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Adaptation and Performance Evaluation of Updraft Biomass Gasifier Stove with Sawdust as Fuel

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Abstract: This study aims to adapt and evaluate an updraft biomass gasifier stove using sawdust biomass. It was a cylindrical gasifier having a diameter of 32.5cm*40cm height and a rectangular box-like base that served as a set and had a primary air hole of 20cm*6cm sliding type door. Fuels made from renewable biomass might easily take the place of fossil fuels in a variety of energy-using applications with favorable environmental effects. Gasification is a method of converting biomass energy into a fuel that potentially replace fossil fuels in the production of high-efficiency electricity. The future of energy is looking promising for biomass energy as one of the most important renewable energy sources. This work has been carried out to adapt, construct, and test an applicable biomass gasifier stove. This is for producing producer gas from locally available biomass fuel. The gasifier was constructed and tested on Water Boiling Test (WBT). The test was run using sawdust as feeding fuel. Various factors, including primary and secondary air inlets, operation, fuel type, and manufacturing materials and techniques, were presented and assessed. The updraft gasifier stove was evaluated at a biomass feeding rate of 0.5kg per batch. The results obtained from this study show a combustion efficiency of 84.2% and a thermal efficiency of 30.6% respectively. Therefore, the outcome could offer contemporary energy services for necessities and useful uses.

Keywords: Ash, Biomass Fuels, Construction, Fuel Efficiency, Gasification, Updraft Gasifier

1. Introduction

Solid fuels are transformed into gas through a process called micro gasification in gasifiers that are tiny enough to fit beneath a cooking pot at a comfortable height. The first practical micro-gasifier cook burner became available in 2003 in accordance with the hypothesis [1]. Thus, gasifiers are equipment that enables the thermochemical conversion of solid fuel to gaseous fuel. Drying at a temperature greater than 100°C, Pyrolysis at a temperature greater than 300°C, and combustion of wood gas are all steps in this process [2]. When fossil fuels were hard to come by in Europe during the Second World War, the concept of gasification became particularly important. However, when fuel availability became too commonplace, research and development drastically decreased [3].

The majority of advancements in biomass stoves have been centered on intuitive methods to look at factors of heat transport, pushing the combustion concerns to the sidelines [1]. In this instance, integrating simulation into the design phase offers a solution. A simulation-based design increases precision and reduces the expense of making numerous prototypes [4]. Without measurements, it is difficult to forecast how a cook stove will function. Testing is, therefore, a crucial tool for any designer to use when creating solutions and estimating any negative effects on the environment, human health, and the economy [5].

A water boiling test (WBT) is used to evaluate a stove's performance in terms of its thermal efficiency, emissions, particular fuel consumption, firepower, and safety [6]. Because they pose serious health risks, Carbon Monoxide and Particulate Matter are among the dangerous indoor air pollutants that should be minimized. [7]. A rough estimate of the percentage of the fuel's overall energy output that is used to heat the water pot is known as thermal efficiency. The majority of biomass-based stoves have extremely low usage efficiencies, ranging from 10 to 20% [8].

As previously mentioned, the developed experimental cook stove was evaluated using the Water Boiling Test. However, it's crucial to remember that there are additional tests, such as controlled cooking tests and kitchen performance tests. Three phases make up WBT: a cold start high-power phase, a hot start high-power phase, and a simmering low-power phase. There are numerous measurements and calculations for each stage. [2].

For the numerous varieties of dishes served all over the world, various cooking techniques, such as simmering and heat levels, are required. Cooks alter the fuel or air supply to the fire to alter how hot it becomes [6]. One stove may be used to prepare a variety of dishes thanks to design characteristics that make air adjustment simple. But fluctuations in airflow may influence each of the following: the pace of fuel combustion, thermal efficiency, and the amount of combustion. As a result, performance and user advantages must be balanced. Depending on the location of the fire, a cook stove's air supply is commonly divided into two modes [9]. The combustion region is instantly flooded with primary air, which reacts with the fuel there. The fuel aperture is where primary air enters rocket burners [10]. Some stoves include input ports on the base of the stove, underneath the fuel, allowing oxygen to be delivered to the bed of burning charcoal residue while being prepared before entering the combustion zone. Secondary air is fed into the stove after the combustion area to provide oxygen to the generating gas for the reaction [11].

