EXPERIMENTAL ANALYSIS OF PERFORMANCE OF PINE NEEDLE GASIFIER

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Abstract: This entire work is deal with the analysis of pine needle gasifier performance on the bases of experimental results. It begins with an analysis of dry pine needle as an alternative fuel; e.g. its distribution, composition, caloric value etc., and as processes attractive place with the biomass gasification. To Experimental analysis of performance of pine gasifier by using dry pine needles used as a biomass in downdraft gasifier for power generation. In the present study on the effect of gasifier responses are ER and CV has been investigated for pine needle downdraft gasifier. The experiments were conducted under various parameters setting of Air flow rate (m^3/h), initial moisture content, biomass consumption rate (kg/h). L-9 array based on Taguchi Design was performing intended by Minitab software is used for analysis the result and their responses were moderately validated experimentally.

Keywords: Equivalent ratio (ER), Calorific Value (CV), pine needle, biomass, gasification, producer gas.

1. Introduction

In India forest fire in summer days is a familiar problem in all Himalayas region like in Uttrakhand, which cause global warming, air pollution, harm of biodiversity and also troubling the ecological unit. The main cause of uncontrolled fire is forest residue such as dry grass, tree's leafs, bamboos plants and above the shivalik range of mountains i.e.[3] middle and the great Himalayas the main cause of forest fire is dry pine needles, this type of forest residue have a high calorific value which enhances it to a rapid burning. away of all these forest residue the pine needle are the major cause of forest fire in Himalayan region, as we seen in past some days, the Himalayas forest regions are come under the fire in the period of April to august, and govt takes action to stop this fire by taking help of helicopters and army which is an expansive process and this action is just stop it for once only, we need to find a permanent solution of this problem. In the entire subtropical pine forest cover across the Himalayan ranges, pine needles are identified as major source for forest fire, causing massive threat to Environment, jungle Biodiversity and narrow Economy. Pine Needle (dry leafs) cause major risk to environment, forest biodiversity and local economy in entire Himalayan Region due to their non biodegradable and highly ignitable in nature. In this work, we propose to address the challenge of utilizing pine needles for social benefit by generating power which can be used as fuel for domestic/industrial level for electricity generation purposes.

1.1 Factors for electricity Generation Using Dry Pine Needles.

The present study is focusing on use of locally available biomass save, for example, dry pine needles (pirul) for decentralized force era utilizing biomass gasification transmit. Some primary warm properties of dry pine needle (pirul) are given in the accompanying table 1.

Table 1 Thermal Properties of Dry Pine Needle [11]

	Ash contents%	Volatile matter %	Fixed carbon %	Calorific Value (kCal/kg)
Pine needle	5.4	67.07	15.55	4811

Table 2 compares the ultimate analysis highlights the different elemental and chemical constituent such as Carbon, Hydrogen, Oxygen and Nitrogen etc. It play vital role in examined the quantity of air needed for combustion and the volume and composition of the combustion gases.

Table 2 Ultimate analysis of pine needles

Ultimate analysis (% by wt. dry basis)			
Carbon	Hydrogen	Oxygen	Nitrogen
50.54	7.08	41.11	0.15

1. Gasification Technology

Pine needle gasification includes the thermo substance transformation to the carbon material. The reactor, normally known as a gasifier, cleaved and dried pirul experience pyrolysis, oxidation and lessening responses at the overabundance of temperatures with a constrained and controlled supply of air, bringing about a blend of burnable gasses known as syngas (carbon monoxide, hydrogen and methane). The downdraft gasifier has four separate response zones: Drying, Pyrolysis, Oxidation, Reduction.

