International Journal of Scientific & Engineering Research Volume 8, Issue 12, December-2017
ISSN 2229-5518

A Review on Pine Needle and Its Potential to Develop Energy

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Abstract

Pine trees cover large areas of the Kumaon Hills and are considered a threatening to cultivation and agriculture as well as the environment. Because during the summer season, pine needles continuously fall from the pine trees and most of the ground surface is covered by pine needles and pine cones. This leads to cause of uncontrolled forest fire and it also affect the wildlife and environment also. This review paper will discuss all the facts and uses of pine needles to generate energy via several methods. Proper utilization of pine leaves will contribute to the social growth of the people nearer to the It would also greatly reduce the risk of forest fires, and beneficial for our ecosystem.

Index Terms: Pine needles, Ecosystem, Forest fire, Pine cones.

Introduction

The Himalayan pine forests are mostly coniferous forests covering the land of India, Nepal, Pakistan and Bhutan. These pine forest covers for 3000 km across the lower elevations of the Himalaya range for almost its entire length and it also includes the parts of Pakistan's Punjab Province in the west through Azad Kashmir, Jammu and Kashmir, Uttarakhand and Sikkim, Nepal, Himachal Pradesh and Bhutan.

According to the Department of Renewable Energy Govt. of Uttarakhand the total area of Pine Forest in Uttarakhand is nearly about 3.43 Lakh Hectare. These Pine forests in Uttarakhand produce more than 20.58 lakhs tonnes of biomass which means every hectare produces 6 tons of pine needles

In the summer season, forest fires are very dangerous in these areas as pine needles have a needle shaped leaves and which keep falling off trees from the middle of March up-to the mid of July, and these are highly inflammable. Even a burnt cigarette carelessly thrown by stranger can cause fires that can burn the whole forest. These fires destroy the local ecology, damaging the fertile layer of the soil and destroy grazing grounds for cattle. Pine needles basically have a very low density and very low heating values so it is not practical to use them for heating and cooking purposes.

Fuel Analysis for Pine needles: Fuel analysis is basically used to check the availability of various elements in the fuel (pine needles). And it also used to check the thermal capacity of the fuel.

i. **Proximate analysis:** Proximate analysis indicates the amount of fixed carbon, ash, moisture and volatile matter in the fuel.

ii. **Ultimate analysis:** Ultimate analysis indicates the amount of percentage of various elements in the fuel such as carbon, hydrogen, oxygen, nitrogen, Sulphur. It is used to find the amount of air required for the combustion of fuel.

Biomass Gasification: Biomass gasification is the thermochemical conversion of solid biomass into combustible fuel in the presence of a low quantity of oxygen. Gasification process is generally carried out in a reactor called a gasifier, and it involves the conversion of carbonaceous fuel into combustible gases and liquid fuels for various applications. For example- running a gas engine and gas turbines, direct heating applications and fuel cells.

Gasification of pine leaves is a promising technology for thermal and power generation applications, biomass gasification has several technological barriers which restrict its commercialization. In engine operations, the producer gas becomes the alternative fuel for electricity generation and transportation also. It produces electricity and reduces the health hazard problems. It is essential to make modifications in the engine to get the benefit of the producer gas. The producer gas must have high gas purity, high

calorific value and very low tar content (< 100 mg/Nm3) and it doesn't contain ammonia and sulfur dioxide.

Further, the fuel characteristics of producer gas vary with the end uses, like gas reforming and engine applications for electricity generation and transportation. But, in general, the basic requirements of producer gas as a fuel remain the same. Much research related to producer gas through gasification has been carried out by researchers worldwide over the last few decades.

Gasification process: Biomass gasification occurs through a sequence of complex thermochemical reactions and hence, it is unrealistic to split the gasifier into different zones carrying out many gasification reactions simultaneously. The various stages involved in gasification process are

Drying zone or bunker section: In this process the moisture present in the biomass is removed with the help of heat transfer from combustion zone. Drying of biomass occurs at 100 ºC and takes place at bunker section. Moist feedstock + Heat → Dry feedstock + H2O

Pyrolysis: In this process the volatile matter are released and char is produced. This process occurs at 200 ºC - 300 ºC and determines the structure and composition of char.

Dry feedstock + Heat → Char + Volatiles

Partial oxidation or combustion zone: Residual char matrix or solid carbonised fuel is further burned producing more gaseous product where heterogeneous reaction take place as the following equation:

$$C + O = CO + 393.8 \text{ MJ/kmol}$$

Fuel-bound hydrogen reacts with air blast oxygen, producing steam

$$H + 1/2\ O = H\ O + 242 \text{ MJ/kmol.}$$

Reduction zone: Raw material is completely gasified using oxygen from the air and/or steam to form syngas through a series of reactions:

$C + CO_2 \rightarrow 2\ CO - 172.6$ kJ/g. mole (Boudourd reaction)

$C + H_2O \rightarrow CO + H_2 - 131.4$ kJ/g. mole (Water gas reaction)

$CO + H_2O \rightarrow CO_2 + H_2 + 42.3$ kJ/g. mole (Water gas shift reaction)

$C + 2H_2 \rightarrow CH_4 + 75$ kJ/g. mole (Hydrogasification reaction)

By Product: The byproduct of gasifier can be used to make briquettes that can be used for heating purposes. The simplest process to make a briquette is that the char is mixed with some binding material such as clay, rice husk, bagasse, etc. and then filled in briquetting mould of any shape and at last dried in sunlight.

