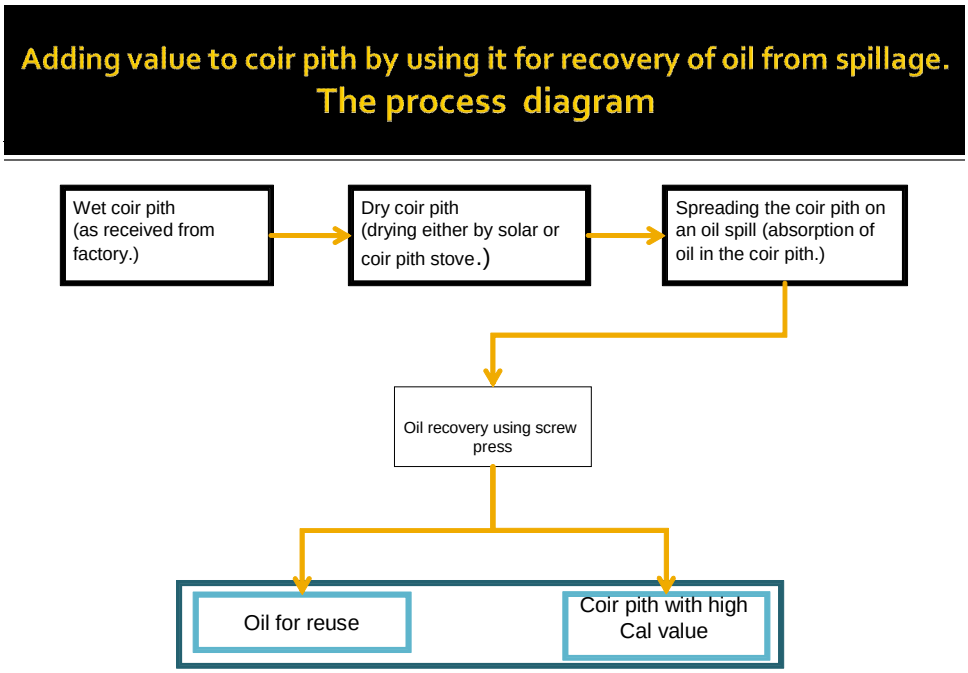

Fig1. Block diagram showing the process and components

Table1. Results of proximate analysis

Expt	Moisture %	VS %	Ash content %	FC %	Bulk density Kg/m^3
1	22.47	72.23	7.8	27.8	220
2	22.35	72.35	7.5	27.7	218
3	22.98	71.67	7.3	28.3	222
Average	22.6	72.09	7.5	27.9	220

Methodology

A joint team of TERI professional along with Coir Board officials visited the Padma Fibre Industries at Cherthala, Alapuzha Industrial clusters. During this visit the team has conducted a detailed survey of coir pith processing industries with specific focus on waste treatment and disposal characterisation of the coir waste and present practises of waste disposal and environmental impacts and availability of coir pith.

Majority of the industries in this cluster adhere to a common practice to procure coconut husk from the near by coir industry cluster. Further this husk is a waste generated from the process of separating the fibre (coir) in the Coir industry.

The coir pith hence obtained from the coconut shells goes through various processes including soaking in water to separate the coir and pith. Few representative samples of the material were collected to study the properties of the materials and for characterisation of the same. A detailed discussion of the process and resource assessment is carried out in the more details on in Annexure 1. The samples collected from the site is than analysed for the following parameters as listed below:

i) Moisture content
ii) Heat content
iii) The oil absorption capacity
iv) Oil recovery factor
v) Increased Calorific value of the residual coir pith after oil extraction

Initially a set of experiments was conducted at our research facility at Gual Phari campus to arrive at the design parameters for the screw press and also to estimate the oil absorption capacity of the coir pith sample. A manually operated hydraulic press, having pressure level indicator, was used for experimental purpose. During the experiments of oil absorption and oil recovery the pressure indicator was used to determine the required parameter for arriving an optimum level of oil extraction (recovery). Fig.2 shows the hydraulic press used during experiment. Fig.3 shows the clean oil recovered from the coir pith. Since part of the oil remaining in coir pith, the heat value of the residual coir pith increases than the normal coir pith, the calorific value increase with respect to increase in the percentage of residual oil content in the pith.