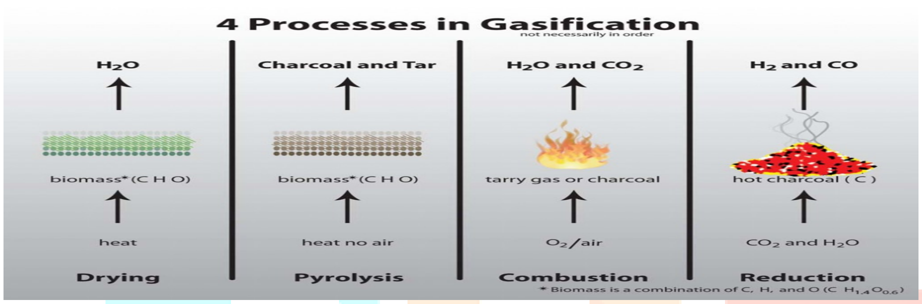

Fig 1 Different gasification processes [47]

A few of the major chemical reactions involved in this step are listed below [3, 4]:

Exothermic Reactions:

(1) Combustion	{biomass volatiles or char} + O_2	→	CO_2
(2) Partial Oxidation	{biomass volatiles or char} + O_2	→	CO
(3) Methanation	{biomass volatiles or char} + H_2	→	CH_4
(4) Water-Gas Shift	CO + H_2O	→	$CO_2 + H_2$
(5) CO Methanation	CO + $3H_2$	→	$CH_4 + H_2O$

Endothermic Reactions:

(6) Steam-Carbon reaction	{biomass volatiles or char} + H_2O	→	CO + H_2
(7) Boudouard reaction	{biomass volatiles or char} + CO_2	→	2CO

Experimental Set Up.

In this test the entire work done by a downdraft gasifier and 9 kW and an I.C motor is utilized for power generation as a part of Avani Bio Energy, Barinag, Distt-Pithoragarh. Analyses are completed with the dry pine needles (pirul) as a feedstock material utilized as a part of the downdraft gasifier for gasification. The syngas produced in pine gasifier utilizing pirul can be straightforwardly blazed in the furnace with a controlled overheating condition. This analysis is significant to choose the workplace of downdraft biomass gasifiers

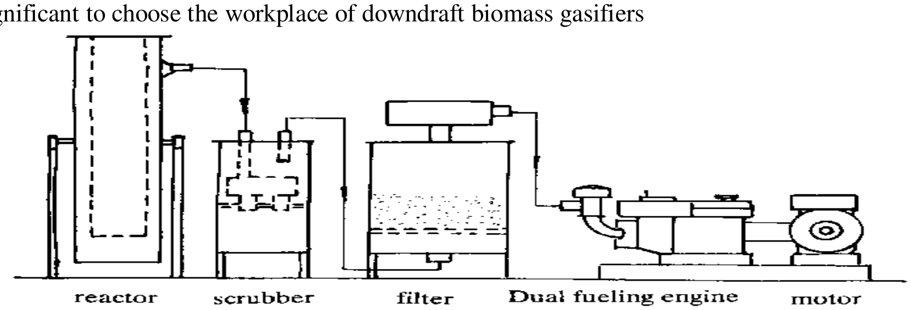

Fig. 2 Line diagram of downdraft gasifier [22].

3.1 Producer Gas Analyser

Syngas analysers is a contraption utilized for acquiring the individual structure of maker gas stream and give live values This gear is utilized as an electro-synthetic sensor, identifying O_2; infra-red finder, CO, CH_4 and CO_2; warm conductivity locator, H_2. The temperature scope of working is from - 30 °C to 37.77 °C. The syngas analyser is fitted with a presentation board which is given in Figure 3. Results got from the investigation are the normal qualities more than 5 min interim acquired each for five interims. The normal quality deals with the distinction are regarding time. The specimen gas is broke down by gas chromatograph named (NUCON 5765) with warmth conductivity indicator uncovered in fig 4. Every single exploratory run are secured in 10 min.

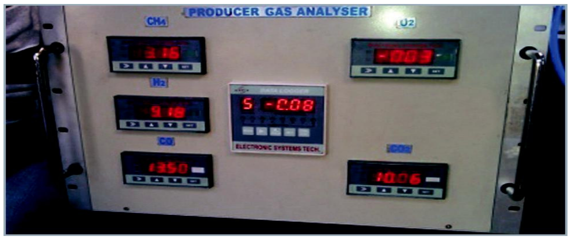

Fig. 3 Gas analyzer.

Fig. 4 Portable combustion analyser

3.1.1 Mechanism for finding Equivalent Ratio (ER)

An equivalence ratio is defined to reflect the mutual effect of air flow rate, rate of biomass supply and duration of the run. The ER for all run is calculated by Equation 1.