Ethiopia is one of the developing nations with limited access to clean energy sources, but because of the advantages it provides to both users and the general public, biomass gasifier stove technology may be a part of the answer. It is an excellent alternative to an LPG stove, especially in terms of fuel savings and flame quality [12]. will also aid in reducing environmental pollution, particularly that caused by waste dumped along river banks and burned on roadsides [13], Additionally, it will help lessen airborne emissions of carbon dioxide, carbon monoxide, and particulate matter brought on by the excessive burning of wood and other biomass fuel in conventional cookstoves. This excessive burning destroys the ozone layer, which in turn causes the "GHG effect" in the atmosphere [14], In addition, by reducing the need to cut down trees for the production of wood fuel and wood charcoal, it will help manage the forest by reducing concerns with summertime dryness and wintertime flooding.

Gasifier stoves that burn wood have been created in the US, China, India, and other underdeveloped Asian countries. These gasifier stoves, like Teri gasifiers and Philips Wood stoves, produce flammable gas by burning the fuel with little to no air [15].

For forced draft cook stoves to work effectively, design factors such as airflow rates, reactor diameter, and reactor height are critical. The diameter of the reactor has a significant impact on the power output of the stove; hence, the larger the reactor's diameter, the more energy the stove can produce. Additionally, since gas production is a function of the gasification rate (measured in kilograms of fuel burned per unit of time) and reactor area, more fuel should be burned per unit of time [10]. The total running time to create gas is also influenced by the reactor's height. Finally, the size of the air intake is influenced by the size of the reactor. The greater the reactor's diameter, the more airflow is needed. The higher the reactor, the more pressure is needed to overcome the fuel's resistance [16].

Practically any carbonaceous or biomass fuel may be gasified in a laboratory or experimental context. A fuel evaluation is necessary to determine the fuel's moisture content, carbon content, volatile material, heat energy calorific value, and ash content. For this study, the homogeneity criteria were accomplished by using sawdust pellets with a diameter of 2 to 10 mm and a length of less than 40 mm. The goal of this work was to develop and evaluate a gasifier stove that uses sawdust biomass as a feedstock instead of softwood as a potential alternative fuel source for home fuel consumption.

2. Materials and Method

2.1. Description of the Study Area

The experiment was carried out at the Bako Agricultural Engineering Research Center (BAERC), located 250 kilometers west of Ethiopia's capital Addis Abeba. Its precise location is at 9°06'N latitude, 37°09'E longitude, and 1650 m above mean sea level. According to Ethiopia's central statistical office (CSA), the city had a total population of roughly 184,925 in 2017 G C.

2.2. Materials

Materials and equipment utilized in this experiment include:

1. A wood gas stove made at a BAERC workshop and made of mild steel.
2. Domestically produced three-stone cooking stove (TSCS).
3. A metal cooking pot that was bought at a market.
4. Stopwatch.
5. An IR thermometer.
6. An electronic thermometer (±0.5).
7. K-type thermocouple.
8. Digital scale (5 kg, ± 1 gram precision).
9. Hygrometer (10% to 90% air relative humidity).
10. Woodchip fuel.

2.3. Description of Sawdust Gasifier Stoves

The BAERC workshop created the sawdust gasifier stove with an updraft (figure 1). The gasifier stove featured a single combustion chamber and was built with two cylinders. The outer cylinder is open at both ends, and the cylinder set box has a sliding door and ventilation holes at the bottom of the cylinder. A combustion chamber is created when the inner cylinder's two ends open. It nestles inside the outer cylinder.

The perforated sheet or grate serves as its support, while the bottom air box serves as its base. This cylinder's top end is punctured with a ring of ventilation holes. The size of the top cylinder, which is only a little smaller than the outer cylinder, is decreased to form a cap for the inner and outer cylinders. This cylinder's upper end has a ring of ventilation holes punched into it for airflow. The top cylinder, which is only slightly smaller than the outer cylinder, is shrunk in size to form a cap for the inner and outer cylinders. The cap contains a riser to increase the efficiency of producer gas combustion and a hole that is about the same diameter as the inner cylinder. The hole, however supported by the upper lip of the combustion chamber, was large enough not to obstruct the passage of heat up through the top of the chamber. The pot seat was supported by the cap.