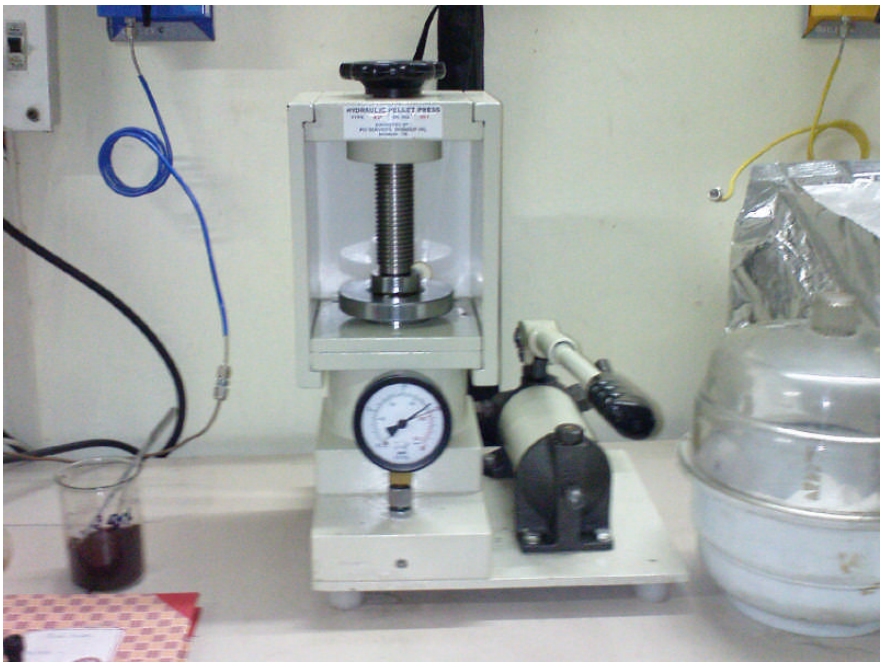

Fig.2. Hydraulic press used during experiment

A detailed review of the experimental data was conducted which lead to build up on the conceptual design which was tested during the experimentation process. The sizing of the screw press is then finalized to meet the following To keep the structure stable and strengthen the structure adequate stiffener were provided. The screw press was design to reduce the effort required to extract oil from the pith. The components of the press are as listed below

- ✓ **Central screw:** A Critical component in this entire design of the press is the central screw and the design of
- ✓ **Handle**: The handle to reduce the effort required for oil extraction.
- ✓ **Press plate:** It was designed to be sufficiently heavy enough to provide adequate strength.
- ✓ **Perforated plate:** Perforated plate for allowing a maximum of oil extraction from the coir pith

The perforated plate with fine holes is design to facilitate easy extraction of oil from the coir pith. Further perforated plate was designed such a way that there will not be any deformation of shape or blockage, thus a sustainable efficiency of oil extraction is maintained. The perforated plate can be cleaned easily once a while when the oil recovery becomes lower. The operator's wheel is conveniently located at a height so that the operator can handle the equipment comfortably and safely. A tray was provided below the perforated plate to collect the oil recovered from the coir pith. After extraction of oil, the coir pith was removed from the top of the perforated plate, and the oil collected in the tray can be re-used after simple filtration. The drawing of the screw press is given in Fig.4. The view of the

screw press is shown in Fig.5. The oil extracted from the coir pith using the screw press in shown in Fig.6.