Types of gasifier: Depending upon the shape and size, gasifier may be classified as fixed bed and fluidized bed gasifier. On the basis of flow direction of air/ oxygen with the gasifier, it is classified as downdraft, updraft and crossdraft gasifier.

I. **Fixed bed gasifier**: In a Fixed bed or moving bed type gasifier the gasifying agents or gas pass either up or down through a bed of solid fuel particles. They are the simplest type of gasifier consisting of a cylindrical vessel for fuel and gasifying agents, fuel feeding unit, ash collection unit and gas exit. These types of gasifiers are deigned to operate at moderate pressure conditions of 25–30 atm. They are highly affected by the formation of tar contents,

Downdraft or co-current gasifier: In downdraft gasifier, as clear from the name itself, air interacts with the solid biomass fuel in the downward direction which results in the movement of wastes and gases in the co-current direction and hence, these gasifiers are also called as co-current gasifiers.

Updraft or counter-current gasifier: In updraft gasifier, the gasifying agent such as, air, oxygen and steam are introduced at the bottom to interact with biomass and the combustible gases in counter current direction. The main advantages of updraft gasifiers are good thermal efficiency, small pressure drop and the slight tendency to slag formation. These gasifiers are suitable for the applications where the high flame temperature is required and a moderate amount of dust in the fuel gas are acceptable.

Crossdraft gasifier: Crossdraft gasifiers have certain advantages over updraft and downdraft gasifier but they are not of ideal type. In Crossdraft gasifier the fuel enters from top and the thermochemical reaction occurs as the fuel descends in the reactor. Here air enters from sides rather than from top or bottom. Its main advantages are fast response against the load, flexible gas producer, small start-up time, compatibility with dry air blast and have short design height. This type of gasifier is not capable of handling high tar content and very small fuel particles. It also produces high temperature fuel gases and has the poor reduction of carbon dioxide gas.

II. **Fluidized bed type gasifier:** Its principle is based on fluidization in which both the fuel and inert bed material behaves like a fluid. The basic concept of fluidized bed has been adopted to enhance the heat transfer between the fuel particles for better gasification process and therefore, a fluidized bed can operate under nearly isothermal conditions.

Gas cleaning: The high temperature gas generated during the gasification process contains a large amount of ash. Due to ash present in the gas there is a possibility of jamming the machine parts. The high temperature of this gas reduces the volumetric efficiency of IC engine, since at high temperature the density of gas is low so the engine aspirate less amount of air this leads to decrease in power output. Thus there is a need of proper cleaning and cooling of produced gas before its use. Dust filters can be used to prevent the entry of ash in the moving parts. In order to get proper cooling and cleaning of the gas more than one these type of systems are used in series.

Literature Survey

Sansaniwal et al. (2017): In the present study, various critical issues (technical and non-technical) related to subprocesses are discussed, such as biomass supply chain management, biomass pretreatment, gasification technology, syngas conditioning, power generation through gasification, environmental issues and other generic barriers

Chiodo et al. (2017): This study tells about the feasibility to produce hydrogen rich gas from citrus peel residue by steam gasification process. Thermodynamic evaluations were performed by simulation modelling thus preliminary experiment was carried out at 1023 K. The effect of different types of catalytic materials (minerals and synthetic catalyst) on steam gasification process was investigated in terms of efficiency, hydrogen formation tendency and outlet stream composition

Villetta et al. (2017): This work is a review of the most important models in the scientific literature applying the so-called stoichiometric method. The authors' aim is to discuss dedicated analyses regarding the effect of biomass moisture content, gasification equivalence ratio, pressure variations and oxygen enrichment on the quality of the produced syngas in particular in terms of lower heating value and cold gas efficiency. Essentially, almost all presented models show that: an increase of moisture content produces a decrease of lower heating value, due to a reduction of the CO yield that has a greater weight with respect to the increase of H2; an increase of equivalence ratio and pressure variations produce a decrease of lower heating value, due to the simultaneous decrease of CO and H2; an increase of oxygen enrichment produces an increase of lower heating value, due to the simultaneous increase of CO and H2. Analogous considerations are applicable the cold gas efficiency of the gasification process.