Figure 1. Main Components of a Stove.

Sawdust At the base of the grate, there is unburned fuel. An additional layer of charcoal was produced when the fuel charge was burnt. Above the layer of charcoal was the flaming pyrolysis. The principal air used in the pyrolysis process entered the bottom of the outer cylinder through holes punched therein, traveled up, and formed gases in the burning pyrolysis zone. In addition to main air passing through the combustion chamber's inner and outer cylinders as well as through holes drilled onto the top of the combustion chamber above the charcoal zone, secondary air was also employed to ignite the pyrolysis gas.

2.4. Design Calculation

The BAERC's workshop served as the design and manufacturing location for the updraft biomass gasifier stove. If necessary, we have created a cylinder-shaped biomass gasifier with a ring-shaped combustion chamber. The size of the combustion chamber, which penetrated the whole stove, was determined using the formula.

$$A_c = \pi r_c h \quad (1)$$

where A_c denoted the combustion chamber's surface area, r_c denoted its radius, and h denoted the height of the cylinder-shaped combustion chamber. Consequently, the combustion chamber had a 0.4082m^2 area. The circumference of the region that the hot gasses flow through was used to calculate the combustion chamber gap required at the edge. This measurement was made by measuring the distance between the combustion chamber outlet's center and its farthest edge (rc). By applying the formula, one can calculate the circumference that corresponds to this distance.

$$C_c = 2 * \pi * r_c \quad (2)$$

Where, C_c= combustion chamber radii are measured. Cc=1.021m was the combustion chamber's circumference as a result. The distance between the bottom of the pot and the top edge of the combustion chamber is then calculated by dividing the cross-sectional area, Ac, given by equation (1) by the Cc found by equation (2). This was $G_c = \frac{A_c}{C_c}$ Where Gc, in this instance, is the required distance between the circle of our pot and the top edge of the combustion chamber.

$$C_p = 2 * \pi * r_p \text{ and } G_p = {A_c}/{C_p} \quad (3)$$

where Cp and Gp were the circumferences of our pot and the necessary gap at the edge of the pot from the combustion chamber. Therefore C_p=41.762cm and G_p=13.2cm and the gap between the top of the fire chamber and the bottom of the pot from our design was 15.5cm-13.2cm=2.3cm which was very safe for better firepower capturing.

2.5. Features of Biomass Fuel

Average softwood (conifer) that was left over from other activities at the facility was divided into sawdust for the studies, and it was then air-dried. For each experiment, semi-cylindrical pieces of wood (ranging in length from 0.5 to 3 cm) were utilized. The water boiling test version 4.2.3 software was used to calculate the moisture content (13.5%) and calorific value at the conclusion of the full series of trials.

2.6. Experimental Setup for Performance Evaluation

A condensed approximation of the cooking process is the Water Boiling Test (WBT). It attempts to evaluate the efficiency with which a stove utilizes fuel to heat water in a cooking pot as well as the volume of pollutants produced during cooking [1]. It measures the amount of fuel utilized and the length of time required for the simulated cooking and is often used to examine cookstove performance under various operating conditions.

The standard WBT consists of three phases that happen right after one another. We began the test for the cold-start high-power phase with the stove at room temperature and utilized fuel from a pre-weighed fuel bundle (2kg) to boil a set volume of water (3 liters) in a stainless-steel vessel with a 13.3 cm diameter. In order to complete the second process, we next swapped the boiling water out for new water that was at room temperature. After the first phase, while the stove and cooking vessel were still hot, the hot-start high-power phase was done. Again, we boiled 2 kilograms (0.5 kg) of water in the vessel using fuel from a pre-weighed bundle of fuel. Finding performance variations between a stove when it is cold and when it is hot requires repeating the test with a hot stove. The simmer phase provides the fuel needed to simmer a measured amount of water for 45 minutes at a temperature slightly below boiling. This process mimics the prolonged boiling of pulses or beans that is customary throughout most of the world. The boiling water was simmered for 45 minutes during this stage using a pre-weighed amount of fuel. Because it provided a rapid technique of evaluating cookstove performance [1], In order to compare the performance of the enhanced biomass cook stove to that of the 3-stone conventional cook stove, which it is meant to replace, we used it to evaluate the performance of the better biomass cook stove. The first two stages were carried out three times for each stove.