Fig.3 Oil recovery from the coir pith

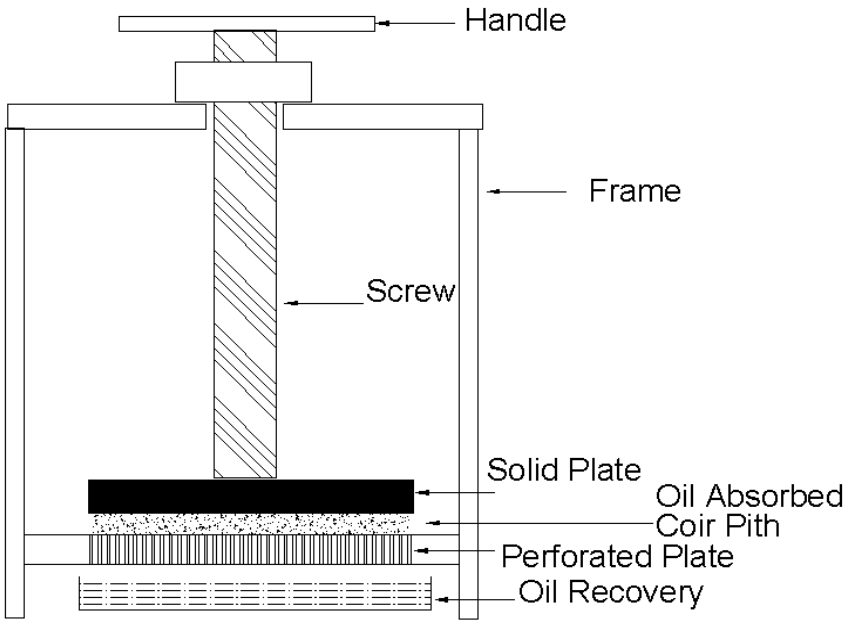

Fig.4. Drawing of the screw press

Fig.5(a). View of the screw press

Fig.5(b). View of the screw press

Fig.6. Oil extracted from the coir pith using the screw press

Performance result of the screw press

During the experiments, it was found that the coir pith can absorb upto 300% of the oil which is 3 times of the weight of the coir pith. Up to 200% of oil absorption it takes lesser time and easy in mixing. In order to save time and to facilitate easy absorption, it is ideal to allow the coir pith to absorb the waste oil around 200%, and recover the oil for reuse. It is also observed that the fresh coir pith takes more time for absorption while compared to that pith after oil extraction. Reuse of coir pith for multiple times is more appropriate in effective oil absorption point of view at the maximum oil absorption level of 300%. About 75% of the oil was recovered using the screw press, at 300% oil absorption level. 200% of oil absorption level the oil recovery rate is about 65%.

Fig.7 shows the percentage of oil absorbed versus the percentage of oil recovered. Fig.8 shows the calorific value of the residual coir pith corresponding to the respective oil absorption and oil recovery level. Table 2 provides the details of oil absorption capacity, possibility of oil recovery and added heat value of the residual coir pith.

