Pyrolysis for coffee pulp valorization

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Abstract

Much literature about the use of pyrolysis in the coffee production sector focuses on a stationary plant design. We evaluate the benefits of a mobile plant to also serve small coffee farmers where the harvesting season lasts only about three months. In such situations most other treatments/ valorizations methods cannot be economically applied. Thousands of tons of coffee pulp are therefore not valorized and left to rot. This not only means releasing the potent greenhouse gas (GHG) methane but also contaminating seeping water, polluting rivers and ground water resources. Not valorizing readily available resources means also ignoring a competitive advantage. For this study, the technology component of the joint global UNIDO-UNEP Resource Efficient and Cleaner Production (RECP) program, identified pyrolysis as a potential technology for step-reductions in terms of byproduct treatment and their valorization. The sectorial study included a top down and bottoms up approach to cross check the findings. This included a desk review of existing RECP assessment and conducting five new RECP assessments in representative agro-industrial coffee companies. Furthermore additional information was attained through first-tier surveys with entities like the commercial camber, regional government or coffee equipment manufacturers.

Keywords: Pyrolysis, coffee, biochar, innovation, cleaner production

1 Introduction

In Peru alone, thousands of tons of coffee pulp are not valorized and left to rot because of a lack of proper treatment. This not only means releasing the potent greenhouse gas (GHG) methane but also contaminating seeping water, polluting rivers and ground water resources. But this is not only a Peruvian problem. The Guatemala-based Instituto Centroamericano de Investigación y Tecnología Industrial estimated that over a six month period during 1988, the processing of 547,000 tons of coffee in Central America generated 1.1 million tons of pulp and polluted 110,000 cubic meters of water per day, resulting in discharges to the region's waterways equivalent to raw sewage dumping from a city of four million people.1

At the same time authorities, environmental organizations, neighbors and label organization demand for sustainable production without giving practical solutions.

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[1] Gilberto Amaya H., Appropriate Technology International, personal communication, January 22, 1996.

The technology component of the joint global UNIDO-UNEP Resource Efficient and Cleaner Production (RECP) program, identified pyrolysis as a potential technology for step-reductions in terms of byproduct treatment and their valorization. The main advantages are as follows:

- Production of renewable energy, which can be used for the drying process with a reduction of their traditional thermal energy consumption of around 40-70%. In Peru the drying process is usually the bottleneck and key for coffee quality.
- Reducing the need for wood, coffee husks or fossil energy and hence a reduction in CO_2 emissions
- Fast, appropriate and clean solution for their coffee pulp “disposal”.
- Production of Biochar, a product to improve soil characteristics, especially of tropical soils, to achieve higher yields and save costs for expensive and scarce fertilizer.
- Biochar is also regarded as a carbon sequester.

1.1 Study/ Project scope and purpose

Scope:

While there is undoubtedly several potential severe environmental impacts along the value chain of coffee production like deforestation, overuse of agrochemicals or soil deterioration etc. this study focuses on the in Latin America most common, wet process.

Figure 1 *Generic flowchart of coffee production in Peru*

Figure 2 *Unused coffee pulp*

Purpose:

This project aims to provide agro-industrial companies a Cleaner Production Technology to maximize the valorization of their organic waste (coffee pulp) and minimize its negative environmental impact. A mobile Pyrolysis plant is a very interesting solution as it turns the coffee pulp into biochar, a soil enhancer, and gas, which in turn can be used for the drying process. Additionally the production costs in Peru must not exceed 20’000$ for the mobile plant.

2 Innovation for Resource Efficiency

2.1 Research and design of a mobile pyrolysis plant

During five CP-Assessments in three typical coffee growing regions, it was soon realized that a stationary pyrolysis plant would not be economically feasible because if the short harvest seasons and therefore short operational time.

The main factor for the time of year of the harvest is altitude. In Peru coffee is grown at altitudes 800-1'500 MASEL. Thus a mobile plant, which can be easily driven to different altitudes, could be run almost throughout the year. Knowing that the pyrolysis plant can be also used in other agro-industrial sectors i.e. cacao, banana, sugar cane, gives exiting options for different business models.

Industrial pyrolysis plants do already exist i.e. the Pyreg500, an industrial plant from Germany, which can convert 1'700 tons per year in heat and coal. This system is very expensive and very time-consuming and has a big drawback: The reactor is heated from the outside with the hot exhaust gases from the pyrolysis gas combustion. This then demands for very high heat and high-temperature corrosion resistance of the used material. Because of this, expensive heat resistant steel must be used and furthermore the temperature must be accurately controlled for these delicate heat exchangers. The idea is to exchange the expensive and complicated reactor with a simplified technology. This chosen process, FLOX burner, with recirculation of exhaust gases for heating is still comparatively new, but is already applied in torrefaction.
Unfortunately for the time being there is no such mobile pyrolysis plant commercially available. For this reasons a prototype plant, that can process 90 kg coffee pulp per hour is being developed and planned to give results by November 2014.