2.7. Variables That Are Constant Throughout All Phases

1. HHV (kJ/kg) gross calorific value of dry wood.
2. LHV (kJ/kg) Net calorific value for dry wood.
3. MC Moisture percentage in wood on a wet basis.
4. EHV Taking into account the moisture content of the wood, effective calorific value.
5. P (grams) Dry mass of an empty pot.
6. K Empty char container weight in grams.
7. Ta Temperature at Ambience (°C).
8. Tb Water's local boiling point (in °C).

2.8. Determination of Performance Parameters

a) Fuel utilized (dry base): How much wood was required to heat water from room temperature to boiling [19]. And it takes into consideration two things: (1) the energy required to burn out the fuel's moisture and (2) the quantity of char that was left over after burning, given by:

$$\text{Mass of dry fuel=Fuel mass (wet)*(1-M)} \tag{4}$$

b) Specific fuel consumption (SFC): This metric determines the quantity of fuel needed to boil (or simmer) one liter of water. It is computed by dividing the amount of water still in the tank at the end of the test by the equivalent dry fuel used less the energy in the leftover charcoal. In this method, an equation can be utilized to account for and determine the amount of fuel needed to generate a useable liter of "food" as well as the time required [20].

$$SFC \frac{massoffuelconsumed(kg)}{totalmassofboilingwater(lit)} \tag{5}$$

c) Burning rate: The burning rate is the proportion of the entire amount of time (in minutes) to the mass of fuel burned (measured in grams). Using the formula, it was computed.

$$Br = \frac{\text{fcb}(gm)}{\text{dtc}(\text{min})} \tag{6}$$

where br is the burning rate (g/min).

fcbc = Equivalent Dry Fuel Consumption; tbc = Boiling Time (Minutes).

d) Firepower (Fp): These measures how much energy from wood the stove burns through in a certain amount of time. It is a helpful gauge of the stove's heat production and a sign of how consistently the user operated the stove during several testing. Furthermore, the firepower (Fp) is provided by equation.

$$Fp = \frac{fcd * LHV}{change\ T * 60} \tag{7}$$

Where LHV- is the lower heating value of the fuel, fcd=Equivalent specific fuel consumption.

e) Turn-down ratio: The ratio of the average high to average low firepower. It provides as an illustration of how much the stove's firepower may be modified by the user. The equation below shows the equation for the turn-down ratio.

$$TDR = \frac{FPC}{FPS} \tag{8}$$

Where, *TDR*=Turn-down ratio, *FPC* =Fire power during cold start (W) and *FPS* =Fire power during simmering (W).

f) Thermal efficiency (η_{th}): Thermal efficiency is a measure of the fraction of heat produced by the fuel that made it directly to the water in the pot. The remaining energy is lost to the environment. So, a higher thermal efficiency indicates a greater ability to transfer the heat produced into the pot. While thermal efficiency is a well-known measure of stove performance, a better indicator may be specific consumption, especially during the low-power phase of the WBT. This is because a stove that is very slow to boil may have a very good-looking TE. After all, a great deal of water was evaporated. However, the fuel used per water remaining may be too high since so much water was evaporated and so much time was taken while bringing the pot to boil [10] and determined using an equation.

$$\eta th = \frac{4.186*mwb*\Delta T+LHW*Vmass}{fuelconsumeddrybase*LHV} \tag{9}$$

Where, LHV=lower heating value of the fuel wood, LHW=is latent heat of vaporization of Water and mwb=mass of water boiled Therefore; the thermal efficiency of the fabricated sawdust updraft biomass gasifier stove efficiency was 30.6%

g) Temp-Corrected Specific Fuel Consumption (SCTc) — This method adjusts specific fuel consumption to take into account variations in beginning water temperatures. This makes it easier to compare stoves tested on several occasions or under various climatic circumstances. The adjustment is a straightforward variable that "normalizes" the temperature change seen under test settings to a "standard" temperature change of 75°C [4]. It is calculated in the following way:

$$\text{SCtc} = SCc\frac{75}{Tfcf - T1c1} \quad (10)$$

h) Specific Energy Consumption with Correction for Temperature (SETc)- The fuel energy needed to create one liter (or kg) of boiling water from a cold stove starting point is measured by this metric, which is similar to temperature-corrected specific fuel consumption. It is the particular fuel consumption multiplied by the fuel's energy content after temperature correction. [10].