ER= (air flow rate/biomass consumption rate) / (air flow rate/biomass consumption rate for complete combustion) ……..1

3.1.2 Mechanism of CV

Calorific Value (CV) is defined as the amount of energy liberated by complete combustion of unit quantity of fuel or any materials. Unit of calorific value is Joule per kg (J/kg). The CV is given by the below mention equation .2.

$$CV\ (Kj/Nm^3) = 4.2\ (30\ CO + 25.7\ H_2 + 85.4\ CH_4 + 151.3\ C_nH_m) \quad \ldots\ldots\ldots\ldots 2$$

2. Taguchi Design Experiments In MINITAB

The product utilized for examination as a part of this anticipates is Minitab. MINITAB work for both static and element reaction tests, in a static reaction tests and the component nature of interest has an altered level The target of intense experimentation is to locate an ideal stage of control variable setting that accomplishes durability not for commotion elements. It investigations and makes reaction tables and assesses fundamental impacts and communication plots for, Signal to commotion proportions (S/N proportion) versus control variables. A Taguchi outline additionally called as orthogonal cluster the strategy is planning the investigational method utilizing different kind of configuration like, 2, 3, 4, 5, furthermore for blend level. This study having 4-elements and 3-level setup is chosen with a sum of 9 keeps running of trials to be behavior and therefore the orthogonal exhibit L9 was favoured.

The levels of test parameters are Air stream rate, beginning dampness substance and bio mass utilization rate are uncovered in Table 3 and the configuration grid is portrayed in Table 3.

Table3 Reactor Parameter and Their Level

Name	Units	LEVEL	L1	L2	L3
Air flow rate	(m^3/h)	3	9.11	13.27	14.32
Initial moisture content	-	3	0.04	0.08	0.1
Bio mass consumption rate	(kg/h)	3	7.89	10.06	11.36

3. Observation of Results

The reaction of ER and CV as per the information parameters and section data sheet are covered in Table 4. Which is acquired by record variant 9.0.2.0, and having factorial sort study. No square framework is utilized as a part of the takes after perception.

Table 4 Final (Calculated) Value of ER and CV

		Factor 1	Factor 2	Factor 3	Response 1	Response 2
Run	Std	Air flow rate (m^3/h)	Initial moisture content	Bio mass consumption rate (kg/h)	Equivalent ratio	Calorific value
1	7	9.11	0.04	7.89	0.251	8.97
2	3	9.11	0.08	10.06	0.196	7.11
3	9	9.11	0.1	11.36	0.174	6.36
4	2	13.27	0.04	10.06	0.286	5.35
5	8	13.27	0.08	11.36	0.253	9.00
6	1	13.27	0.1	7.89	0.265	7.03
7	4	14.32	0.04	11.36	0.276	5.72
8	6	14.32	0.08	7.89	0.284	5.30
9	5	14.32	0.1	10.06	0.209	7.80

The analysis of variances for S/N ratio for ER is shown in Fig. 5 which is noticeably indicates that all the factors influence the ER. The regression equation for ER is,

ER^0.5 = 0.5239 + 0.01144 air flow - 0.918 moisture - 0.01069 biomass

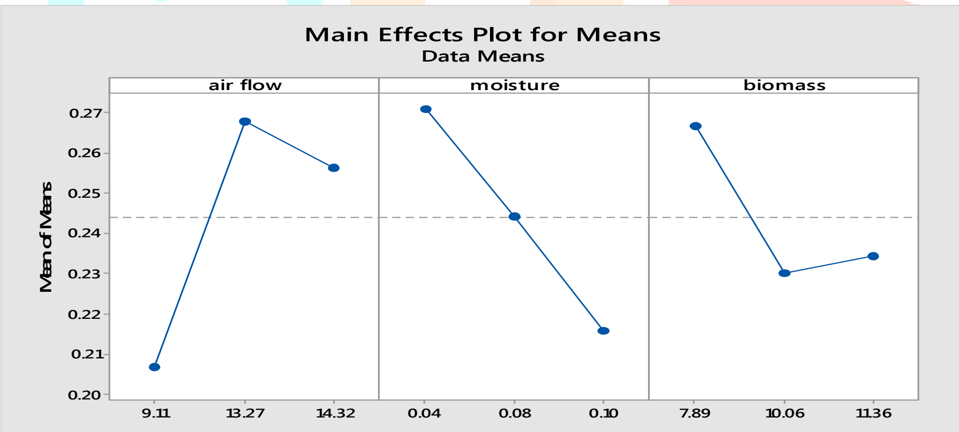

Fig. 5. Main Effect Plots for Means (ER)

