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PINE NEEDLE CHARCOAL BRIQUETTES: RURAL TECHNOLOGY OPTION IN PINE FOREST REGION

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Abstract: The use of fuel wood, crop residue or cow dung for cooking is widespread in rural India and, as it is not purchased, is often the only option for the rural poor. Besides the low calorific value of these residues, it also affects the health due to indoor air pollution. Briquette technology can reduce this rural problem. Moreover the technology can also prevent forest fires. They are the annual phenomenon in Himachal Pradesh as the forests are dense and catch fire easily due to natural and man-made reasons. Himalayan forests are rich in Pine trees (Pinus roxburghii Sarg.) and the pine needle is one of the reasons to enhance the forest fire. There is a necessity to handle this forest waste efficiently. This paper attempts to explain the briquetting technology of pine needles and the results showed that a significant improvement in calorific value.

Key words: *pine needles, charcoal briquetting technology, proximate analysis, calorific value, water boiling test.*

I. INTRODUCTION:

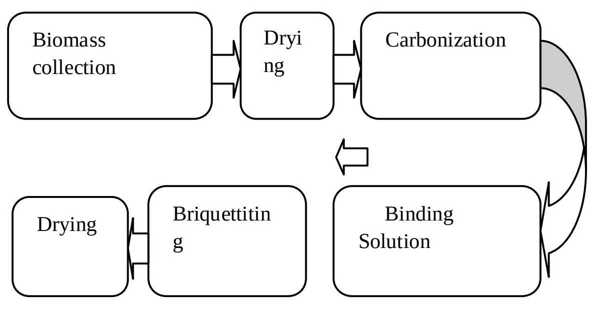
Most of the countries including India are dependent on fossil fuel energy supply. Its use is neither sustainable nor renewable. Excessive use of fossil fuels and conventional energy with their associated increase in CO2 emissions is creating detrimental effects to the climate and atmosphere. Of all the renewable energy sources which will ultimately displace the use of fossil fuels over time, the largest contribution, especially in the short to medium term, is expected to come from biomass [1]. Currently solid biomass represents 45% of primary renewable energy in OECD countries [2]. Its largest contribution is in developing countries meeting on average between a third and a fifth of their national primary energy demand compared with 3% on average in industrialized countries [3].

Cooking and heating dominate the traditional use of non-commercial biomass although this is not sustainable because the continued use of dung and fuel wood will deprive local soils of needed nutrients. In developing countries, traditional biomass remains the main source of energy. Several countries particularly in Africa (e.g. Kenya) and Asia (e.g. Nepal) derive over 90% of their primary energy supply for cooking and heating from firewood and dung. In India, the rural population does not have access to reliable energy. The main source of energy for this section of the society is the use of firewood. The people living in rural areas burn firewood inefficiently (mainly for cooking), releases harmful black smoke resulting in indoor and outdoor air pollution, and poor health. Millions of tons of biomass gets generated from forest residues especially pine needles in himachal Pradesh [4]. These pine needles can cause lot of damage to the environment if not removed due to its highly inflammable nature and they often become the cause for forest fires in the Himalayan forests. Pine tree trunk is heat resistant [4, 5] hence, in case of a forest fire pine trees survive the fire but in the process destroy the growth of other plant species whose produce provide sustenance to villagers and thus also disturb the ecological balance of the region. Additionally, dry pine foliage stops water from being absorbed by the soil and thus causes the depletion of ground water table [4]. Furthermore, fallen dry pine foliage acts like a carpet on the forest floor and blocks the sunshine reaching ground and thereby stops the growth of grass which the cattle feed upon. Although dry pine needles and other forest.

II. CHARCOAL BRIQUETTING:

Biomass briquetting is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes. The biomass charcoal briquetting technology developed at MCRC [6] uses the modified kiln and a briquetting machine that can fabricate locally to produce bio-char from various biomass samples. The technology involves use of a cost effective binder to prepare the briquettes.

Biomass charcoal Briquetting process:



Experimental

2. MATERIAL AND METHOD:

Sample collect were pine needle (Pinus roxburghii) from Hamirpur district, himachal Pradesh India.

Preparation of the biomass:
The biomass collected were air dried for ten days to reduce moisture content of the material. The material cut into small pieces (2mm-size). These materials were than processed for the determination their proximate analysis in chemistry department of the NIT Hamirpur.

Proximate Analysis of the Material:
The moisture content, ash, volatile matter, and fixed carbon of the pine needles were determined by using standard method ASTM D-3173. The calorific value of pine needles and briquette samples was determined using microprocessor bomb calorimeter of model CC01/M3.

Preparation of the briquette samples:
Material required: forest wastes (pine needles), binding materials (brown clay and rice starch), Charcoal kiln/drum and Briquetting mould/machine.