$$\text{SEtc} = SCt * \frac{HLV}{1000} \quad (11)$$

i) The local boiling point (Tb) of water is the temperature at which it will not continue to increase no matter how much heat is supplied. Altitude, small thermometer errors, and meteorological conditions are only a few of the variables that might affect the local boiling temperature. These facts make it impossible to believe that the local boiling point is 100°C. The following formula can be used to predict the boiling point of water at a given height, h (in meters [10]:

$$\text{Tb} = (100 - \frac{h}{300})oC \quad (12)$$

j) Temperature Corrected Time to Boil (TCTB) - The amount of time it takes the vessel to reach boiling point, corrected to reflect a temperature rise of 75 degrees Celsius from start to boil. The "speed" of the stove at high power, which is frequently a crucial aspect for chefs, may be determined by comparing this measurement between tests and stoves. [4]

$$\Delta\text{Tct} = \Delta tc * \frac{75}{T1cf - T1ci} \quad (13)$$

Where, $\Delta Tc\ t$=Temperature-correlated time to boil (min).
$\Delta c\ t$ =Time to boil (min).
$T1ci$= Water temperature at start of test (°C).
$T1cf$ =Water temperature at end of the test (°C).

2.9. Data Analysis

All the collected data were analyzed using R-Software (Rx64 4.1.0) and Micro Soft Excel 2010 for preparing their graph. Analysis of variance (ANOVA) was performed on the experiment's data using graphics and statistics, with a 5% threshold of significance.

3. Results and Discussion

3.1. Observation Result

At first, the flames emerge from the stove's top through orifice holes, however after a few minutes, the combustion alters., and a fire vortex with unexpected flame is produced. The sawdust is gradually turned into charcoal, and the gas that is generated as a result of this conversion burns for a considerably longer time and at a higher flame height than would be possible with wood. After some time, the flames start to emerge from the base of the outer cylinder rather than the stove's top. The heat that is escaping is diverted around the combustion chamber's outside perimeter, flows upward, is absorbed by the cap, and is then injected back into the chamber through a ring of holes at the top. Performance indicator parameters determined by the above equations.

Here is a summary and statistical discussion of the thermal and stove characteristics indicators that were covered previously under this paper's determination of performance parameter section.

Table 1. *Calculation result Summary.*

parameters	Updraft SDGS		TSCS		mean	LSD	CV
	Cold phase	Hot phase	Cold phase	Hot phase			
Boiling Time, BT (min)	15.66[b]	12.66[b]	33.00[a]	30.00[a]	22.83	4.66	10.57
Tcore- time to boil TCBT (min)	16.00[b]	13.00[b]	34.66[a]	33.66[a]	24.33	5.09	10.85
Burning Rate, BR (gm/min)	25.03[a]	28.83[a]	12.00[b]	12.33[b]	19.55	10.04	26.60
Fuel consumed, FC (gm)	480.00[b]	471.66[b]	500.00[a]	500.00[a]	487.91	9.06	0.96
Firepower, FP (watts)	7684.00[a]	8865.33[a]	3735.66[b]	3814.00[b]	6024.75	3055.50	26.26
Specific fuel consumption, SFC (g/liter)	137.00[a]	129.70[a]	127.33[a]	118.33[a]	128.09	22.31	9.02
Temp corrected, TCSFC (g/lite	137.50[a]	136.03[a]	133.67[a]	132.33[a]	134.88	20.97	8.05
Temp-corrected, TCSEC (kj/lit)	2536.00[a]	2448.33[a]	2329.33[a]	2435.00[a]	2437.16	311.72	6.62
Thermal Efficiency, TE, Ƞ (%)	20.33[ab]	24.66[a]	15.66[bc]	14.333[c]	18.75	5.72	15.81

Where, TSCS indicates a three-stone cook stove and SDGS sawdust Gasifier stove, LSD=list significant difference and CV= critical value for comparison.