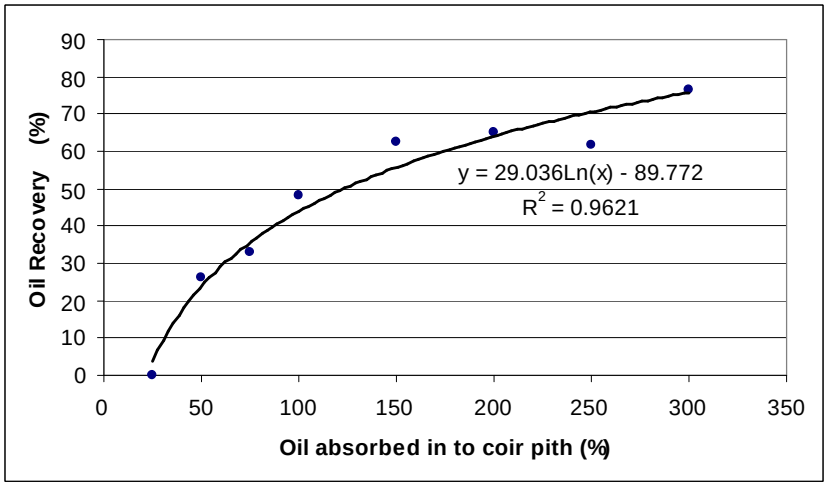

Fig.7. Oil absorbed in to coir pith

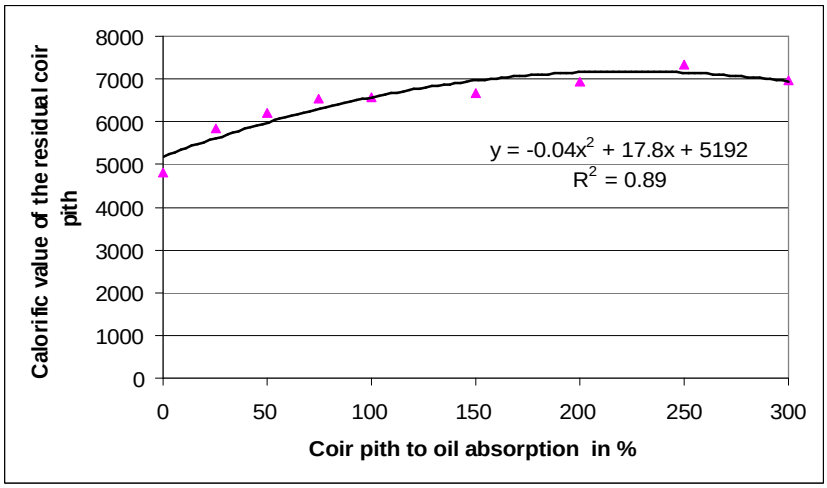

Fig.8. Coir pith to oil absorption

Table2. Details of oil absorption capacity, possibility of oil recovery and added heated value of the residual coir pith

Sl No	Quantity of coir pith used (in gm)	Quantity of oil absorbed (in gm)	Oil absorbed by coir pith in percentage (%)	Oil recovered by using the screw press (gm)	Percentage of recovered from coir pith	Heat content of the residual coir pith after extraction of oil in Kcal/kg
1.	250	0	-	-	-	4800*
2.	250	62.5	25	0	0	5840
3.	250	125	50	33	26.40	6199
4.	250	187.5	75	62	33.07	6547
5.	250	250	100	120	48.00	6579
6.	250	375	150	235	62.67	6667
7.	250	500	200	325	65.00	6941
8.	250	1250	250	772	61.76	7342
9.	250	1500	300	1145	76.33	6959

*Calorific value of coir pith without oil absorption (dry basis)

Conclusions

Coir pith is one of the best materials for oil absorption and can be used as waste oil recovery medium in oil spillage areas. Coir pith can absorb waste oil in a proportion of at least twice of its weight that is about 200% of oil absorption. About 70% of the oil absorbed in the coir pith can be recovered using screw press. The screw press designed for removal of oil absorbed in coir pith found to be working well. The screw press is manually operated one and does not require any external energy to operate it. The coir pith after removal of the oil has much higher calorific value more than 6600 Kcal/Kg which is about 42% more than the calorific value of coir pith. The residual oil in the coir pith adds the heat content of the coir pith. So the residual coir pith can be used as fuel for cooking applications and other heating applications.

Scope of further research to add value to coir pith

In addition to the work carried out in this project, the coir pith can be used to produce pyrolysis oil. Pyrolysis oil is similar to bio-oil, the concept is known as biomass to liquid (BTL). There is a possibility of producing oil from coir pith through pyrolysis, to an extract of 40% efficiency that is 2.5 kg of coir pith can produce 1 litre of oil. The oil can be used for furnaces and cooking application. The charcoal obtained as by-product can be used as a valuable fuel for many applications. Initiation of research in this area will result in to value addition to coir pith. More details on pyrolysis process are given in Annexure-II.

Annexure I
Coir pith- production as a byproduct

Fig.1 (a). A view of the crusher used to crush the Coconut husk

Fig.1 (b). The inner view of the coconut husk crusher

Fig 2(a): A Rotating mesh screen separating the coir and coir pith

Fig 2(b): Coir pith is collected from the bottom of the screen.

Fig.3: The Coir ready to transport along with the view of storage of coconut husk

Fig.4: The coir pith as byproduct from the coir industry

Annexure II

Scope for future study: Conversion of coir pith in to liquid fuel

"Pyrolysis oil production from coir pith"

Principles

In fast Pyrolysis biomass decomposes to generate mostly vapours and aerosols and some charcoal. After cooling and condensation, a dark brown mobile liquid is formed which has a heating value about half that of conventional fuel oil. While it is related to the traditional Pyrolysis processes for making char coal, fast Pyrolysis is an advanced process, with carefully controlled parameters to give high yields of liquid. The essential features of a fast Pyrolysis process for producing liquids are:

- Very high heating and heat transfer rates at the reaction interface, which usually requires a finely ground biomass feed, carefully controlled Pyrolysis reaction temperature of around 500 ºC and vapor phase temperature of 400-450 ºC,
- Short vapor residence times of typically less than 2 seconds, and Rapid cooling of the Pyrolysis vapor to give the bio-oil product.

The main product, bio-oil, is obtained in yields of up to 75% wt on dry feed basis, together with by-product char and gas which are used within the process so there are no waste streams other than flue gas and ash.