Ahm et al. (2016): This review focused on statistical independent component and regression analysis of BC(biochar) production technologies and physicochemical properties of different BCs. It was observed that raw woody materials were the best which possess essential BC physicochemical properties such as surface area and elemental composition. Other raw materials such as food waste and agricultural materials could also be potentially used for producing BCs with good physicoechemical properties. Some feedstocks such as pine shaving, pine needles, wood, wheat residues, and giant reed showed high surface area and carbon content at a pyrolysis temperature of 500 ºC. BCs produced through slow pyrolysis are widely used.

Sansaniwal et al. (2017): In this review article, the followings have been illustrated:

The present status of biomass gasifier with respect to the developing countries is reviewed. A comprehensive review on the design, development, and performance evaluation of various types of biomass gasifiers has been presented. Technological and commercial barriers in biomass gasification have been depicted. Techno-economic study of various types of biomass gasifiers has been demonstrated. Global scenario and future directions on biomass gasification have been illustrated.

Vassilev et al. (2017): Biomass has highly variable ash yields and contents of ash forming elements due to biodiversity and different composition and abundance of genetic classes of organic and inorganic matter in biomass varieties.

The ash yield of biomass (dry basis) varies in the interval of 0.1–67% (mean 7.2%) and normally shows much lower value than in coal. The mean ash yields for the biomass groups decrease in the order: animal and human biomass wastes > aquatic biomass > contaminated biomass and industrial biomass wastes > herbaceous and agricultural biomass > wood and woody biomass.

Bisht et al. (2014): This paper tells about the pine needle gasification technique that make decentralized power generation system in terms of improving the quality of life, which includes supply of hygienic drinking water, irrigation and supply of quality electricity for rural Himalayan regions. The generation of power is not the only benefit of this technology; it also contributes towards protecting the environment. The result is a two-pronged strategy of development where we can save the environment and the cost for this is itself paid by energy production.

Joshi et al. (2015): This paper may be summarized as to unearth and establish an implementable methodology between forest user and forest bioresidue resource management while achieving a much vital goal of climate change mitigation with economic empowerment of local communities through basic technological interventions.

Chauhan & Saini (2015): The present study encompasses the utilization of renewable energy sources for energy access in rural areas of Uttarakhand state. Availability of renewable energy resources in the state has been presented in the paper. Depending on the site conditions, various alternative technologies, working independently or aggregated mode, can be selected. A modelling method is also covered, involving a definite configuration of integrated resources entitled for rural electrification. Barriers and issues were discussed, that helps one to evaluate the parameters most susceptible to deviate during the implementation of integrated renewable energy system for off-grid applications.

Ismail & Salam (2017): This paper tells about the numerical simulation and experimental studies of different operating conditions of biomass gasification on the performance of an updraft gasifier high temperature air gasification (HTAG). The influence of gasification temperature and equivalence ratio (ER) on gas production and tar yield were examined. A mathematical model was used to simulate the effects of the parameters that influence the process of gasification.

Conclusions: This review paper concludes that pine needles have a tremendous energy. Proper utilization of these pine needles will greatly help to meet the energy shortage in a particular region. And this will surely raise the living standard of the people by giving job in these gasification plants. This also leads to save our forest and our ecosystem from forest fires. The byproduct of this gasification plant can be also used to make briquettes for heating purposes. So this is a technique to get dual energy from a single biomass.

References:

`1) World Wildlife Fund, Himalayan subtropical pine forests, online http://www.worldwildlife.org/ecoregions/im0301Himalayan subtropical pine forests

2) Online at www.gasifiers.org

3) Peter MK. Energy production from biomass (part gasification technologies. Bio resource Technol 2002;83:55–63.

4) Biomass to Energy – The Science and Technology of IISc Bio-Energy Systems, ABETS, Indian Institute of Science, Bangalore,

5) Kumar M, Sansaniwal SK, Khatak P. Progress in solar dryers for drying various commodities. Renew Sustain Energy Rev 2016;55:346–60.

6) Overend RP. Direct combustion of biomass. Renewable Energy sources charged with energy from the sun and originated from earth moon interaction. ⟨http:// www.eolss.net/sample-chapters/c08/e3-08-01-04.pdf)

7) Vyarawalla F, Parikh PP, Dak HC, Jain BC. Utilization of Biomass for Motive Power Generation - Gasifier Engine System. Biomass 1984;5:227–42.

8) Sudip Pandey Pine needle briquettes A renewable source of energy, IJES Volume 3 Issue 3, JUNE 2013

9) Yoon SJ, Son Y-I, Kim Y-K, Lee J-G. Gasification and power generation Characteristics of rice husk and rice husk pellet using a downdraft fixed-bed gasifier. Renew Energy 2012;42:163–7

10) A. Sett, S.C. Bhattacharya, Mathematical modeling of a fluidized bed charcoal gasifier, Appl. Energy 30 (1) (1988) 161–186.

11. R.N. Singh, U. Jena, J.B. Patel, A.M. Sharma, “Feasibility study of cashew nut shells as an open core gasifier feedstock,” vol. 31, 2006, pp. 481–487.