Means with the same letters for the same parameters that have the same level of significance for both cold and hot phases are none significant for updraft SDGS and TSCS whereas the others are highly significant in terms of comparing the performances and efficiencies of updraft SDGS and TSCS at 5% level of probability. The effects of burning rate for both updraft SDGS and TSCS are not significant in terms how long it takes to completely boil a given amount of water. Whereas it is highly significant in comparison of updraft SDGS with the TSCS for both phases respectively.

Table 2. *Mean Comparison of Cold Start Phase for Updraft SDGS and TSCS.*

Parameters	Units	Updraft SDGS			TSCS		
		Mean	STD	COV	Mean	STD	COV
time to boil	Min	13.67	1.53	0.11	33	1.00	0.03
Tcore- time to boil	Min	13.74	1.71	0.12	34.69	1.39	0.04
fuel consumed (dry)	Gm	486.67	0.96	0.002	500	-	-
Burning rate	Gm/min	26.95	4.56	0.23	12.16	0.61	0.05
Thermal Efficiency,	ɳ (%)	0.23	0.01	0.06	0.14	0.01	0.10
Specific fuel consumption, SFC	g/liter	133.11	7.66	0.06	127.26	13.62	0.11
Temp corrected SFC	g/liter	133.58	5.11	0.04	133.63	12.34	0.09
Temp-corrected SEC	kJ/liter	2461.677	94.23	0.04	2462.78	227.40	0.09
Firepower	Watts	8277.67	1399.72	0.17	3735.74	188.15	0.05

3.2. Boiling Time-Cold Phases and Its Tcore-Time to Boil

From the above table of Mean comparison of the cold start phase for Updraft SDGS and TSCS, the Boiling Time for Cold phases and its Tcore- time to boil the mean boiling times were 13.67, 13.74, and 33, 34.69 for both stoves which shows that the fabricated stove uses less boiling with less biomass consumption and fast boiling time than the three stone cooking stoves.

Where BT=boiling time and TCBT=T Corrected time to boiling

Figure 2. *Graph of Boiling Time (BT) and its TCBT.*

Enhancing the pot's ability to transport heat may significantly reduce the quantity of firewood used, which is a great benefit. In general, the manufactured updraft SDG stoves outperform TSCS in terms of heat transfer efficiency at high power. When compared to the conventional TSCS at intervals of 486.67gm, 8277.67watt, 26.95gm/min and 500gm, 3735.74watt, 12.16gm/min, respectively, it was found that the updraft SDGS consumes less fuel while having a greater firepower and burning rate.

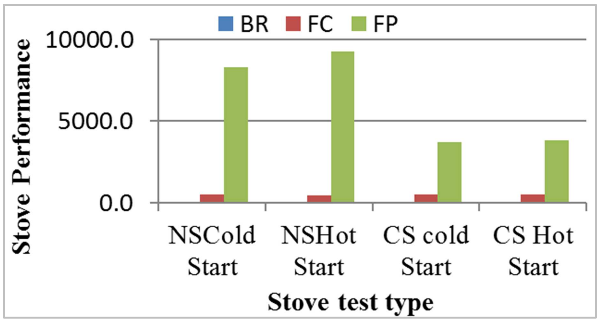

Figure 3. *The Graph of Fuel Consumed, Burning Rate, and its Fire Power.*

Table 3. *Mean Comparison of Hot Start Phase for Updraft SDGS and TSCS.*

Parameters	units	Updraft biomass gasifier			TSCS		
		Mean	STD	COV	Mean	STD	COV
time to boil	min	11.33	1.15	0.10	30	-	-
Tcore- time to boil	min	11.62	1.48	0.13	33.61	0.58	0.02
fuel consumed (dry)	gm	473.33			500		
Burning rate	Gm/min	30.21	4.92	0.16	12.42	1.78	0.14
Thermal Efficiency, ɳ (%)		0.25	0.02	0.09	0.15	0.02	0.11
Specific fuel consumption, SFC	g/liter	125.31	12.12	0.10	118.11	15.18	0.13
Temp corrected SFC	g/liter	128.09	7.57	0.06	132.13	14.83	0.11
Temp-corrected SEC	kJ/liter	2360.64	139.44	0.06	2435.16	273.23	0.11
Firepower	watts	9280	1512.01	0.16	3813.79	545.61	0.14

The experimental results show that from the above table of Mean comparison test of the hot start phase for Updraft SDGS and TSCS; the updraft SDGS performance indicates better boiling time than the cold start phase.