Carbonization: For carbonization, loosely pack the collected biomass into the kiln. The kiln will accommodate ~100kg dry biomass. After loading the biomass into the kiln close top of the kiln with metal lid attached to a conical chimney. Use little amount of biomass in the firing portion to ignite in the kiln and close the doors tightly and fired for 45 minutes to1hr (depending upon the biomass) using biomass [6]. In the absence of air, the burning process is slow and the fire slowly spreads to the biomass though the hole in the perforated sheets. In this method 30 % of carbonized char can be obtained [6].

Fig1: Carbonizer drum

Table 1: Time cycle of one batch carbonization

Process duration	
Loading	30 minutes
carbonization	60 minutes
Cooling	5 hours
Unloading	30 minutes
Total processing time	7 hours

Binder preparation and mixing: A binder is used for strengthening the briquettes. The carbonized char powder can be mixed with different binders (100 kg of char +5kg of starch) such as commercial starch, rice powder, rice starch (rice boiled water) and other cost effective materials like brown clay soil. Binder mixed with water and boiled for 20 minutes [6]. After boiling the liquid solution is poured into char powder and mixed to ensure that every particle of carbonized charcoal material is coated with binders. It enhances charcoal adhesion and produce identical briquettes.

Fig2: Binder preparation and carbonized charcoal mixed with the binder

Briquettes: The charcoal mixture is made into briquettes either manually or using machines. Pour the mixture directly into the briquetting mould/ machine to form uniform sized cylindrical briquettes.

Fig3: Briquette samples

Table 2: Char and binder material used in biocoal briquettes

sample	char	Binding material
S1	1kg	500g clay
S2	1kg	333g clay
S3	1kg	50g rice starch + 100g clay
S4	1kg	50g starch

Characterization of the samples:
Ignition time: Each briquette sample was ignited at the base in a drought free corner. The time required for the flame to ignite the briquette was recorded as the ignition time using stop watch.

Water Boiling Test: This was carried out to compare the cooking efficiency of the briquettes. It measured the time taken for each set of briquettes to boil an equal volume of water under similar conditions. 185g of each briquette sample was used to boil one Liter of water using small stainless cup and domestic briquette stove [7]. During this test, other fuel properties of the briquettes like burning rate and Specific fuel consumption was also determined. Also, the level of smoke evolution was observed. Burning rate is the ratio of the mass of the fuel burnt (in grams) to the total time taken (in minute).
Burning rate = Mass of fuel consumed (g) / Total time taken (min.)……………………………….. (1)
The specific fuel consumption indicates the ratio of the mass of fuel consumed (in grams) to the quantity of boiling water (in liter).
Specific fuel consumption = Mass of fuel consumed (g) / total mass of boiling water (liter)………….. (2)
Efficiency of the briquette was calculated from the formula:

Table 3: The result of proximate analysis of raw material (pine needle) and biocoal briquette samples

Sample	Pine needle	S1	S2	S3	S4
Moisture content (%)	11.98	6.2	5.9	5.1	4.6
Ash content (%)	5.4	32.6	29.3	19.2	15.2
Volatile matter (%)	67.07	50.7	55.4	67.41	73.21
Fixed carbon (%)	15.55	10.5	9.4	8.29	6.99
Calorific value (kcal/kg)	4811	4970	5687	6343	6447

The result of ignition time in fig.4 showed that the ignition time of the briquettes decrease with increase in biomass concentration. The biomass charcoal briquette sample S1took the longest time to ignite 430.00 second. It results in greater use of ignition material and consequently more smoke. But with incorporation of biomass, the ignition time dropped progressively. The ignition time of biomass charcoal Briquette using starch as a binding material was shorten than that of biomass charcoal briquette using clay as a binding material.

$$\square = M_{w.i} \text{ X } C_{p.w} \text{ X } (Te-Ti) + M_{w.evap} \text{ X } H_l / M_f \text{ X } h_f \quad \ldots\ldots (3)$$

Where,
h_f - calorific value of fuel, kj/kg.
M_f - mass of fuel burned, kg.
$M_{w.i}$ - initial mass of water in the cooking vessel, kg.
Ti - initial temperature of water in ºC
Te - temperature of boiling water in ºC
$M_{w.evap}$ - mass of water evaporated, kg.
H_l - latent heat of evaporated at 100 ºC in kj/kg.
$C_{p.w}$ - specific heat of water, kj/kg ºC

III. RESULTS AND DISCUSSION

The results of proximate analyses of the pine needle and biomass charcoal briquettes are shown in table 3. From the results, it is clearly show that the biomass charcoal briquette sample S4 using starch as a binder has higher calorific value (6447kcal/kg) low Ash content (15.2%) and high volatile matter (73.21%) than biomass charcoal briquette samples using clay as a binder. The briquette sample S1 has high ash content .the high ash content of sample S1 is an indication that it contains more mineral (non combustible) matters.