A fast Pyrolysis process includes drying the feed to typically less than 10% water in order to minimise the water in the product liquid oil (although up to 15% can be accept able), grinding the feed (to around 2 mm in the case of fluid bed reactors), to give sufficiently small particles to ensure rapid reaction, Pyrolysis reaction, sep a ration of solids (char), and collection of the liquid product (bio-oil).

Fast Pyrolysis is one of the three main thermal routes, with gasification and combustion, in producing a useful and valuable bio-fuel. It is one of the most recent renewable energy processes to have been introduced and offers the advantages of a liquid product – bio-oil – that can be readily stored and transported, and used as a fuel, an energy carrier and a source of chemicals. Fast Pyrolysis has now achieved commercial success for production of some chemicals, liquid fuel and electricity. However, fast

Pyrolysis is one of the most recently emerging biomass technologies used to convert biomass feedstock into higher value products. Commercial interest in Pyrolysis is related to the many energy and non-energy products than can potentially be obtained, particularly liquid fuels and solvents, and also the large number of chemicals (e.g. adhesives, organic chemicals, and flavouring) that also addresses the issues of its converting the waste to energy and environmental protection.

Benefits of Pyrolysis oil production from coir pith

The benefit of converting the locally available coir pith (which is a by-product of the coir industry) produced from coir industry can be added value, that can replace the conventional fossil fuel and also to contribute towards environmental protection.

The Bio-oil hence produced from coir waste can be tested for its suitability to use in the domestic cook stoves/ diesel engines and in furnace/ boilers in medium and small micro enterprise for their process heat requirements. Successful demonstration of the concept would trigger a large-scale replication across the country and other parts for the world.

Further liquefaction to an intermediate energy carrier; at a scale that matches the local logistics of collection and storage, seems to be beneficial in following cases:

- Has an energy density of up 10 times higher than the biomass bulk material of which it has been made;
- Can be handled and stored easily as a uniform low-viscosity liquid without any risk of natural degradation;
- Can be collected from various production areas and shipped easily over long distances to central sites for further applications;
- Can be traded in large quantities as a world wide commodity through the existing infrastructure of bulk tankers and harbour facilities;
- Can be pressurized and pumped through pipelines;
- Can be used as a liquid fuel in modern conversion equipment (gas turbines, diesel engines, oil and gas furnaces);

Fig.1 A view of the Pyrolysis oil produced from Saw dust using a proto type reactor

Fig.2: View of a pyrolyser rector (proto type) used for conversion of biomass in to liquid fuel

Annexure III (progress report sent on July 08)

Coir pith : A potential industrial residue for high value addition

Adding value to coir pith by using it for recovery of oil from spillage. The process adopted to absorb and recover the oil is shown in the following diagram, Figure 1. The project activities are in the line of the concept and stages as described in the diagram.