The analysis of variances for S/N ratio for CV is shown in Fig. 4 which is clearly indicates that all the factors influence the CV. The regression equation for CV is,

CV^0.5 = 3.017 - 0.0369 air flow + 1.59 moisture - 0.0058 biomass

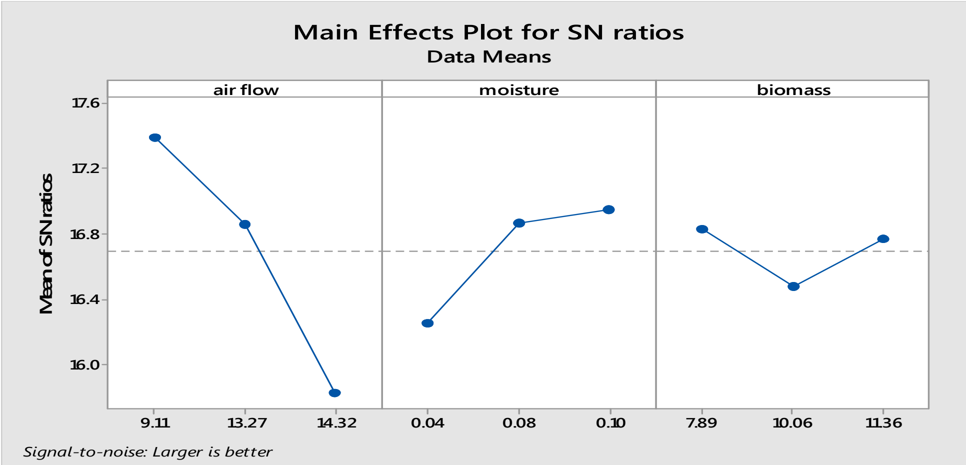

Figure 4 Main Effect Plots for S/N Ratios (CV)

4. CONCLUSION

- Finding the result of ER air flow rate is most influencing factor and then initial moisture third is Biomass consumption. In the case of CV air flow rate is most influencing factor and then initial moisture third is Biomass consumption as shown in Fig. 5.

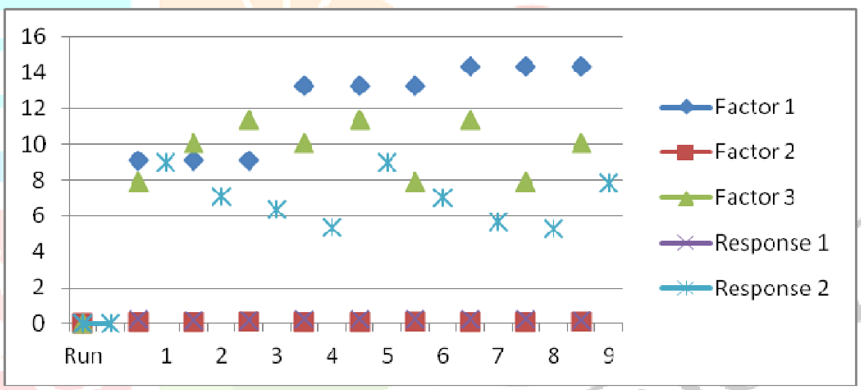

Fig. 5 ER and CV air flow rate is most influencing factor.

- Finding the result of ER Air flow rate is most influencing factor and then initial moisture and, the last biomass consumption rate. ER increased with the Air flow rate and the moisture contents extended, the ER decreases but for biomass consumption is decreases till 10.00 and after that it increases to 11.50 Kg.
- In the case of CV the most important factor is Air flow rate then initial moisture and, the last biomass consumption rate. It means biomass consumption rate affects it very less. For the value of air flow rate CV decreases continuously. But for moisture contents it increases for the value of 0.04 to 0.10. Where as in case of biomass the value of CV is first decrease and after the value of 10.06 it starts increase.

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