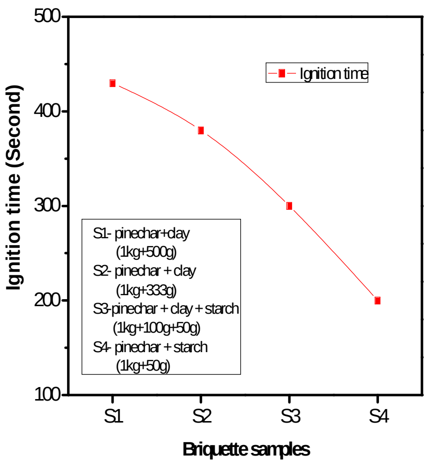


Fig 4: The effect of binding material consentration on the ignition time of briquettes

Fig 5-6 show the result of the parameters determined during the water boiling test. Briquette using clay as a binder takes more time for water boiling than briquette using starch as a binder. The reason is the higher percentage of clay than starch in Briquettes and the non-combustible character of the clay in comparison to the starch. Clay is mineral matter, does not burn. This can result in problems with cooking and fire extinction, as it blocks the stove's air ventilation. The stove needs to be shacked often in order to clean it. The briquette sample S1 took longest time to boil water (45 min) while the sample S4 took the shortest time (30 min) .The burning time of briquette using starch as a binder more than briquette using clay as a binder.

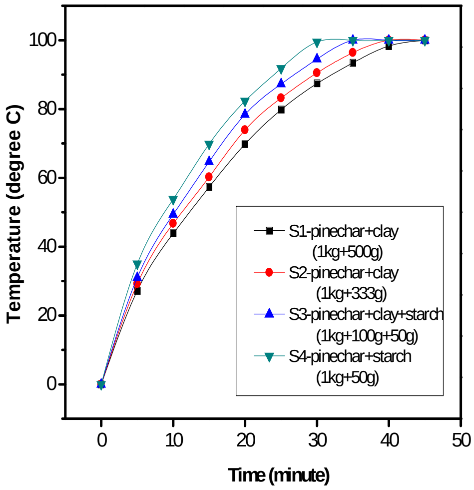


Fig 5: Temperature evaluation during the high power phase-cold start of the water boiling test for different briquette samples

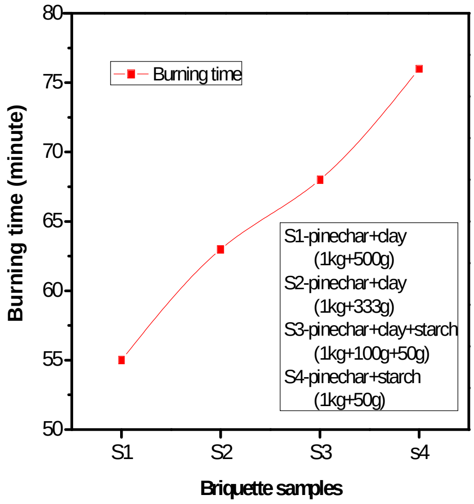


Fig 6: The effect of binding material consentration on the burning time of briquettes

Table 4: Some fuel characteristics during the boiling phase

Sample	Burning rate (g/minute)	Specific fuel consumption (g/liter)	Efficiency of briquette (%)
S1	2.5	170	29
S2	3.0	155	30
S3	6.7	110	35
S4	10.3	100	38

Burning rate indicate the mass of fuel burned per minute during the boiling phase. The specific consumption indicates the mass of fuel required to produce one liter of boiling water. Table 4 describes fuel characteristics of biocoal briquettes during water boiling test. As a result of the comparison of both characteristics for the 4 tested biocoal briquette samples, we can say that Biocoal briquettes made with starch burns faster and are more efficient than biocoal briquettes made with clay. Briquette sample S4 burn and boil water faster and less quantity (100g/liter) of them were required to produce one liter of boiling water compared to other briquette samples .the briquette sample S4 has the higher efficiency (38%) than other biocoal briquette samples. On the other hand, briquette sample S1 has the least cooking efficiency (29%). It burns slowly without flame, took the longest time to boil the water and much quantity (170g/liter) of it was needed to boil water. This is because of the fact that the briquette burns slowly, as a result, lots of the heat released was lost before the water boils. The burning rate (how fast the fuel burns) and the caloric value (how much heat released) are two combined factors that controlled the water boiling time. This explained why sample S4 was able to boil water and burn faster than other Samples. This means that the calorific value alone is not a single factor controlling cooking efficiency but burning rate is equally important.

IV. CONCLUSIONS:

The biomass resource is abundant in many countries and is based primarily on organic waste products including forest waste. Utilization of Pine needle is crucial in preventing forest fire. Briquette technology is one step towards utilization. The biomass briquettes bonded with starch are very efficient compared to biomass briquette bonded with clay. The efficiency depends on its ability to: ignite easily without any danger, generate less smoke, high calorific value, generate less ash as this will constitute nuisance during cooking and to be strong enough for safe transportation and storage. The technology has a great potential for converting waste biomass into a superior fuel for household use, in an affordable, efficient and environment friendly manner.

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