Development of Pilot Scale Pyrolysis Test Unit for Production of Liquid Bio-fuels and Value Added By-products from Biodiesel Plant Wastes

Executive summary

This project, jointly sponsored by MNRE and TERI, involves the design development of a pilot scale Pyrolysis Test Unit (PTU) to convert toxic oil seed wastes from the Biodiesel Industry (Karanja and Jatropha oil seed residues like seed hulls, shells, cakes, etc.) into liquid fuels.

Under this project, a PTU (of capacity 100 kg/day or 20kg/h max) is designed, developed commissioned and tested in TERI Gualpahari for the feasibility of bio oil production from oil seed residues. This system has a novel design where the thermal gasifier coupled with the PTU provides the combustion gases that come in direct contact with the pyrolysis feed materials. In the current design developed by TERI, conventional heat carriers like sand are substituted by flue gases.

The central pyrolysis unit is an Auger reactor where the flow rate and the residence time of the biomass inside the reactor are adjusted by controlling the shaft speed with a variable speed motor. The residence time of the pyrolysis vapour inside the reactor is maintained within desired limits and finally quenched in the condenser train maintained at subzero temperature. The condenser train has a series of condensers maintained at different preset temperatures. The advantage of not having the fluidized bed reactor is to reduce the pre-processing steps of biomass before thermal conversion and to avoid complexities in design.

The basic objective for selecting the Auger reactor is to have a reactor competitive to fluidized bed reactors, the most successfully demonstrated reactors at commercial scale, and at the same time, to overcome the inherent need of large volumetric requirement of inert hot carrier gases like nitrogen. It is also advantageous with respect to reduced char carryover / attrition in the pyro-vapour. Another significant advantage of the present reactor is having both co-current and counter-current movements of the biomass. An equal heat distribution along the reactor length is also achieved with the provision of two burners placed at both the front and rear ends of the reactor.

The preliminary experiments have been conducted in the PTU. Pyrolysis studies with Jatropha and Karanja oil seed residues have been carried out for proof-of-concept and the primary product distribution, and energy and mass balance of the process has been evaluated.

The experiments with Jatropha seed cakes conducted in the pilot unit yield a maximum total liquid of ~41 wt. % at 5000C. Jatropha shells on the other hand at 5500C give a maximum of 34 wt. % of total liquid. Karanja oil seed residue at 5000C produces a maximum total liquid yield of ~54 wt. % while Karanja shells at 5500C produce 44 wt. % total liquid The maximum value of oil to liquid ratio is found to be 0.4 and 0.5 for Jatropha and Karanja oil cakes and 0.3 and 0.3 respectively for Jatropha and Karanja shells.

Calorific value of pyrolysis oil from Jatropha oil cakes and shells are 25-26 MJ/kg and 18-21 MJ/kg respectively. Respective calorific values of pyrolysis oils from Karanja oil cakes and shells are 27-28 MJ/kg and 20-21 MJ/kg.

This prototype pilot pyrolysis unit is the first stage towards realizing a close coupled system in future where pyrolysis gases could be recycled and combusted to provide the required heat without any external heat sources.

A patent has been filed on the design and working methodology of this Pyrolyser.