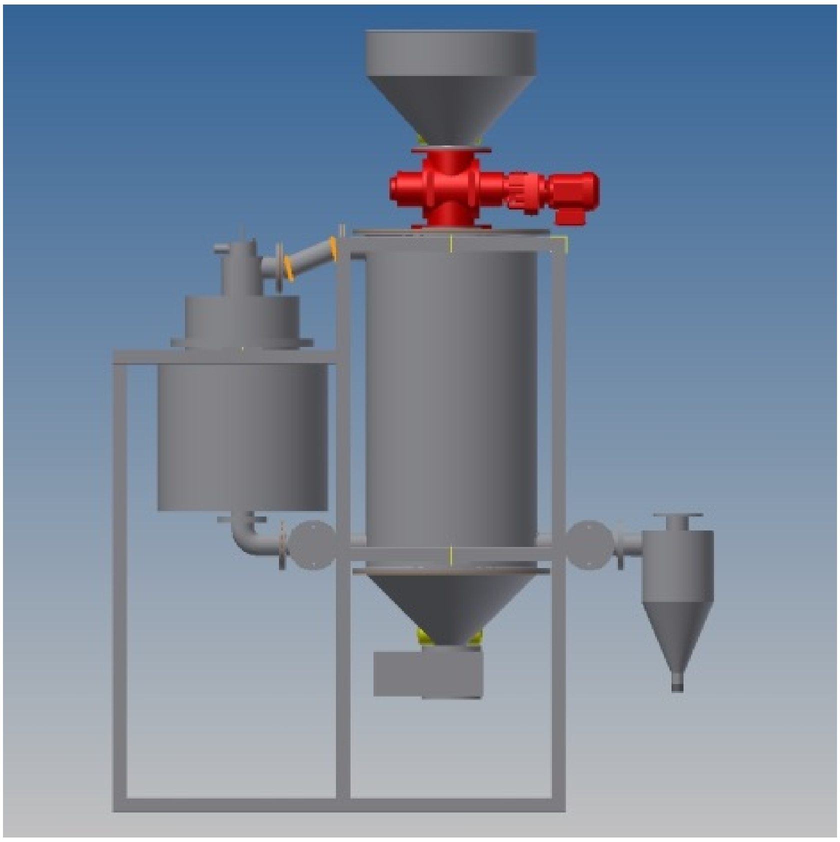

Figure 3 *CAD Modell of the pyrolysis prototype including FLOX burner, reactor and cyclone separator*

A major advantage of this system is the production of renewable energy, which can be used for the drying process. It is expected to save around 40-70% of their traditional thermal energy consumption. In Peru the drying process is usually the bottleneck and key for coffee quality.