3.3. Specific Fuel Consumption, SFC, and Its Temp Corrected SFC

The experimental test indicates that stove fuel consumption was high for both in case of cold start high power phases. Whereas, medium for hot start phases because the pot was pre-heated and it does not require more fuel.

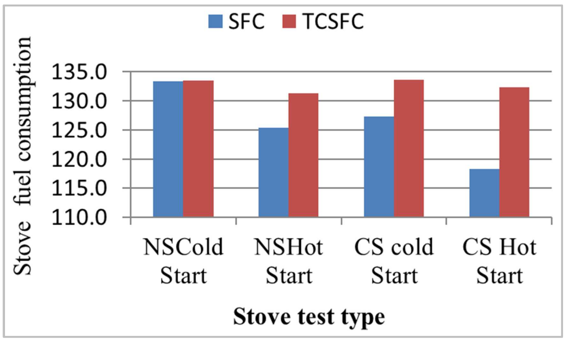

Figure 4. *Graph of Specific fuel Consumption, SFC and its Temp Corrected SFC for ll Phases.*

3.4. Thermal Efficiency and Its Temp-Corrected SEC

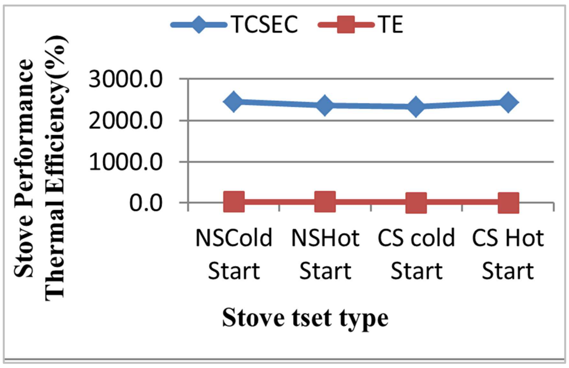

Figure 5. *The graph of Thermal Efficiency for both phases of the Updraft SDGS and TSCS.*

The experimental tests were conducted on the Water boiling test (WBT) by using 500gm of air-dry sawdust as biomass for fueling to boil three liters of water and the highest thermal efficiency was recorded for water boiling tests conducted during hot start test for updraft SDGS and TSCS respectively. The least efficiency was recorded during clod start test phases for updraft SDGS and TSCS respectively. The high-power thermal efficiency was 24.6% and 15.6% for updraft SDGS fabricated at BAERC for hot start phases and TSCS as control respectively according to [18] 26% and 12%, and low power efficiency was 20.3% and 14.3% for updraft SDGS fabricated at BAERC for cold start (high power) phases and TSCS as control respectively according to [18] 21% and 13.5%. the fabricated updraft sawdust biomass gasifier stove has the best combustion efficiency of 84.2% as the results of the experimental performance evaluation indicate it.

4. Conclusion

An environmentally friendly updraft biomass gasifier stove was developed, built, and tested using sawdust as a fuel source. It can burn fuels effectively and emit fewer pollutants into the atmosphere. Particularly in rural areas, its ease of use, effectiveness, and safety make it an easy choice for homeowners as well as business owners. The performance evaluation of an updraft biomass gasifier stove was tested by using 0.5kg of sawdust per batch and has a combustion efficiency of 84.2% and thermal efficiency of 24.6% respectively. The updraft SDGS has a thermal efficiency of 24.6% during hot start phase high power tests and 15.6% when compared with Traditional cooking stoves (TSCS) and 20.3% for cold start high power phases for an updraft SDGS and 14.3% for control. The stove performed better than TSCS for all performance indicators of thermal parameters. The technology performed better than traditional stoves by most thermal performance indicators and it is important to promote to end users.

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