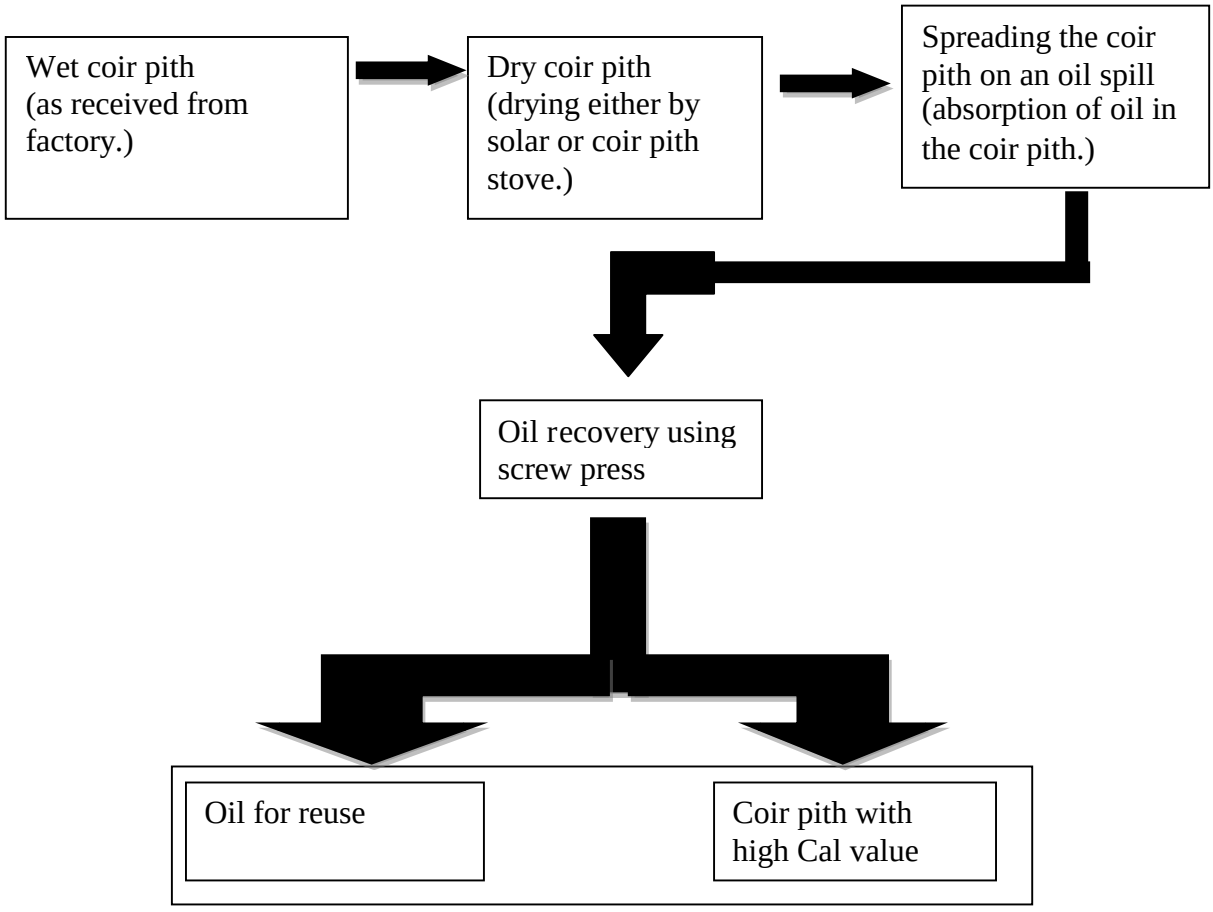

Fig.(1) The process of oil recovery using coir pith.

Effective & enhanced oil absorption in Coir Pith:

As such the available coir pith from the industry is wet and having a very high moisture content. The level of moisture content of the coir pith varies depending upon the season. In summer it will have a lower moisture content and in rainy season it increases. To

have a maximum oil absorption capacity the coir pith needs to be dried well to bring down to a minimum moisture content around 10%. The drying of coir pith can e done by solar are by using biomass stove (in monsoon).
It was found that well dried coir pith is the best one to absorb the oil to the maximum level. So, the dry coir pith is used for studying the different level of oil absorbing capacity. Coir pith was procured from cochin and furnace oil is procured from delhi for experimental purpose.

The studies conducted:

A brief list of study carried out towards finding various parameters for usage of coir pith towards oil recovery purpose.

1.Inherent moisture content in the coir pith, as received from the factory.

2.Minimum moisture content achieved by sun drying.

3.Characterisic analysis of coir pith (moisture content, bulk density, volatile matter, fixed carbon, ash content and calorific value)

4.Oil expelling capacity at various level of oil absorption .

5.Maximum oil absorbing capacity and maximum oil recovery level.

6.Calorific value of the coir pith after oil recovery.

Observation:

The preliminary study reveals that the coir pith can be effectively and efficiently used for oil absorption (upto three times of the coir pith i.e. 300%). Also it is observed that the coir pith can loose the oil to a large extent (about 70% of the oil, absorbed in the coir pith). The concept of a screw press was tested and nessecary parameters were arrived to design the oil recovering press .

Status:

The laboratory results are expected by third week of august, on quantifying

(i)Oil recovery factor at vasrious oil absorbant capacity of the coir pith.

(ii)Calorific value of th residual coir pith at different oil absorbant level.

Fabrication of a screw press is in progress and expected to be completed by mid of september ‘08. By end of october the performance result of the screw machine and the procedure for oil recovery using coir pith will be available. The findings can be adopted to use the technology at the industry level.