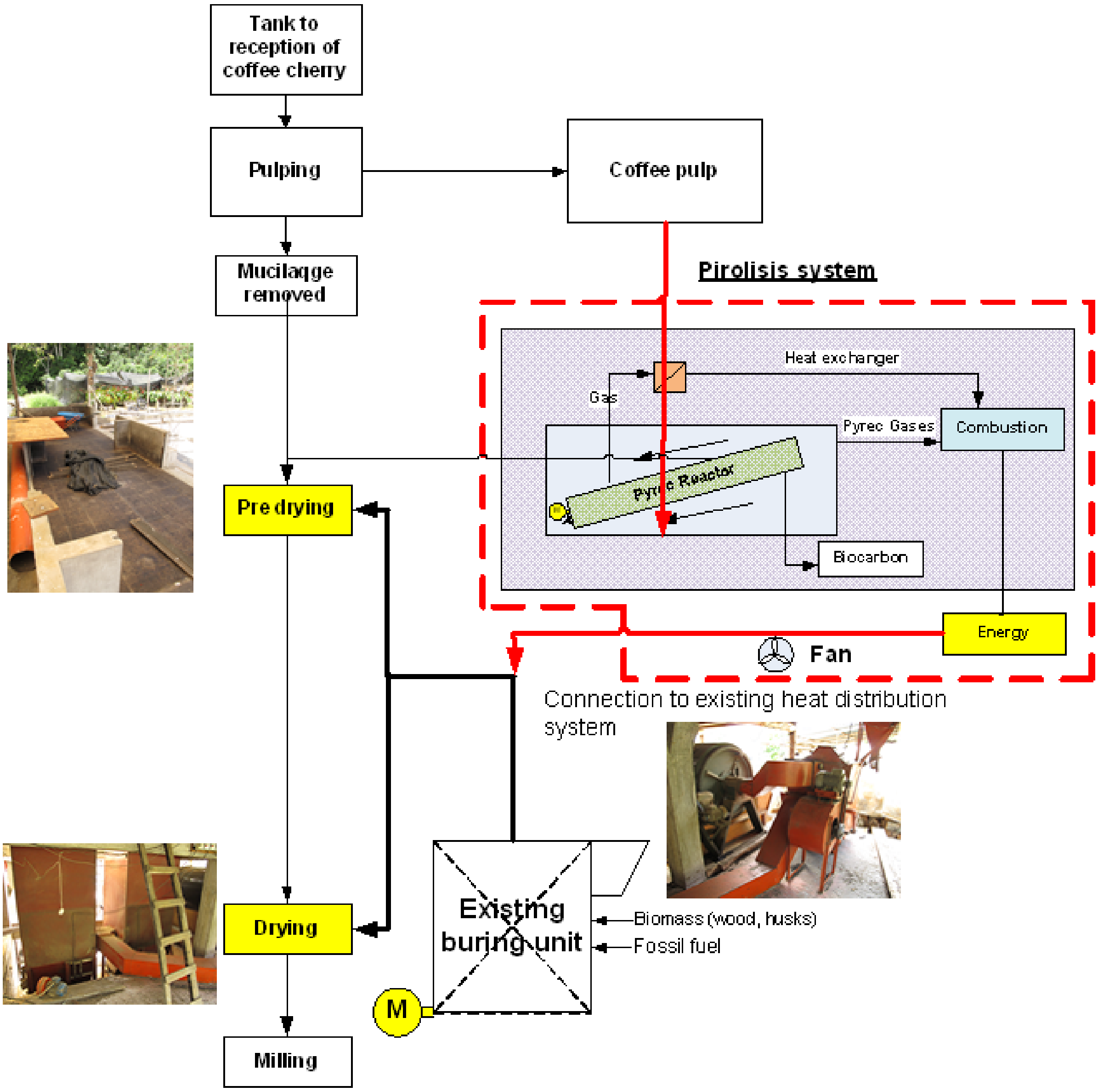

Figure 4 *Connection of the pyrolysis plant to the existing burning unit (wood, fossil fuel or coffee husks) as well to the existing pre-drying and drying process.*

For the time being CATSE states: “From technical and economical point of view, it seems to be feasible to operate mobile pyrolysis plants as a solution for the coffee pulp wastes highlands of Peru. Creating an environmental benefit without costs and while creating jobs”

2.2 Simplified biochar field tests

While there is abundance of information available on biochar and its effects on soil, there is little knowledge on its specific application and benefits in the coffee growing sector. As biochar is one of the main benefits of the pyrolysis plant it is important to estimate its effects on the coffee plant. More accurate data will facilitate acquisition of additional funding which is needed for the next step: Technology transfer and practical implementation (more information: see 2.3).

In consequence a plan for simplified biochar field tests was elaborated. Included but not limited to:

- define and finding a suitable sample field,
- conduct several analysis for: soil, fresh and dry pulp, and compost
- Production of biochar
- Activation of biochar with compost
- Actual insertion of the “nueva terra preta”
- Follow up and analysis of the results

One major challenge was the lack of biochar from a pyrolysis plant which was substituted by biochar produced with a handcrafted kiln. (see below)

Figure 5 *Simple Biochar production with a double cylinder oven*

2.3 Technology transfer and practical implementation

Often, projects are made with technology that is hard to understand and too difficult to repair, resulting in unavoidable failure over time. To avert this, a local “coffee processing machinery” company was involved and consulted. Before the final technical drawings will be created, a “technology transfer mission” with the key engineer, who is responsible for the fabrication of the plant, will be held. This will assure the local availability and understanding of the proposed technologies, materials and spare parts.

Subsequently the Swiss made pilot plant will be shipped to Peru and tested within the chosen coffee producer. Dissemination of the project results will be done through various well established channels. If the results are as expected there will be little challenges for commercialization through our local counterpart.

3 Conclusions

A mobile pyrolysis plant can decrease the need of traditional heat energy by 40-70%. With the byproduct biochar, a soil improver, the consumption of often scarce and expensive fertilizer can be reduced by 25-30%. The building cost of a mobile pyrolysis plant in Peru is around 15'000 USD. While this study/ project focuses on coffee pulp valorization in Peru, the technology can easily be adapted to other biomass and therefore has a high replication potential worldwide. A mobile pyrolysis plant is an innovative way to improve competiveness, productivity and resource efficiency while at the same time, minimizing the negative environmental impacts of the coffee production.

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